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Cryogenic Fluid Management: 2000-2004

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OCTOBER 2004

20040110242 NASA Goddard Space Flight Center, Greenbelt, MD, USA
Enhancements to a Superconducting Quantum Interference Device (SQUID) Multiplexer Readout and Control System
Forgione, J.; Benford, D. J.; Buchanan, E. D.; Moseley, S. H.; Rebar, J.; Shafer, R. A.; May 2004; In English, June 2004, Glasgow, Scotland, UK; No Copyright; Avail: CASI; A03, Hardcopy

Far-infrared detector arrays such as the 16x32 superconducting bolometer array for the SAFIRE instrument (flying on the SOFIA airborne observatory) require systems of readout and control electronics to provide translation between a user-driven, digital PC and the cold, analog world of the cryogenic detector. In 2001, the National Institute of Standards and Technology (NIST) developed their Mark III electronics for purposes of control and readout of their 1x32 SQUID Multiplexer chips. We at NASA s Goddard Space Flight Center acquired a Mark 111 system and subsequently designed upgrades to suit our and our collaborators purposes. We developed an arbitrary, programmable multiplexing system that allows the user to cycle through rows in a SQUID array in an infinite number of combinations. We provided hooks in the Mark III system to allow readout of signals from outside the Mark 111 system, such as telescope status information. Finally, we augmented the heart of the system with a new feedback algorithm implementation, flexible diagnostic tools, and informative telemetry.
Author
Squid (Detectors); Superconductivity; Control Systems Design; Multiplexing; Quantum Mechanics; Cryogenics; Sensors

20040090623 NASA Goddard Space Flight Center, Greenbelt, MD, USA
The Cryogenic, High-Accuracy, Refraction Measuring System (CHARMS): A New Facility for Cryogenic Infrared through Vacuum Far-Ultraviolet Refractive Index Measurements
Frey, Bradley J.; Leviton, Douglas B.; [2004]; In English, 21-25 Jun. 2004, USA; No Copyright; Avail: Other Sources; Abstract Only

The optical designs of future NASA infrared (IR) missions and instruments, such as the James Webb Space Telescope's (JWST) Near-Mixed Camera (NIRCam), will rely on accurate knowledge of the index of refraction of various IR optical materials at cryogenic temperatures. To meet this need, we have developed a Cryogenic, High-Accuracy Refraction Measuring System (CHARMS). In this paper we discuss the completion of the design and construction of CHARMS as well as the engineering details that constrained the final design and hardware implementation. In addition, we will present our first light, cryogenic, IR index of refraction data for LiF, BaF2, and CaF2, and compare our results to previously published data for these materials.
Author
Cryogenics; Refractometers

20040086905 NASA Ames Research Center, Moffett Field, CA, USA
On-Orbit Performance of the Spitzer Space Telescope
Roellig, Thomas; Werner, Michael; Gallagher, David; Irace, William; Fazio, Giovanni; Houck, James; Rieke, George; Wilson, Robert; Soifer, Thomas; March 15, 2004; In English, 21-25 Jun. 2004, Glasgow, Scotland, UK
Contract(s)/Grant(s): WBS 21-456-06-1R; No Copyright; Avail: CASI; A01, Hardcopy

The Spitzer Space Telescope (formally known as SIRTF) was successfully launched on August 25, 2003, and has completed its initial in-orbit checkout and science validation and calibration period. The measured performance of the observatory has met or exceeded all of its high-level requirements, it has entered normal operations, and is beginning to return high-quality science data. A superfluid-helium cooled 85 cm diameter telescope provides extremely low infrared backgrounds and feeds three science instruments covering wavelengths ranging from 3.2 to 180 microns. The telescope optical quality is excellent, providing diffraction-limited performance down to wavelengths below 6.5 microns. Based on the first helium mass and boil-off rate measurements, a cryogenic lifetime in excess of 5 years is expected. This presentation will provide a summary

of the overall performance of the observatory, with an emphasis on those performance parameters that have the greatest impact on its ultimate science return.
Author
Space Infrared Telescope Facility; Astronomical Observatories; NASA Space Programs

20040086803 NASA Langley Research Center, Hampton, VA, USA
A Cryogenic Magnetostrictive Actuator using a Persistent High Temperature Superconducting Magnet, Part 1: Concept and Design, Part 1, Concept and Design
Horner, Garnett C.; Bromberg, Leslie; Teter, J. P.; [2001]; In English; Copyright; Avail: CASI; A02, Hardcopy

Cryogenic magnetostrictive materials, such as rare earth zinc crystals, offer high strains and high forces with minimally applied magnetic fields, making the material ideally suited for deformable optics applications. For cryogenic temperature applications, such as Next Generation Space Telescope (NGST), the use of superconducting magnets offer the possibility of a persistent mode of operation, i.e., the magnetostrictive material will maintain a strain field without power. High temperature superconductors (HTS) are attractive options if the temperature of operation is higher than 10 degrees Kelvin (K) and below 77 K. However, HTS wires have constraints that limit the minimum radius of winding, and even if good wires can be produced, the technology for joining superconducting wires does not exist. In this paper, the design and capabilities of a rare earth zinc magnetostrictive actuator using bulk HTS is described. Bulk superconductors can be fabricated in the sizes required with excellent superconducting properties. Equivalent permanent magnets, made with this inexpensive material, are persistent, do not require a persistent switch as in HTS wires, and can be made very small. These devices are charged using a technique which is similar to the one used for charging permanent magnets, e.g., by driving them into saturation. A small normal conducting coil can be used for charging or discharging. Very fast charging and discharging of HTS tubes, as short as 100 microseconds, has been demonstrated. Because of the magnetic field capability of the superconductor material, a very small amount of superconducting magnet material is needed to actuate the rare earth zinc. In this paper, several designs of actuators using YBCO and BSCCO 2212 superconducting materials are presented. Designs that include magnetic shielding to prevent interaction between adjacent actuators will also be described. Preliminary experimental results and comparison with theory for BSSCO 2212 with a magnetostrictive element will be discussed.
Author
Actuators; Cryogenics; Magnetostriction; Superconducting Magnets; Design Analysis

20040086783 NASA Ames Research Center, Moffett Field, CA, USA
Solar System Studies in the Infrared with the Spitzer Space Telescope
Cruikshank, D. P.; Stansberry, J. A.; Cleve, J. Van; Burgdorf, M. J.; Fernandez, Y. R.; Meadows, V. S.; Reach, W. T.; May 05, 2004; In English; Committee on Space Research Meeting, 18-25 Jul. 2003, Paris, France
Contract(s)/Grant(s): 456-06-1C; No Copyright; Avail: Other Sources; Abstract Only

The Spitzer Space Telescope, formerly known as SIRTF, is a cryogenic telescope (85 cm diameter) operating in a heliocentric orbit trailing the Earth. Its three instruments provide capabilities for spectroscopy, wide-field and small-field imaging at many wavelengths in the range 3.5-160 microns. Observations to be executed in the first two years in programs defined by the Guaranteed Time Observer (GTO) group (the authors of this presentation) consist of photometry, spectroscopy, and radiometry of many Solar System objects, including Titan and other satellites of the outer planets, Pluto, Centaurs, trans-Neptunian objects, comers, asteroids, Uranus, and Neptune. At the time of the preparation of this abstract, some preliminary observations have been made, but the final calibration and reduction of the data are still in progress. The latest results of the Solar System investigations will be presented here.
Author
Solar System; Infrared Astronomy; Space Infrared Telescope Facility

20040086684 NASA Marshall Space Flight Center, Huntsville, AL, USA
Automated Composites Processing Technology: Film Module
Hulcher, A. Bruce; Aerospace America Magazine; [2004]; In English; No Copyright; Avail: CASI; A01, Hardcopy

NASA's Marshall Space Flight Center (MSFC) has developed a technology that combines a film/adhesive laydown module with fiber placement technology to enable the processing of composite prepreg tow/tape and films, foils or adhesives on the same placement machine. The development of this technology grew out of NASA's need for lightweight, permeation-resistant cryogenic propellant tanks. Autoclave processing of high performance composites results in thermally-induced stresses due to differences in the coefficients of thermal expansion of the fiber and matrix resin components. These

stresses, together with the reduction in temperature due to cryogen storage, tend to initiate microcracking within the composite tank wall. One way in which to mitigate this problem is to introduce a thin, crack-resistant polymer film or foil into the tank wall. Investigation into methods to automate the processing of thin film or foil materials into composites led to the development of this technology. The concept employs an automated film supply and feed module that may be designed to fit existing fiber placement machines, or may be designed as integral equipment to new machines. This patent-pending technology can be designed such that both film and foil materials may be processed simultaneously, leading to a decrease in part build cycle time. The module may be designed having a compaction device independent of the host machine, or may utilize the host machine's compactor. The film module functions are controlled by a dedicated system independent of the fiber placement machine controls. The film, foil, or adhesive is processed via pre-existing placement machine run programs, further reducing operational expense.
Author (revised)
Fiber Composites; Fabrication; Polymeric Films

20040086005 NASA Langley Research Center, Hampton, VA, USA
Tensile Properties of Polymeric Matrix Composites Subjected to Cryogenic Environments
Whitley, Karen S.; Gates, Thomas S.; [2004]; In English; No Copyright; Avail: CASI; A03, Hardcopy

Polymer matrix composites (PMC s) have seen limited use as structural materials in cryogenic environments. One reason for the limited use of PMC s in cryogenic structures is a design philosophy that typically requires a large, validated database of material properties in order to ensure a reliable and defect free structure. It is the intent of this paper to provide an initial set of mechanical properties developed from experimental data of an advanced PMC (IM7/PETI-5) exposed to cryogenic temperatures and mechanical loading. The application of this data is to assist in the materials down-select and design of cryogenic fuel tanks for future reusable space vehicles. The details of the material system, test program, and experimental methods will be outlined. Tension modulus and strength were measured at room temperature, -196 C, and -269 C on five different laminates. These properties were also tested after aging at -186 C with and without loading applied. Microcracking was observed in one laminate.
Author
Tensile Properties; Polymer Matrix Composites; Cryogenic Temperature; Fuel Tanks

20040085970 NASA, Washington, DC, USA
The Hybrid Propellant Module (HPM): A New Concept for Space Transfer in the Earth's Neighborhood and Beyond
Mankins, John C.; Mazanek, Daniel D.; [2001]; In English; No Copyright; Avail: CASI; A03, Hardcopy

The safe, affordable and effective transfer of ever-larger payloads and eventually personnel beyond Low Earth Orbit (LEO) is a major challenge facing future commercial development and human exploration of space. Without reusable systems, sustained exploration or large scale development beyond LEO appears to be economically non-viable. However, reusable systems must be capable of both good fuel efficiency and 'high utilization of capacity', or else economic costs will remain unacceptably high. Various options exist that can provide high fuel efficiency - for example, Solar Electric Propulsion Systems (SEPS) - but only at the cost of low thrust and concomitant long transit times. Chemical propulsion systems offer the potential for high thrust and short transit times - including both cryogenic and non-cryogenic options - but only at the cost of relatively low specific impulse (Isp). Nuclear thermal propulsion systems offer relatively good thrust-to-weight and Isp - but involve public concerns that may be insurmountable for all except the most-critical of public purposes. Fixed infrastructures have been suggested as one approach to solving this challenge; for example, rotating tether approaches. However, these systems tend to suffer from high initial costs or unacceptable operational constraints. A new concept has been identified - the Hybrid Propellant Module (HPM) - that integrates the best features of both chemical and solar electric transportation architectures. The HPM approach appears to hold promise of solving the issues associated with other approaches, opening a new family of capabilities for future space exploration and development of near-Earth space and beyond. This paper provides a summary overview of the challenge of Earth neighborhood transportation and discusses how various systems concepts might be applied to meet the needs of these architectures. The paper describes a new approach, the HPM, and illustrates the application of the concept for a typical mission concept. The paper concludes with a discussion of needed technologies and a possible timeline for the development and evolution of this class of systems concepts.
Author
Hybrid Propellants; Modules; Cryogenics; Propulsion System Performance; Solar Electric Propulsion; Thrust-Weight Ratio

20040085899 NASA Marshall Space Flight Center, Huntsville, AL, USA

Advanced Chemical Propulsion Study

Woodcock, Gordon; Byers, Dave; Alexander, Leslie A.; Krebsbach, Al; [2004]; In English, 11-14 Jul. 2004, Fort Lauderdale, FL, USA; Copyright; Avail: CASI; A03, Hardcopy

A study was performed of advanced chemical propulsion technology application to space science (Code S) missions. The purpose was to begin the process of selecting chemical propulsion technology advancement activities that would provide greatest benefits to Code S missions. Several missions were selected from Code S planning data, and a range of advanced chemical propulsion options was analyzed to assess capabilities and benefits re these missions. Selected beneficial applications were found for higher-performing bipropellants, gelled propellants, and cryogenic propellants. Technology advancement recommendations included cryocoolers and small turbopump engines for cryogenic propellants; space storable propellants such as LOX-hydrazine; and advanced monopropellants. It was noted that fluorine-bearing oxidizers offer performance gains over more benign oxidizers. Potential benefits were observed for gelled propellants that could be allowed to freeze, then thawed for use.

Author

Chemical Propulsion; Space Missions; Gelled Propellants; Liquid Rocket Propellants; Cryogenic Rocket Propellants; Cryogenic Cooling; Storable Propellants

20040085787 NASA Langley Research Center, Hampton, VA, USA

Thermal/Mechanical Durability of Polymer-Matrix Composites in Cryogenic Environments

Gates, Thomas S.; Whitley, Karen S.; Grenoble, Ray W.; Bandorawalla, Tozer; [2003]; In English, 7-10 Apr. 2003, Norfolk, VA, USA

Report No.(s): AIAA Paper 2003-7408; No Copyright; Avail: CASI; A03, Hardcopy

In order to increase the reliability of the next generation of space transportation systems, the mechanical behavior of polymeric-matrix composite (PMC) materials at cryogenic temperatures must be investigated. This paper presents experimental data on the residual mechanical properties of a carbon fiber polymeric composite, IM7/PETI-5 as a function of temperature and aging. Tension modulus and strength were measured at room temperature, -196 C, and -269 C on five different specimens ply lay-ups. Specimens were preconditioned with one set of coupons being isothermally aged for 576 hours at -184 C, in an unloaded state. Another set of corresponding coupons were mounted in constant strain fixtures such that a constant uniaxial strain was applied to the specimens for 576 hours at -184 C. A third set was mechanically cycled in tension at -184 C. The measured properties indicated that temperature, aging, and loading mode can all have significant influence on performance. Moreover, this influence is a strong function of laminate stacking sequence. Thermal-stress calculations based on lamination theory predicted that the transverse tensile ply stresses could be quite high for cryogenic test temperatures. Microscopic examination of the surface morphology showed evidence of degradation along the exposed edges of the material because of aging at cryogenic temperatures. ________________

Author

Polymer Matrix Composites; Mechanical Properties; Thermal Fatigue; Stress Analysis; Cryogenic Temperature

20040084662 NASA Stennis Space Center, Bay Saint Louis, MS, USA

Facility Activation and Characterization for IPD Workhorse Preburner and Oxidizer Turbopump Hot-Fire Testing at NASA Stennis Space Center

Sass, J. P.; Raines, N. G.; Ryan, H. M.; May 10, 2004; In English, 10-13 May 2004, Las Vegas, NV, USA

Contract(s)/Grant(s): SSC/FED-99-006-03

Report No.(s): SSTI-8080-0001; No Copyright; Avail: CASI; A03, Hardcopy

The Integrated Powerhead Demonstrator (IPD) is a 250K lbf (1.1 MN) thrust cryogenic hydrogen/oxygen engine technology demonstrator that utilizes a full flow staged combustion engine cycle. The Integrated Powerhead Demonstrator (IPD) is part of NASA's Next Generation Launch Technology (NGLT) program, which seeks to provide safe, dependable, cost-cutting technologies for future space launch systems. The project also is part of the Department of Defense's Integrated High Payoff Rocket Propulsion Technology (IHPRPT) program, which seeks to increase the performance and capability of today s state-of-the-art rocket propulsion systems while decreasing costs associated with military and commercial access to space. The primary industry participants include Boeing-Rocketdyne and GenCorp Aerojet. The intended full flow engine cycle is a key component in achieving all of the aforementioned goals. The IPD Program recently achieved a major milestone with the successful completion of the IPD Oxidizer Turbopump (OTP) hot-fire test project at the NASA John C. Stennis Space Center (SSC) E-1 test facility in June 2003. A total of nine IPD Workhorse Preburner tests were completed, and subsequently 12 IPD OTP hot-fire tests were completed. The next phase of development involves IPD integrated engine system testing also

at the NASA SSC E-1 test facility scheduled to begin in late 2004. Following an overview of the NASA SSC E-1 test facility, this paper addresses the facility aspects pertaining to the activation and testing of the IPD Workhorse Preburner and the IPD Oxidizer Turbopump. In addition, some of the facility challenges encountered during the test project shall be addressed.
Author
Combustion; Cryogenic Equipment; Engine Tests; Hydrogen Oxygen Engines

20040084595 Combustion Research and Flow Technology, Inc., Pipersville, PA, USA
Multi-Element Unstructured Analyses of Complex Valve Systems
Sulyma, Peter, Technical Monitor; Ahuja, Vineet; Hosangadi, Ashvin; Shipman, Jeremy; May 1, 2004; In English, 10-13 May 2004, Las Vegas, NV, USA
Contract(s)/Grant(s): NAS13-03009
Report No.(s): SSTI-3000-0001-FLUIDS; No Copyright; Avail: CASI; A03, Hardcopy

The safe and reliable operation of high pressure test stands for rocket engine and component testing places an increased emphasis on the performance of control valves and flow metering devices. In this paper, we will present a series of high fidelity computational analyses of systems ranging from cryogenic control valves and pressure regulator systems to cavitating venturis that are used to support rocket engine and component testing at NASA Stennis Space Center. A generalized multi-element framework with sub-models for grid adaption, grid movement and multi-phase flow dynamics has been used to carry out the simulations. Such a framework provides the flexibility of resolving the structural and functional complexities that are typically associated with valve-based high pressure feed systems and have been difficult to deal with traditional CFD methods. Our simulations revealed a rich variety of flow phenomena such as secondary flow patterns, hydrodynamic instabilities, fluctuating vapor pockets etc. In the paper, we will discuss performance losses related to cryogenic control valves, and provide insight into the physics of the dominant multi-phase fluid transport phenomena that are responsible for the choking like behavior in cryogenic control elements. Additionally, we will provide detailed analyses of the modal instability that is observed in the operation of the dome pressure regulator valve. Such instabilities are usually not localized and manifest themselves as a system wide phenomena leading to an undesirable chatter at high flow conditions.
Author
Computerized Simulation; Computational Fluid Dynamics; Rocket Engines; Control Valves; Cryogenics; Multiphase Flow; Unstructured Grids (Mathematics)

20040084370 NASA Ames Research Center, Moffett Field, CA, USA
Characterization of an Integral Thermal Protection and Cryogenic Insulation Material for Advanced Space Transportation Vehicles
Salerno, L. J.; White, S. M.; Helvensteijn, B. P. M.; [2000]; In English, 10-13 Jul. 2000, Toulouse, France
Contract(s)/Grant(s): RTOP 242-81-01
Report No.(s): Paper 00ICES-264; No Copyright; Avail: CASI; A02, Hardcopy

NASA's planned advanced space transportation vehicles will benefit from the use of integral/conformal cryogenic propellant tanks which will reduce the launch weight and lower the earth-to-orbit costs considerably. To implement the novel concept of integral/conformal tanks requires developing an equally novel concept in thermal protection materials. Providing insulation against reentry heating and preserving propellant mass can no longer be considered separate problems to be handled by separate materials. A new family of materials, Superthermal Insulation (STI), has been conceiving and investigated by NASA's Ames Research Center to simultaneously provide both thermal protection and cryogenic insulation in a single, integral material.
Author
Insulation; Cryogenics; Thermal Protection

20040084295 Northrop Grumman Space Technology, Redondo Beach, CA, USA
Design and Development of the Primary and Secondary Mirror Deployment Systems for the Cryogenic JWST
Reynolds, Paul; Atkinson, Charlie; Gliman, Larry; 37th Aerospace Mechanisms Symposium; May 2004; In English; No Copyright; Avail: CASI; A03, Hardcopy

With a 7-meter primary mirror (PM) aperture, the James Webb Space Telescope will require structures that remain stable to levels on the order of 10 nanometers out of plane under dynamic and thermal loading while operating at cryogenic temperatures. Moreover, the JWST will be the first telescope in space to deploy primary and secondary mirrors. The resulting primary mirror (PM) aperture will not only be segmented, but will have hinge-lines and associated latches. The secondary

mirror will be deployed with folding booms that latch to support it approximately 7 m away from the PM. This paper describes the design of the JWST Optical Telescope Element (OTE) structures and mechanisms, focusing primarily on the primary and secondary mirror deployment systems. It discusses the driving design requirements, how the resulting designs satisfy those requirements, and how the risk associated with these very large, stable, deployed structures was reduced through development and testing of the Development Optical Telescope Assembly (DOTA).
Author
James Webb Space Telescope; Mirrors; Cryogenic Temperature; Deployment

20040084227 Maryland Univ., College Park, MD, USA
Boiling Heat Transfer Mechanisms in Earth and Low Gravity Boundary Condition and Heater Aspect Ratio Effects
Kim, Jungho; Strategic Research to Enable NASA's Exploration Missions Conference; June 2004; In English; No Copyright; Avail: CASI; A01, Hardcopy

Boiling is a complex phenomenon where hydrodynamics, heat transfer, mass transfer, and interfacial phenomena are tightly interwoven. An understanding of boiling and critical heat flux in microgravity environments is of importance to space based hardware and processes such as heat exchange, cryogenic fuel storage and transportation, electronic cooling, and material processing due to the large amounts of heat that can be removed with relatively little increase in temperature. Although research in this area has been performed in the past four decades, the mechanisms by which heat is removed from surfaces in microgravity are still unclear. Recently, time and space resolved heat transfer data were obtained in both earth and low gravity environments using an array of microheaters varying in size between 100 microns and 700 microns. These heaters were operated in both constant temperature as well as constant heat flux mode.
Author
Boiling; Heat Flux; Heat Transfer; Mass Transfer; Hydrodynamics; Cooling; Heaters; Microgravity

20040084080 NASA, Washington, DC, USA
Taming Liquid Hydrogen: The Centaur Upper Stage Rocket, 1958-2002
Dawson, Virginia P.; Bowles, Mark D.; 2004; In English; Original contains black and white illustrations
Report No.(s): NASA/SP-2004-4230; LC-2004-042092; No Copyright; Avail: CASI; A13, Hardcopy

During its maiden voyage in May 1962, a Centaur upper stage rocket, mated to an Atlas booster, exploded 54 seconds after launch, engulfing the rocket in a huge fireball. Investigation revealed that Centaur's light, stainless-steel tank had split open, spilling its liquid-hydrogen fuel down its sides, where the flame of the rocket exhaust immediately ignited it. Coming less than a year after President Kennedy had made landing human beings on the Moon a national priority, the loss of Centaur was regarded as a serious setback for the National Aeronautics and Space Administration (NASA). During the failure investigation, Homer Newell, Director of Space Sciences, ruefully declared: 'Taming liquid hydrogen to the point where expensive operational space missions can be committed to it has turned out to be more difficult than anyone supposed at the outset.' After this failure, Centaur critics, led by Wernher von Braun, mounted a campaign to cancel the program. In addition to the unknowns associated with liquid hydrogen, he objected to the unusual design of Centaur. Like the Atlas rocket, Centaur depended on pressure to keep its paper-thin, stainless-steel shell from collapsing. It was literally inflated with its propellants like a football or balloon and needed no internal structure to give it added strength and stability. The so-called 'pressure-stabilized structure' of Centaur, coupled with the light weight of its high- energy cryogenic propellants, made Centaur lighter and more powerful than upper stages that used conventional fuel. But, the critics argued, it would never become the reliable rocket that the USA needed.
Derived from text
Liquid Hydrogen; Centaur Launch Vehicle; Cryogenic Rocket Propellants

20040083982 Texas A&M Univ., College Station, TX, USA
Numerical Modeling, Thermomechanical Testing, and NDE Procedures for Prediction of Microcracking Induced Permeability of Cryogenic Composites
Noh, Jae; Whitcomb, John; Oh, Bongtaek; Lagoudas, Dimitris; Maslov, Konstatin; Ganpatyre, Atul; Kinra, Vikram; 5th Conference on Aerospace Materials, Processes, and Environmental Technology; November 2003; In English; Original contains color and black and white illustrations
Contract(s)/Grant(s): NCC8-223; No Copyright; Avail: CASI; A02, Hardcopy

Reusable Space Vehicles will include light cryogenic composite fuel tanks that must not leak excessively even after multiple launches. Damage in cryogenic composite fuel tanks induced during manufacturing and advanced by

thermomechanical cycling can accelerate leakage of the propellant. Whether the leakage exceeds tolerable levels depends on many factors, including pressure gradients, microcrack density, other damage such as delamination, connectivity of the cracks, residual stresses from manufacture, service-induced stresses from thermal and mechanical loads, and composite lay-up. Although it is critical to experimentally characterize permeability during various thermal and mechanical load histories, optimal design depends on having analytical models that can predict the effect of various parameters on performance. Our broad goal is to develop such models that are experimentally validated by destructive and non-destructive evaluation means.
Derived from text
Mathematical Models; Thermodynamics; Nondestructive Tests; Cracks; Cryogenics

20040083977 NASA Marshall Space Flight Center, Huntsville, AL, USA
Manufacturing Process Simulation of Large-Scale Cryotanks
Babai, Majid; Phillips, Steven; Griffin, Brian; 5th Conference on Aerospace Materials, Processes, and Environmental Technology; November 2003; In English; Original contains color illustrations; No Copyright; Avail: CASI; A01, Hardcopy

NASA's Space Launch Initiative (SLI) is an effort to research and develop the technologies needed to build a second-generation reusable launch vehicle. It is required that this new launch vehicle be 100 times safer and 10 times cheaper to operate than current launch vehicles. Part of the SLI includes the development of reusable composite and metallic cryotanks. The size of these reusable tanks is far greater than anything ever developed and exceeds the design limits of current manufacturing tools. Several design and manufacturing approaches have been formulated, but many factors must be weighed during the selection process. Among these factors are tooling reachability, cycle times, feasibility, and facility impacts. The manufacturing process simulation capabilities available at NASA.s Marshall Space Flight Center have played a key role in down selecting between the various manufacturing approaches. By creating 3-D manufacturing process simulations, the varying approaches can be analyzed in a virtual world before any hardware or infrastructure is built. This analysis can detect and eliminate costly flaws in the various manufacturing approaches. The simulations check for collisions between devices, verify that design limits on joints are not exceeded, and provide cycle times which aide in the development of an optimized process flow. In addition, new ideas and concerns are often raised after seeing the visual representation of a manufacturing process flow. The output of the manufacturing process simulations allows for cost and safety comparisons to be performed between the various manufacturing approaches. This output helps determine which manufacturing process options reach the safety and cost goals of the SLI. As part of the SLI, The Boeing Company was awarded a basic period contract to research and propose options for both a metallic and a composite cryotank. Boeing then entered into a task agreement with the Marshall Space Flight Center to provide manufacturing simulation support. This paper highlights the accomplishments of this task agreement, while also introducing the capabilities of simulation software.
Derived from text
Manufacturing; Computerized Simulation; Cryogenic Tanks; Reusable Launch Vehicles; Optimization

20040082314 NASA Marshall Space Flight Center, Huntsville, AL, USA
Mirror Requirements for SAFIR
Stahl, H. Philip; Leisawitz, David T.; Benford, Dominic J.; [2004]; In English, 21-25 Jun. 2004, Glasgow, Scotland, UK; No Copyright; Avail: Other Sources; Abstract Only

Large-aperture lightweight low-cost cryogenic mirrors are an enabling technology for planned NASA far-infrared and sub-millimeter missions such as CMB-Pol, SAFIR and SPECS. This paper examines d e mirror requirements necessary to design, build and characterize mirror segments for large space telescopes operating at temperatures of less than 1OK. Such mirrors should be diffraction limited in the far-IR with an areal density of less than 10 kg/sq m, aperture of 1 to 2 meters and cost of less than $500,000 per square meter.
Author
Cryogenics; Mirrors; Far Infrared Radiation; Diffraction; Low Cost

20040082145 NASA Goddard Space Flight Center, Greenbelt, MD, USA
Fabrication of MEMS-Based Microshutter Arrays for Optical Transmission Selection
Lynch, Bernard A.; Franz, David E.; Hu, R. G.; Jhabvala, M. D.; Kotecki, C. A.; Li, M. J.; Oh, H.; Zheng, Y.; [2004]; In English; 2004 MEMS Alliance Symposium on MEMS in Homeland Security Defense and Aerospace Applications, 29-30 Mar. 2004; No Copyright; Avail: CASI; A01, Hardcopy

A MEMS-based programmable aperture mask is under development at the NASA Goddard Space Flight Center. Termed the Microshutter (u-shutter) Array, the device will be used to control the transmission of light, with both high efficiency and

contrast, to a multi-object spectrometer on the James Webb Space Telescope. Fabrication of the p-shutter array employs several novel designs and processing techniques. The current generation of micro-shutters consists of 128x64 pixel arrays with unit cell dimensions of 100x200 microns. Shutters are patterned in silicon nitride and sit on a 100 micron silicon frame that is DRIE etched below each shutter. The front and back sides of the device are shown. A magnetic cobalt-iron alloy patterned on top of the shutter allows it to be actuated 90 degrees out-of-plane, into the frame, by an external magnetic field. An electrode on the shutter and a vertical electrode on the sidewall of the frame, approximately 90pm deep, allow them to be electrostatically latched in their rotated position. The vertical electrode is deposited and patterned on the backside of the frame in a single step using a directionally controlled evaporation. Individual addressing of shutters for electrostatic latching is accomplished via a crosspoint addressing scheme, with no on-chip active components. A portion of an array with shutters in the open, latched, and closed positions is shown. Light loss at shutter edges is minimized by an overhanging aluminum light-shield that is anchored to the frame. A photoresist sacrificial layer is used to raise the light-shield up and over the 2 micron gap that surrounds each pixel. After completion, arrays are subjected to life cycle, environmental and optical testing. Fabricated devices have survived 10(exp 6) actuation cycles at both room and cryogenic temperatures and a 14g rms launch-simulation test. Optical testing has shown contrast measurements between open and closed shutters up to 10000:1.
Author
Fabrication; Light Transmission; Microelectromechanical Systems; Arrays

20040081165 NASA Goddard Space Flight Center, Greenbelt, MD, USA
Cryogenic Characterization and Testing of Magnetically-Actuated Microshutter Arrays for the James Webb Space Telescope
King, T. T.; Kletetschka, G.; Jah, M. A.; Li, M. J.; Jhabvala, M. D.; Wang, L. L.; Beamesderfer, M. A.; Kutyrev, A. S.; Silverberg, R. F.; Rapchun, D.; Schwinger, D. S., et al.; [2004]; In English, 6-10 Jun. 2004, Hilton Head, SC, USA; Original contains color and black and white illustrations; Copyright; Avail: CASI; A01, Hardcopy

Two-dimensional MEMS microshutter arrays (MSA) have been fabricated at the NASA Goddard Space Flight Center (GSFC) for the James Webb Space Telescope (JWST) to enable cryogenic (approximately 35 K) spectrographic astronomy measurements in the near-infrared region. Functioning as a focal plane object selection device, the MSA is a 2-D programmable aperture mask with fine resolution, high efficiency and high contrast. The MSA are close- packed silicon nitride shutters (cell size of 100 x 200 microns) patterned with a torsion flexure to allow opening to 90 degrees. A layer of magnetic material is deposited onto each shutter to permit magnetic actuation. Two electrodes are deposited, one onto each shutter and another onto the support structure side-wall, permitting electrostatic latching and 2-D addressing. New techniques were developed to test MSA under mission-similar conditions (8 K less than or equal to T less than 300K). The magnetic rotisserie has proven to be an excellent tool for rapid characterization of MSA. Tests conducted with the magnetic rotisserie method include accelerated cryogenic lifetesting of unpackaged 128 x 64 MSA and parallel measurement of the magneto-mechanical stiffness of shutters in pathfinder test samples containing multiple MSA designs. Lifetest results indicate a logarithmic failure rate out to approximately 10(exp 6) shutter actuations. These results have increased our understanding of failure mechanisms and provide a means to predict the overall reliability of MSA devices.
Author
Actuation; Cryogenics; James Webb Space Telescope; Microelectromechanical Systems; Fabrication; Magnetic Materials; Focal Plane Devices

20040081128 NASA Goddard Space Flight Center, Greenbelt, MD, USA
Surface Figure Measurement at 20K: Silicon Carbide and Cesic Mirrors
Blake, Peter; Mink, Ronald G.; Content, David; Davila, Pamela; Chambers, John; Robinson, F. David; 2004; In English, 21-25 Jun. 2004, Glasgow, Scotland, UK; No Copyright; Avail: Other Sources; Abstract Only

This report presents the facility, methods, and results of testing cryogenically-cooled spherical mirrors, using standard phase-shifting interferometry, at the Goddard Space Flight Center (GSFC). Two mirrors were supplied to GSFC by the European Space Technology Center, so that GSFC could render a second, independent cryo-measurement of their surface figures at 20K. These mirrors, produced by Galileo Avionica and its partners, demonstrate the technology of silicon carbide and SiC-composite lightweighted mirrors, designed for high accuracy (10 nm rms surface figure error) at both room temperature and 20K. The two mirrors provided for testing at GSFC include one made of sintered silicon carbide (mirror blank by Bettini), and a second made of the C/Si/SiC composite known as Cesic (supplied by ECM). Both mirrors are f/2 spheres with 150 mm clear aperture, and with integral mounts. At GSFC, the mirrors will be measured first at at room temperature, making use of standard techniques, with a predicted uncertainty of 2 nm. Then each mirror will be tested in the cryostat, down to 20K: first freely supported and, second, mounted to a Cesic plate that models a Cesic optical bench. The uncertainty of the

resultant surface figure error is predicted to be about 5 nm rms. Details of the uncertainty budget are discussed in a related poster. GSFC's techniques and results can be usefully compared to the measurements performed on the same two mirrors by and for Galileo Avionica, who used a somewhat different test configuration and alignment approach.
Author
Mirrors; Silicon Carbides; Spheres; Cryogenics; Composite Materials; Surface Properties; Temperature Dependence

20040079371 NASA Goddard Space Flight Center, Greenbelt, MD, USA
Fabrication of Microshutter Arrays for James Webb Space Telescope
Li, Mary J.; Zheng, Yun; Hess, Larry; Hu, Ron; Kelly, Dan; Lynch, Barney; Oh, Lance; Ray, Chris; Smith, Wayne; Babu, Sachi, et al.; [2004]; In English; No Copyright; Avail: Other Sources; Abstract Only

Two-dimensional MEMS microshutter arrays are being developed at NASA Goddard Space Flight Center for use in the near-infrared region on the Next Generation Space Telescope (NGST). The microshutter arrays are designed for the selective transmission of light with high efficiency and high contrast. The NGST environment requires cryogenic operation at 45K. Microshutter arrays are fabricated out of silicon-oxide-insulated (SOI) silicon wafers. Arrays are close-packed silicon nitride membranes with a pixel size of 100x100 microns. Individual shutters are patterned with a torsion flexure permitting shutters to open 90 degrees with a minimized mechanical stress concentration. The mechanical shutter arrays are fabricated using MEMS technologies. The processing includes a multi-layer metal deposition and patterning of shutter electrodes and magnetic pads, reactive ion etching (RE) of the front side to form shutters out of the nitride membrane, an anisotropic back-etch for wafer thinning, followed by a deep RIE (DRIE) back-etch down to the nitride shutter membrane to form frames and relieve shutters from the silicon substrate. An additional metal deposition and patterning is used to form back electrodes. Shutters are actuated using a magnetic force and latched using an electrostatic force.
Author
Microelectromechanical Systems; Etching; James Webb Space Telescope; Spaceborne Telescopes; Silicon Nitrides; Membranes; Electrostatics

20040076588
Optimized autonomous operations of a 20 K space hydrogen sorption cryocooler
Borders, J.; Morgante, G.; Prina, M.; Pearson, D.; Bhandari, P.; Cryogenics. 2003 Space Cryogenics Workshop; June/August 2004; ISSN 0011-2275; Volume 44, no. 6-8; In English; Copyright; Avail: Other Sources

The development of a 20 K space hydrogen sorption cryocooler for optimized autonomous operations is discussed. The cooler is required to provide a stable temperature reference and appropriate cooling to the two instruments on-board, with a flight operational time of 18 months. An engineering bread board (EBB) cooler was assembled and tested to evaluate the behavior of the system under conditions simulating flight operations and the test data were used to refine and improve the operation control software. The ability of the system to minimize the time spent in off-nominal operation results in an essential accomplishment for the successful achievement of the Planck mission scientific objectives.
EI
Compressibility; Cryogenic Cooling; Cryogenics; Gases; Hydrogen; Sorption

20040076587
Continuous cooling from 10 to 4 K using a toroidal ADR
DiPirro, Michael; Canavan, Edgar; Shirron, Peter; Tuttle, James; Cryogenics. 2003 Space Cryogenics Workshop; June/August 2004; ISSN 0011-2275; Volume 44, no. 6-8; In English; Copyright; Avail: Other Sources

Future large infrared space telescopes will require cooling to 4 K to achieve background limited performance for submillimeter wavelengths. These observatories will require lifetimes of many years and will have relatively large cooling requirements making stored helium dewars impractical. We have designed and are building an adiabatic demagnetization refrigerator (ADR) for use in cooling relatively large loads (10-100 mW) at 4 K and rejecting that heat to a cryocooler operating at 10 K. The ADR magnet consists of eight short coils wired in series and arranged in a toroid to provide self shielding of its magnetic field. We will use gas gap heat switches to alternately connect the toroid to the cold load and the warm heat sink. A small continuous stage will maintain the cold end at 4 K while the main toroid is recycled. (copyright) 2004 Published by Elsevier Ltd.
EI
Cooling; Cryogenic Cooling; Demagnetization; Electric Coils; Magnetic Fields; Solenoids; Submillimeter Waves

20040076586

AMS-02 cryocooler baseline configuration and EM qualification program

Banks, Stuart; Breon, Susan; Shirey, Kimberly; Cryogenics. 2003 Space Cryogenics Workshop; June/August 2004; ISSN 0011-2275; Volume 44, no. 6-8; In English; Copyright; Avail: Other Sources

Four Sunpower M87N Stirling-cycle cryocoolers will be used to extend the lifetime of the Alpha Magnetic Spectrometer-02 (AMS-02) experiment. The cryocoolers will be mounted to the AMS-02 vacuum case using a structure that will thermally and mechanically decouple the cryocooler from the vacuum case while providing compliance to allow force attenuation using a passive balancer system. The cryocooler drive is implemented using a 60 Hz pulse duration modulated square wave. Details of the testing program, mounting assembly and drive scheme are presented. AMS-02 is a state-of-the-art particle physics detector containing a large superfluid helium-cooled superconducting magnet. Highly sensitive detector plates inside the magnet measure a particle's speed, momentum, charge, and path. The AMS-02 experiment, which will be flown as an attached payload on the International Space Station, will study the properties and origin of cosmic particles and nuclei including antimatter and dark matter. Two engineering model cryocoolers have been under test at NASA Goddard since November 2001. Published by Elsevier Ltd.

EI

Cryogenic Cooling; Cryogenics; Low Temperature; Square Waves; Stirling Cycle; Superconducting Magnets

20040076569

Estimation of thermal conduction loads for structural supports of cryogenic spacecraft assemblies

Ross, Jr. , Ronald G.; Cryogenics. 2003 Space Cryogenics Workshop; June/August 2004; ISSN 0011-2275; Volume 44, no. 6-8; In English; Copyright; Avail: Other Sources

Early in the design process of cryogenic space systems there is a critical need for means of estimating the parasitic conduction loads associated with structural supports. In a mature design, the conduction loads can be computed with good accuracy based on the design details. However, for a generic trade study early in the design process, what is desired is a generic relationship (for typical launch loading conditions) between overall support conductance, the Delta T involved, and the supported mass. This work derives such a universal relationship by examining a variety of flight-proven designs for cryogenic structural supports and then normalizing the data given the known relationships between material conductivity and temperature, between launch acceleration level and assembly mass, between launch acceleration loads and stresses and required support-member cross-sections, and between support-member cross-section and conductive load. (copyright) 2004 Published by Elsevier Ltd.

EI

Assembling; Cryogenics; Loads (Forces); Spacecraft; Thermal Conductivity

20040076566

Effect of gravity orientation on the thermal performance of Stirling-type pulse tube cryocoolers

Ross, Jr. , Ronald G.; Johnson, Dean L.; Cryogenics. 2003 Space Cryogenics Workshop; June/August 2004; ISSN 0011-2275; Volume 44, no. 6-8; In English; Copyright; Avail: Other Sources

The effect of angular orientation on the off-state conduction of pulse tube cryocoolers has been previously explored, as has the effect of orientation on the thermal performance of low-frequency ([similar to]2 Hz) GM-style pulse tube refrigerators. The significant effects that have been found are well explained by the presence of free convection that builds up in the hollow pulse tube when the hot end of the pulse tube is not higher than the cold end. This paper extends the investigation of angular orientation effects to the refrigeration performance of high frequency ([similar to]40 Hz) Stirling-type pulse tube cryocoolers typical of those used in long-life space applications. Strong orientation effects on the performance of such cryocoolers have recently been observed during system-level testing of both linear and U-tube type pulse tubes. To quantify the angular dependency effects, data have been gathered on both U-tube and linear type pulse tubes of two different manufacturers as a function of orientation angle, cold-tip temperature, and compressor stroke. (copyright) 2004 Published by Elsevier Ltd.

EI

Cooling Systems; Cryogenic Cooling; Cryogenic Equipment; Refrigerators; Spacecraft; Stirling Cycle

20040076564

On-orbit performance of the RHESSI cryocooler

Boyle, Robert; Cryogenics. 2003 Space Cryogenics Workshop; June/August 2004; ISSN 0011-2275; Volume 44, no. 6-8; In English; Copyright; Avail: Other Sources

The Ramaty High Energy Solar Spectroscopic Imager (RHESSI) spacecraft was launched on February 5, 2002. With more than a year of operation on-orbit, its Sunpower M77 cryocooler continues to maintain the array of nine germanium detectors below 80 K. Trends have begun to emerge in cryocooler power and vibration, suggesting that the cooler's operating point is slowly changing. Possible causes are identified and discussed. (copyright) 2004 Elsevier Ltd. All rights reserved.
EI
Cooling Systems; Cryogenic Cooling; Cryogenics; Germanium; Spacecraft; Stirling Cycle

20040075889 NASA Marshall Space Flight Center, Huntsville, AL, USA
NASA's In-Space Propulsion Technology Program: Overview and Status
Johnson, Les; Alexander, Leslie; Baggett, Randy; Bonometti, Joe; Herrmann, Melody; James, Bonnie; Montgomery, Sandy; [2004]; In English; 52nd Joint Army-Navy-NASA-Air Force Propulsion Meeting, 10-13 May 2004, Las Vegas, NV, USA; No Copyright; Avail: CASI; A02, Hardcopy

NASA's In-Space Propulsion Technology Program is investing in technologies that have the potential to revolutionize the robotic exploration of deep space. For robotic exploration and science missions, increased efficiencies of future propulsion systems are critical to reduce overall life-cycle costs and, in some cases, enable missions previously considered impossible. Continued reliance on conventional chemical propulsion alone will not enable the robust exploration of deep space - the maximum theoretical efficiencies have almost been reached and they are insufficient to meet needs for many ambitious science missions currently being considered. The In-Space Propulsion Technology Program s technology portfolio includes many advanced propulsion systems. From the next generation ion propulsion system operating in the 5 - 10 kW range, to advanced cryogenic propulsion, substantial advances in spacecraft propulsion performance are anticipated. Some of the most promising technologies for achieving these goals use the environment of space itself for energy and propulsion and are generically called, 'propellantless' because they do not require onboard fuel to achieve thrust. Propellantless propulsion technologies include scientific innovations such as solar sails, electrodynamic and momentum transfer tethers, aeroassist, and aerocapture. This paper will provide an overview of both propellantless and propellant-based advanced propulsion technologies, and NASA s plans for advancing them as part of the $60M per year In-Space Propulsion Technology Program.
Author
Spacecraft Propulsion; Aerocapture; Solar Electric Propulsion; Solar Sails; Ion Engines; Solar Thermal Propulsion; Tetherlines

20040074276 NASA Goddard Space Flight Center, Greenbelt, MD, USA
Cryo-Infrared Optical Characterization at NASA GSFC
Boucarut, Ray; Quijada, Manuel A.; Henry, Ross M.; New Concepts for Far-Infrared and Submillimeter Space Astronomy; April 2004; In English; No Copyright; Avail: CASI; A02, Hardcopy

The development of large space infrared optical systems, such as the Next Generation Space Telescope (NGST), has increased requirements for measurement accuracy in the optical properties of materials. Many materials used as optical components in infrared optical systems, have strong temperature dependence in their optical properties. Unfortunately, data on the temperature dependence of most of these materials is sparse. In this paper, we provide a description of the capabilities existing in the Optics Branch at the Goddard Space Flight Center that enable the characterization of the refractive index and absorption coefficient changes and other optical properties in infrared materials at cryogenic temperatures. Details of the experimental apparatus, which include continuous flow liquid helium optical cryostat, and a Fourier Transform Infrared (FTIR) spectrometer are discussed.
Author
Cryogenics; Optical Equipment; Optical Properties; Infrared Spectrometers

20040074273 Jet Propulsion Lab., California Inst. of Tech., Pasadena, CA, USA
Wavefront Sensing and Control Technology for Submillimeter and Far-Infrared Space Telescopes
Redding, Dave; New Concepts for Far-Infrared and Submillimeter Space Astronomy; April 2004; In English; No Copyright; Avail: CASI; A03, Hardcopy

The NGST wavefront sensing and control system will be developed to TRL6 over the next few years, including testing in a cryogenic vacuum environment with traceable hardware. Doing this in the far-infrared and submillimeter is probably easier, as some aspects of the problem scale with wavelength, and the telescope is likely to have a more stable environment; however, detectors may present small complications. Since this is a new system approach, it warrants a new look. For instance,

a large space telescope based on the DART membrane mirror design requires a new actuation approach. Other mirror and actuation technologies may prove useful as well.
Author
Membranes; Mirrors; Submillimeter Waves

20040074263 NASA Goddard Space Flight Center, Greenbelt, MD, USA
Cryogenic Technology: Ongoing Developments for the Next Decade
DiPirro, Michael; New Concepts for Far-Infrared and Submillimeter Space Astronomy; April 2004; In English; No Copyright; Avail: CASI; A02, Hardcopy

To obtain optimum sensitivity a submillimeter space observatory will require low temperature mirrors (approx. 3K) and very low temperature detectors (\h or approx. 0.1 K). Both of these temperatures have been achieved by space cryogenic systems, but neither for a 10 year duration. Past systems used superfluid helium to provide direct cooling in the 1 to 2 K range (IRAS, COBE, IRTS, ISO) or as an upper stage for an adiabatic demagnetization refrigerator to achieve temperatures down to 0.06 K (Astro-E/XRS). Boiloff vapor may be used to cool an otherwise warm telescope as in the Space InfraRed Telescope Facility (SIRTF). In SIRTF a 0.85 m telescope is cooled to 5.5 K by absorbing about 6 mW in the cold vapor. This residual heat is due to both radiation from a helium vapor cooled outer shield at about 20 K and from conduction through a structure mounting the cold telescope and instruments to the warm spacecraft. The boil off rate required to cool the telescope results in a 2.6 to 5 year lifetime, depending on whether other parasitic heat sources such as thermoacoustic oscillations are also present. A helium dewar results in a very heavy system to achieve 2 to 5 year lifetimes. For example it takes roughly 400 kg for XRS to achieve 0.06 K for two year life with a 250 K boundary temperature, and approx. 300 kg (including thermal shielding) for SIRTF to achieve 1.3 K for 5 year life with a 35 K boundary temperature. To go to longer duration and to lower the weight, active cooling methods are required combined with more aggressive passive cooling techniques. It is possible, with some development, to provide cooling for detectors to 0.05 K and telescopes and instruments to \h 4 K for a 10 year mission with a 100 kg system including power sources, structural support, and vacuum enclosures for critical portions of the instruments.
Author
Cryogenic Equipment; Cryogenic Cooling; Astronomical Satellites

20040073441 NASA Glenn Research Center, Cleveland, OH, USA
Infrared Heater Used in Qualification Testing of International Space Station Radiators
Ziemke, Robert A.; May 2004; In English
Contract(s)/Grant(s): WBS-229799-30-01
Report No.(s): NASA/TM-2004-212332; E-13928; No Copyright; Avail: CASI; A03, Hardcopy

Two heat rejection radiator systems for the International Space Station (ISS) have undergone thermal vacuum qualification testing at the NASA Glenn Research Center (GRC), Plum Brook Station, Sandusky, Ohio. The testing was performed in the Space Power Facility (SPF), the largest thermal vacuum chamber in the world. The heat rejection system radiator was tested first; it removes heat from the ISS crew living quarters. The second system tested was the photovoltaic radiator (PVR), which rejects heat from the ISS photovoltaic arrays and the electrical power-conditioning equipment. The testing included thermal cycling, hot- and cold-soaked deployments, thermal gradient deployments, verification of the onboard heater controls, and for the PVR, thermal performance tests with ammonia flow. Both radiator systems are orbital replacement units for ease of replacement on the ISS. One key to the success of these tests was the performance of the infrared heater system. It was used in conjunction with a gaseous-nitrogen-cooled cryoshroud in the SPF vacuum chamber to achieve the required thermal vacuum conditions for the qualification tests. The heater, which was designed specifically for these tests, was highly successful and easily met the test requirements. This report discusses the heating requirements, the heater design features, the design approach, and the mathematical basis of the design.
Author
Infrared Radiation; Heat Radiators; Thermal Cycling Tests; Photovoltaic Cells; Temperature Effects; Infrared Instruments

20040070599
Raman Spectroscopy of Small Para-H(sub 2) Clusters Formed in Cryogenic Free Jets
Tejeda, G.; Fernandez, J. M.; Montero, S.; Blume, D.; Toennies, J. P.; Physical Review Letters; June 04, 2004; ISSN 0031-9007; Volume 92, no. 22; In English; Copyright

Small para-H(sub 2) clusters (pH(sub 2))(sub N) with N=2,[ellipsis (horizontal)],8 have been identified by Raman

spectroscopy in cryogenic free jets of the pure gas, near the Q(0) Raman line of the H(sub 2) monomer. The high resolution in space, time, and number size makes it possible to follow their growth kinetics with distance from the orifice. At lower source temperatures liquid clusters appear early in the expansion and then undergo a gradual phase transition to the solid state. The technique is very promising for exploring superfluidity in pure (pH(sub 2))(sub N) clusters.
Author (AIP)
Atomic Clusters; Free Jets; Gas Jets; Hydrogen; Molecular Spectra; Monte Carlo Method; Perturbation Theory; Raman Spectra; Raman Spectroscopy; Solid Cryogens; Superfluidity

20040068226 Northrop Grumman Space Technology, Redondo Beach, CA, USA
Space Cryocoolers
Tward, Emanuel; International Thermal Detectors Workshop (TDW 2003); February 2004; In English; No Copyright; Abstract Only; Available from CASI only as part of the entire parent document

Cryogenic coolers for use in space require low power and minimum weight. In this paper we describe the typical requirements and performance of a number of reliable, small, efficient, low-power, vibrationally balanced coolers designed and manufactured by NGST (formerly TRW). Eight coolers are currently in orbit on both NASA and military missions. Seven of the eight are pulse tube coolers which since launch have been continuously and successfully cooling ir focal planes to wavelengths up to 16 microns on payloads such as AIRS, Hyperion, Saber, MTI, and CX. The longest of these missions is now greater than 5 years. The eighth is a Stirling cooler that is cooling a high-temperature superconducting mux on the HTSSE payload. The next generation of these coolers and their sophisticated control electronics are even smaller and more efficient and have been scaled over two orders of magnitude in size. Some are already integrated onto payloads and are scheduled for launch this year. Cooler capabilities are being pushed to lower temperatures (6 K), to multiple cooling stages, to higher cooling capacity and to smaller sizes. These developments will be described.
Author
Cryogenic Cooling; NASA Programs; Onboard Equipment; Cooling Systems

20040068225 Raytheon Co., El Segundo, CA, USA
Integration of Oxford Class Cryocoolers with Thermal Detectors
Kirkconnell, Carl S.; Price, Kenneth D.; International Thermal Detectors Workshop (TDW 2003); February 2004; In English; No Copyright; Avail: CASI; A01, Hardcopy

Mechanical cryocoolers are generally preferable to stored cryogen dewar systems for space applications because they are more than an order of magnitude smaller in size and lighter in weight. Successful flight qualification, endurance testing, and on orbit performance of mechanical cryocoolers over the past ten years have made the use of cryocoolers viable from a lifetime and system reliability perspective. However, the size and weight advantage is partially offset by the introduction of operational vibrations, the possibility of temperature fluctuations at the cooler mounting interface and cold tip, and power draw on the spacecraft bus. The first two can directly affect detector performance. These inherent technical challenges are met through the combination of cryocooler-level and system-level design features and accommodation. For example, adaptive feed forward (AFF) active vibration control provided by the cryocooler control electronics significantly reduces vibration output at the cold tip. Using a flexible thermal strap to connect the detector to the cold tip further attenuates vibrations transmitted from cold tip to detector. Unfortunately, thermal strap efficiency and mechanical strap compliance react in opposite directions with respect to strap cross-sectional area, so a system-level design optimum must be found. Lower cryocooler vibration output and/or higher cryocooler efficiency facilitate the identification of an optimum strap design that meets the detector thermal and jitter requirements. The pages that follow discuss these and other examples of system-level issues that arise in the integration of Stirling-cycle, Oxford-class cryocoolers, and more importantly, how those challenges can be overcome.
Author
Cryogenic Equipment; Performance Tests; Technology Utilization; Cryogenic Cooling; Active Control

20040068223 TRW, Inc., USA
Superconducting Electronics for Detector Readouts
Luine, Jerome; Durand, Dale; Eaton, Larry; International Thermal Detectors Workshop (TDW 2003); February 2004; In English; No Copyright; Abstract Only; Available from CASI only as part of the entire parent document

Spacecraft subsystems that support thermal detector imaging arrays that operate at temperatures below 80 K can be benefited by the use of superconducting electronics (SCE). SCE can greatly simplify spacecraft complexity, thereby reducing costs, and significantly enhance the performance of science instruments and control electronics. For example, by integrating

an analog signal processor and analog-to-digital converter with an imaging sensor array, cryogenic system complexity is reduced and instrument performance is increased. The number of signal wires leading from the cryogenic detector environment to higher temperature electronics is reduced thereby reducing cryogenic system complexity. Reduced signal line count not only simplifies the cryogenic package but also reduces the cryogenic heat load. Cryogenic package simplification and reduced heat load result in lower cost and increased reliability. Instrument performance is enhanced by executing as much signal processing at the sensor array as possible. Multiplexing and digitizing the signals in the very low-noise cryogenic environment increases signal-to-noise ratio. These benefits can also be used to dramatically increase the number of sensor elements thereby increasing resolution to levels that are extremely difficult or impossible to achieve with today s technology. Furthermore, materials used for SCE have been found to have orders of magnitude greater radiation hardness than any other electronics materials. SCE is ideal for cryogenic instruments as well as other spacecraft electronic systems. The status of SCE technologies for thermal detector readout and signal processing will be presented.
Author
Superconductivity; Signal Processing; Cryogenics; Thermal Mapping; Signal to Noise Ratios

20040068221 NASA Glenn Research Center, Cleveland, OH, USA
Electrical Devices and Circuits for Low Temperature Space Applications
Patterson, R. L.; Hammoud, A.; Dickman, J. E.; Gerber, S.; Elbuluk, M. E.; Overton, E.; International Thermal Detectors Workshop (TDW 2003); February 2004; In English; No Copyright; Avail: CASI; A01, Hardcopy

The environmental temperature in many NASA missions, such as deep space probes and outer planetary exploration, is significantly below the range for which conventional commercial-off-the-shelf electronics is designed. Presently, spacecraft operating in the cold environment of such deep space missions carry a large number of radioisotope or other heating units in order to maintain the surrounding temperature of the onboard electronics at approximately 20 C. Electronic devices and circuits capable of operation at cryogenic temperatures will not only tolerate the harsh environment of deep space but also will reduce system size and weight by eliminating or reducing the heating units and their associate structures; thereby reducing system development cost as well as launch costs. In addition, power electronic circuits designed for operation at low temperatures are expected to result in more efficient systems than those at room temperature. This improvement results from better behavior in the electrical and thermal properties of some semiconductor and dielectric materials at low temperatures. An on-going research and development program on low temperature electronics at the NASA Glenn Research Center focuses on the development of efficient electrical systems and circuits capable of surviving and exploiting the advantages of low temperature environments. An overview of the program will be presented in this paper. A description of the low temperature test facilities along with selected data obtained from in-house component testing will also be discussed. On-going research activities that are being performed in collaboration with various organizations will also be presented.
Author
Commercial Off-the-Shelf Products; Deep Space; Low Temperature Environments; Low Temperature Tests; Semiconductors (Materials); Technology Utilization; Test Facilities

20040068211 NASA Goddard Space Flight Center, Greenbelt, MD, USA
Arrays of High Performance Thermal Detectors
Moseley, Harvey; International Thermal Detectors Workshop (TDW 2003); February 2004; In English; No Copyright; Abstract Only; Available from CASI only as part of the entire parent document

Thermal detectors have historically been the sensors of choice for applications where photoconductive or photovoltaic detectors are unavailable. While they have the advantage of broad wavelength coverage, a primary disadvantage has been sensitivity; at a given operating temperature, bolometers are typically much less sensitive than photodetectors. The development of cryogenic bolometers has resulted in thermal detectors which can reach fundamental sensitivity limits. When operated at temperatures below 0.3 K these devices can provide background-limited sensitivity for cryogenic imaging and spectroscopy in space. The past decade has seen a rapid growth in sensitivity and array format in cryogenic bolometers. Micromachining technology, combined with advances in superconducting electronics, provides a strong technological base for future developments. I will describe the present state of development of low-temperature thermal detectors, and the possible extension of this technology to higher temperature operation.
Author
Imaging Techniques; Photoconductivity; Superconductivity; Bolometers; Cryogenics

20040068204 NASA Goddard Space Flight Center, Greenbelt, MD, USA

Programmable 2-D Addressable Cryogenic Aperture Masks

Kutyrev, A. S.; Moseley, S. H.; Jhabvala, M.; Li, M.; Schwinger, D. S.; Silverberg, R. F.; Wesenberg, R. P.; International Thermal Detectors Workshop (TDW 2003); February 2004; In English; No Copyright; Abstract Only; Available from CASI only as part of the entire parent document

We are developing a two-dimensional array of square microshutters (programmable aperture mask) for a multi-object spectrometer for the James Webb Space Telescope (JWST). This device will provide random access selection of the areas in the field to be studied. The device is in essence a close packed array of square slits, each of which can be opened independently to select areas of the sky for detailed study.The device is produced using a 100-micron thick silicon wafer as a substrate with 0.5-micron thick silicon nitride shutters on top of it. Silicon nitride has been selected as the blade and flexure material because its stiffness allows thinner and lighter structures than single crystal Si, the chief alternative, and because of its ease of manufacture. The 100 micron silicon wafer is backetched in a high aspect ratio Deep Reactive Ion Etching (Deep RIE) to leave only a support grid for the shutters and the address electronics. The shutter actuation is done magnetically whereas addressing is electrostatic. 128x128 format microshutter arrays have been produced. Their operation has been demostarted on 32x32 subarrays. Good reliability of the fabrication process and good quality of the microshutters has been achieved. The mechanical behavior and optical performance of the fabricated arrays at cryogenic temperature are being studied.

Author

James Webb Space Telescope; Spectrometers; Shutters; Microelectromechanical Systems

20040068196 Jet Propulsion Lab., California Inst. of Tech., Pasadena, CA, USA

NASA Space Cryocooler Programs: A 2003 Overview

Ross, R. G., Jr.; Boyle, R. F.; Kittel, P.; International Thermal Detectors Workshop (TDW 2003); February 2004; In English; No Copyright; Avail: CASI; A02, Hardcopy

Mechanical cryocoolers represent a significant enabling technology for NASA's Earth and Space Science missions. An overview is presented of ongoing cryocooler activities within NASA in support of current flight projects, near-term flight instruments, and long-term technology development. NASA programs in Earth and space science observe a wide range of phenomena, from crop dynamics to stellar birth. Many of the instruments require cryogenic refrigeration to improve dynamic range, extend wavelength coverage, and enable the use of advanced detectors. Although, the largest utilization of coolers over the last decade has been for instruments operating at medium to high cryogenic temperatures (55 to 150 K), reflecting the relative maturity of the technology at these temperatures, important new developments are now focusing at the lower temperature range from 4 to 20 K in support of studies of the origin of the universe and the search for planets around distant stars. NASA's development of a 20K cryocooler for the European Planck spacecraft and its new Advanced Cryocooler Technology Development Program (ACTDP) for 6-18 K coolers are examples of the thrust to provide low temperature cooling for this class of missions.

Author

Cryogenic Cooling; NASA Space Programs; General Overviews; Flight Instruments; Technology Utilization

20040068194 National Inst. of Standards and Technology, USA

Novel Electrically Substituted Optical Detectors

Rice, Joseph; Lorentz, Steven; Houston, Jeanne; International Thermal Detectors Workshop (TDW 2003); February 2004; In English; No Copyright; Abstract Only; Available from CASI only as part of the entire parent document

Several new thermal-type optical detectors have been developed at NIST for various measurement applications over the past few years. These detectors share a common feature in that they incorporate a form of electrical substitution where chopper-synchronized electrical power, controlled by a servo loop, maintains the detector at a fixed operating temperature. This mode of operation increases temporal stability, improves time response, and provides a relatively straightforward basis for calibration. While related to operating modes utilizing electro-thermal feedback, electrical substitution is quite distinct, as will be shown. We will present a general introduction to electrically substituted thermal-type optical detectors, and then provide specific details on up to four new examples: 1) An electrically substituted liquid helium cooled bolometer (ESB) that uses a gold-black coating for optical absorption and as the electrical substitution heater. This detector serves as a spectrally flat reference standard in a new calibration facility at NIST that measures the spectral responsivity of customer infrared detectors using tunable infrared lasers. 2) A liquid helium cooled active cavity radiometer that will serve as a next generation primary standard for optical detector responsivity measurements at NIST, the High Accuracy Cryogenic Radiometer 2 (HACR2). 3) The High-Tc Active Cavity Radiometer (High-Tc ACR), which uses YBCO thin-film sensors on the receiver cavity and only requires cooling to below about 85 K. It has been tested with the YBCO sensors operating both at the midpoint

of the superconductive resistive transition (89 K, resistive-edge mode), and at slightly lower temperatures along the critical current versus temperature curve (85 89 K, critical current mode). One could imagine flying this with radiative cooling. 4) The Scripps-NIST Advanced Radiometer (Scripps-NISTAR), a spaceflight instrument that was developed with NASA and Scripps sponsorship for a flight to the Earth s L-1 point, where it will view the Earth and measure total Earth-emitted and solar-reflected irradiance for a better understanding of the Earth s radiative balance. The Scripps-NISTAR thermal detectors themselves are active cavity radiometers that operate at 40 degrees Celcius near the midpoint of the resistive transition in polycrystalline, doped BST (Barium Strontium Titanate) that is associated with the ferroelectric phase transition. These provide sensitivity that is adequate for accurate measurements of the total irradiance from the Earth at L-1, which is 4 or 5 orders of magnitude lower than the irradiance levels measured by existing spaceflight active cavity radiometers.
Author
Optical Measuring Instruments; Infrared Detectors; Electromagnetic Absorption; Superconductors (Materials)

20040068186 NASA Goddard Space Flight Center, Greenbelt, MD, USA
International Thermal Detectors Workshop (TDW 2003)
Lakew, Brook, Editor; Brasunas, John, Editor; Aslam, Shahid, Editor; Fettig, Rainer, Editor; Boyle, Robert, Editor; February 2004; In English; International Thermal Detectors Workshop, 19-20 Jun. 2003, Adelphi, MD, USA; Original contains color and black and white illustrations
Report No.(s): NASA/CP-2004-212748; Rept-2004-00980-0; No Copyright; Avail: CASI; A08, Hardcopy

NASA's future planetary and Earth Science missions will require ever more sensitive thermal detectors operating between 2K and 300 K. It is in response to this need that the International Workshop on thermal detectors (TDW03) was held. It put together space borne IR/Sub-mm and heterodyne instrument scientists and astronomers, thermal detector developers, cryocooling technologists as well as bandpass and blocking filter experts. Their varied expertise and backgrounds allowed for a fertile discussion on outstanding issues and future detector developments. In this regard TDW03 was a great success.
Author
Measuring Instruments; Infrared Instruments

20040068063 NASA Marshall Space Flight Center, Huntsville, AL, USA
Lessons Learned During Cryogenic Optical Testing of the Advanced Mirror System Demonstrators (AMSDs)
Hadaway, James; Reardon, Patrick; Geary, Joseph; Robinson, Brian; Stahl, Philip; Eng, Ron; Kegley, Jeff; 2004; In English; No Copyright; Avail: Other Sources; Abstract Only

Optical testing in a cryogenic environment presents a host of challenges above and beyond those encountered during room temperature testing. The Advanced Mirror System Demonstrators (AMSDs) are 1.4 m diameter, ultra light-weight (\h20 kg/mA2), off-axis parabolic segments. They are required to have 250 nm PV & 50 nm RMS surface figure error or less at 35 K. An optical testing system, consisting of an Instantaneous Phase Interferometer (PI), a diffractive null corrector (DNC), and an Absolute Distance Meter (ADM), was used to measure the surface figure & radius-of-curvature of these mirrors at the operational temperature within the X-Ray Calibration Facility (XRCF) at Marshall Space Flight Center (MSFC). The Ah4SD program was designed to improve the technology related to the design, fabrication, & testing of such mirrors in support of NASA s James Webb Space Telescope (JWST). This paper will describe the lessons learned during preparation & cryogenic testing of the AMSDs.
Author
Optical Properties; Cryogenics; Mirrors; Calibrating

20040065533
Field-orientation dependent heat capacity measurements at low temperatures with a vector magnet system
Deguchi, K.; Ishiguro, T.; Maeno, Y.; Review of Scientific Instruments; May 2004; ISSN 0034-6748; Volume 75, no. 5; In English; Copyright

We describe a heat capacity measurement system for the study of the field-orientation dependence for temperatures down to 50 mK. A 'vector magnet' combined with a mechanical rotator for the dewar enables the rotation of the magnetic field without mechanical heating in the cryostat by friction. High reproducibility of the field direction, as well as an angular resolution of better than 0.01[deg], is obtained. This system is applicable to other kinds of measurements which require a large

sample space or an adiabatic sample environment, and can also be used with multiple refrigerator inserts interchangeably. [copyright] 2004 American Institute of Physics.
Author (AIP)
Heat Measurement; Low Temperature; Magnetoresistivity; Resistors; Ruthenium Compounds; Specific Heat; Strontium Compounds; Superconducting Magnets; Superconductivity; Superconductors (Materials); Thermodynamic Properties; Thin Films

20040062022 Waseda Univ., Tokyo, Japan
SELENE Gamma Ray Spectrometer Using Ge Detector Cooled by Stirling Cryocooler
Kobayashi, M.-N.; Berezhnoy, A. A.; Fujii, M.; Hasebe, N.; Hiramoto, T.; Miyachi, T.; Murasawa, S.; Okada, H.; Okudaira, O.; Shibamura, E., et al.; Lunar and Planetary Science XXXV: Future Missions to the Moon; 2004; In English; Original contains color illustrations; Copyright; Avail: CASI; A01, Hardcopy; Available from CASI on CD-ROM only as part of the entire parent document

A gamma-ray spectrometer (GRS) will be on board a Japanese lunar polar orbiter at an altitude of 100 km, SELENE, to be launched in 2006. The spectrometer will observe lunar gamma ray for one year or more (possibly extended another year in lower orbit) to obtain spectral information, covering 0.1-12 MeV, on chemical abundance on the entire lunar surface. SELENE GRS employs a Ge detector (252 cc, manufactured by Eurysis) as the main detector. This will be the first lunar mission using Ge detector of which the superior energy resolution can lead to the spectral information of more elements with higher sensitivity. Some missions utilized passive cooler for the cryostat, a two-stage passive cooler for interplanetary mission and a V-groove type radiative cooler for martian missions to cool Ge detector. In lunar orbit, however, a heat flow from sunlight and the lunar albedo to the detector system is very large, moreover it is difficult for heat radiator to have a sufficient field of view to exhaust the heat into cold space due to the expanse of lunar surface. Therefore, we have adopted a Stirling cryocooler as the cooling device from the point of life time and cooling capacity, which was developed (by Sumitomo Heavy Industry Co. Ltd.) and qualified for use in space environment. The Stirling cryocooler generates mechanical vibration, it was therefore considerably concerned that such the mechanical vibration could cause microphonic noise on the Ge detector. Now, the flight model of SELENE GRS was built and qualified by several environment test. It shows an energy resolution of 3 keV @ 1.33 MeV in the GRS system. This paper describes the detail of the detector-cryostat system and the performance.
Derived from text
Gamma Ray Spectrometers; Cryogenic Cooling; Lunar Orbiter; Stirling Cycle; Aerospace Environments

20040059216 Texas A&M Univ., College Station, TX
The Characterization of the Structure-Property Relations of Electron Beam Cured Composites
Morgan, Roger J.; Mar. 2004; In English
Contract(s)/Grant(s): F49620-01-1-0180
Report No.(s): AD-A422141; No Copyright; Avail: CASI; A03, Hardcopy

The ultimate objective of this program was to develop a fundamental understanding of the relations between the processing parameters, the resultant physical and chemical structure and the performance of E-beam cured polymer matrix composites for cryogenic fuel containment structures for future Air Force space operations vehicles. The S-beam induced cure mechanisms for cationic polymerized epoxides and free radical polymerized bismaleimides (BMI) were characterized in terms of processing variables, dissociation chemistry of the catalytic initiators, and inherent absorbed moisture. A general S-beam resin and composite cure model was developed as a function of S-beam processing variables. Stress-thermal cycling of BMI-Carbon fiber composites under cryogenic fuel simulated environments revealed that there is a high probability of microcracking with increasing number of thermo- cycles, higher pre-strain and humidity.
DTIC
Electron Beams

20040052548
Techniques and uncertainty analysis for interferometric surface figure error measurement of spherical mirrors at 20K
Blake, Peter; Mink, Ronald G.; Content, David; Davila, Pamela; Robinson, F. David; Antonille, Scott R.; Proceedings of SPIE - The International Society for Optical Engineering; 2003; ISSN 0277-786X; Volume 5180; In English; Optical Manufacturing and Testing V, Aug. 3-5, 2003, San Diego, CA, USA; Copyright; Avail: Other Sources

This report describes the facility and experimental methods at the Goddard Space Flight Center Optics Branch for the measurement of the surface figure of cryogenically-cooled spherical mirrors using standard phase-shifting interferometry, with

an uncertainty goal of 6nm rms. The mirrors to be tested will be spheres with radius of curvature of 600 mm, and clear apertures of 120-150 mm. The optic surface will first be measured at room temperature using standard 'absolute' techniques with an uncertainty of 2.6 nm rms; and then the change in surface figure error between room temperature and 20 K will be measured with an uncertainty goal of 5.4 nm rms. The mirror will be cooled within a cryostat, and its surface figure error measured through a fused-silica window. The facility and techniques are being developed to measure the cryogenic surface figure error of prototype lightweight mirrors being developed by the European Space Agency (ESA) and by US companies in SBIR's for NASA. This paper will present the measurement facility, methods and uncertainty analysis.
EI
Cryogenics; Error Analysis; Interferometry; Mirrors; Space Flight

20040051727
Material Damping Experiments at Cryogenic Temperatures
Levine, Marie; White, Christopher; Proceedings of SPIE - The International Society for Optical Engineering; 2003; ISSN 0277-786X; Volume 5179; In English; Optical Materials and Structures Technologies, Aug. 4-7, 2003, San Diego, CA, USA; Copyright; Avail: Other Sources

A unique experimental facility has been designed to measure damping of materials at cryogenic temperatures. The test facility pays special attention to removing other sources of damping in the measurement by avoiding frictional interfaces, decoupling the test specimen from the support system, and by using a non-contacting measurement device. Damping data is obtained for materials (Al, GrEp, Be, Fused Quartz), strain amplitudes (less than 10(sup -6)ppm), frequencies (20Hz-330Hz) and temperatures (20K-293K) relevant to future precision optical space missions. The test data shows a significant decrease in viscous damping at cryogenic temperatures and can be as low as 10(sup -4)%, but the amount of the damping decrease is a function of frequency and material. Contrary to the other materials whose damping monotonically decreased with temperature, damping of Fused Quartz increased substantially at cryo, after reaching a minimum at around 150 deg K. The damping is also shown to be insensitive to strain for low strain levels. At room temperatures, the test data correlates well to the analytical predictions of the Zener damping model. Discrepancies at cryogenic temperatures between the model predictions and the test data are observed.
EI
Composite Materials; Cryogenics; Damping; Epoxy Resins

20040051726
Development of a Precision Cryogenic Dilatometer for James Webb Space Telescope Materials Testing
Dudik, Matthew J.; Halverson, Peter G.; Levine, Marie; Marcin, Martin; Peters, Robert D.; Shaklan, Stuart; Proceedings of SPIE - The International Society for Optical Engineering; 2003; ISSN 0277-786X; Volume 5179; In English; Optical Materials and Structures Technologies, Aug. 4-7, 2003, San Diego, CA, USA; Copyright; Avail: Other Sources

The James Webb Space Telescope (JWST) will be a 6-meter diameter segmented reflector that will be launched at room temperature and passively cooled to about 40 Kelvin at the L2 point. Because of the large thermal load, understanding the thermophysical properties of the mirror, secondary optics, and supporting structure materials is crucial to the design of an instrument that will provide diffraction limited performance at 2 microns. Once deployed, JWST will perform continuous science without wave front re-calibrations for durations ranging from one day to a month. Hence understanding of how small temperature fluctuations will impact the nanometric stability of the optical system through thermal expansion is required. As a result, the JWST materials testing team has designed and built a novel cryogenic dilatometer capable of coefficient of thermal expansion (CTE) measurements of ULE accurate to [similar to]1.6 and 0.1 ppb/K for a nominal CTE = 30 ppb/K and 20 and 280 K thermal loads, respectively. The dilatometer will be used to measure the CTE of samples from JWST primary mirror prototypes, local CTE variations from multiple locations on a prototype mirror, CTE variations from batch to batch of the same material, and thermal and mechanical creep measurements from room temperature down to 30 K.
EI
Cryogenic Equipment; Extensometers; Interferometers; Thermal Stresses

20040042488 NASA, Washington, DC, USA
Facesheet Delamination of Composite Sandwich Materials at Cryogenic Temperatures
Gates, Thomas S.; Odegard, Gregory M.; Herring, Helen M.; July 19, 2003; In English, 1-5 Dec. 2003, Colorado Springs, CO, USA
Contract(s)/Grant(s): 794-40--4K; Copyright; Avail: CASI; A03, Hardcopy

The next generation of space transportation vehicles will require advances in lightweight structural materials and related design concepts to meet the increased demands on performance. One potential source for significant structural weight reduction is the replacement of traditional metallic cryogenic fuel tanks with new designs for polymeric matrix composite tanks. These new tank designs may take the form of thin-walled sandwich constructed with lightweight core and composite facesheets. Life-time durability requirements imply the materials must safely carry pressure loads, external structural loads, resist leakage and operate over an extremely wide temperature range. Aside from catastrophic events like tank wall penetration, one of the most likely scenarios for failure of a tank wall of sandwich construction is the permeation of cryogenic fluid into the sandwich core and the subsequent delamination of the sandwich facesheet due to the build-up of excessive internal pressure. The research presented in this paper was undertaken to help understand this specific problem of core to facesheet delamination in cryogenic environments and relate this data to basic mechanical properties. The experimental results presented herein provide data on the strain energy release rate (toughness) of the interface between the facesheet and the core of a composite sandwich subjected to simulated internal pressure. A unique test apparatus and associated test methods are described and the results are presented to highlight the effects of cryogenic temperature on the measured material properties.
Author
Polymer Matrix Composites; Fuel Tanks; Composite Structures; Cryogenic Temperature; Temperature Effects; Weight Reduction; Sandwich Structures

20040031765 NASA Goddard Space Flight Center, Greenbelt, MD, USA
Qualifying the Sunpower M-87N Cryocooler for Operation in the AMS-02 Magnetic Field
Mustafi, Shuvo; Banks, Stuart; Shirey, Kimberly; Warner, Brent; Leidecker, Henning; Breon, Susan; Boyle, Rob; September 4, 2003; In English; 20th Space Cryogenics Workshop, 18-19 Sep. 2003, Girdwood, AK, USA; No Copyright; Avail: Other Sources; Abstract Only
The Alpha Magnetic Spectrometer-02 (AMs-02) experiment consists of a superfluid helium dewar. The outer vapor cooled shields of the dewar are to be held at 77 K by four Sunpower M87N cryocoolers. These cryocoolers have magnetic components that might interact with the external applied field generated by the superconducting magnet, thereby degrading the cryocoolers' performance. Engineering models of the Sunpower M87N are being tested at NASA Goddard Space Flight in order to qualify them to operate in a magnetic environment similar to the AMS-02 magnetic environment. AMS-02 will be a space station based particle detector studying the properties and origin of cosmic particles including antimatter and dark matter. It uses a superconducting magnet that is cooled by the superfluid helium dewar. Highly sensitive detector plates inside the magnet will measure a particle's momentum and charge.
Derived from text
Alpha Magnetic Spectrometer; Cryogenic Equipment; Dark Matter; Liquid Helium; Radiation Counters; Superconducting Magnets; Superfluidity

20040030466 NASA Stennis Space Center, Bay Saint Louis, MS, USA
Modeling and Validation of a Propellant Mixer for Controller Design
Richter, Hanz; Barbieri, Enrique; Figueroa, Fernando; June 1, 2003; In English; Original contains poor quality, truncated or crooked pages
Contract(s)/Grant(s): NASW-99027; NAS13-98033
Report No.(s): SE-2002-12-00083-SSC; No Copyright; Avail: CASI; A03, Hardcopy
A mixing chamber used in rocket engine testing at the NASA Stennis Space Center is modelled by a system of two nonlinear ordinary differential equations. The mixer is used to condition the thermodynamic properties of cryogenic liquid propellant by controlled injection of the same substance in the gaseous phase. The three inputs of the mixer are the positions of the valves regulating the liquid and gas flows at the inlets, and the position of the exit valve regulating the flow of conditioned propellant. Mixer operation during a test requires the regulation of its internal pressure, exit mass flow, and exit temperature. A mathematical model is developed to facilitate subsequent controller designs. The model must be simple enough to lend itself to subsequent feedback controller design, yet its accuracy must be tested against real data. For this reason, the model includes function calls to thermodynamic property data. Some structural properties of the resulting model that pertain to controller design, such as uniqueness of the equilibrium point, feedback linearizability and local stability are shown to hold under conditions having direct physical interpretation. The existence of fixed valve positions that attain a desired operating condition is also shown. Validation of the model against real data is likewise provided.
Author
Controllers; Cryogenic Rocket Propellants; Mixers; Thermodynamic Properties

20040027858 NASA Glenn Research Center, Cleveland, OH, USA

Solar Array in Simulated LEO Plasma Environment

Vayner, Boris; Galofaro, Joel; Ferguson, Dale; [2003]; In English, 20-24 Oct. 2003, Huntsville, AL, USA; Original contains black and white illustrations

Contract(s)/Grant(s): 755-60-04; No Copyright; Avail: CASI; A03, Hardcopy

Six different types of solar arrays have been tested in large vacuum chambers. The low earth orbit plasma environment was simulated in plasma vacuum chambers, where the parameters could be controlled precisely. Diagnostic equipment included spherical Langmuir probes, mass spectrometer, low-noise CCD camera with optical spectrometer, video camera, very sensitive current probe to measure arc current, and a voltage probe to register variations in a conductor potential. All data (except video) were obtained in digital form that allowed us to study the correlation between external parameters (plasma density, additional capacitance, bias voltage, etc) and arc characteristics (arc rate, arc current pulse width and amplitude, gas species partial pressures, and intensities of spectral lines). Arc inception voltages, arc rates, and current selections are measured for samples with different coverglass materials and thickness, interconnect designs, and cell sizes. It is shown that the array with wrapthrough interconnects have the highest arc threshold and the lowest current collection. Coverglass design with overhang results in decrease of current collection and increase of arc threshold. Doubling coverglass thickness cases the increase in arc inception voltage. Both arc inception voltage and current collection increase significantly with increasing a sample temperature to 80 C. Sustained discharges are initiated between adjacent cells with potential differences of 40 V for the sample with 300 micron coverglass thickness and 60 V for the sample with 150 micron coverglass thickness. Installation of cryogenic pump in large vacuum chamber provided the possibility of considerable outgassing of array surfaces which resulted in significant decrease of arc rate. Arc sites were determined by employing a video-camera, and it is shown that the most probable sites for arc inception are triple-junctions, even though some arcs were initiated in gaps between cells. It is also shown that the arc rate increases with increasing of ion collection current. The analysis of optical spectra (240-800 nm) reveals intensive narrow atomic lines (Ag, H) and wide molecular bands (OH, CH, SiH, SiN) that confirms a complicated mechanism of arc plasma generation. The results obtained seem to be important for the understanding of the arc inception mechanism, which is absolutely essential for progress toward the design of high-voltage solar array for space application.

Author

Low Earth Orbits; Solar Arrays; Computerized Simulation; Earth Orbital Environments; Plasma Jets

20040020175

Preliminary Comparison Between Nuclear-Electric and Solar-Electric Propulsion Systems for Future Mars Missions

Koppel, Christophe R.; Valentian, Dominique; Latham, Paul; Fearn, David; Bruno, Claudio; Nicolini, David; Roux, Jean-Pierre; Paganucci, F.; Saverdi, Massimo; AIP Conference Proceedings; February 04, 2004; ISSN 0094-243X; Volume 699, no. 1; In English; SPACE TECHNOLOGY and APPLICATIONS INTERNAT. FORUM-STAIF 2004: Conf.on Thermophys.in Microgravity; Commercial/Civil Next Gen.Space Transp.; 21st Symp.Space Nuclear Power & Propulsion; Human Space Explor.; Space Colonization; New Frontiers & Future Concepts, 8-11 February 2004, Albuquerque, New Mexico, USA; Copyright

Recent US and European initiatives in Nuclear Propulsion lend themselves naturally to raising the question of comparing various options and particularly Nuclear Electric Propulsion (NEP) with Solar Electric Propulsion (SEP). SEP is in fact mentioned in one of the latest versions of the NASA Mars Manned Mission as a possible candidate. The purpose of this paper is to compare NEP, for instance, using high power MPD, Ion or Plasma thrusters, with SEP systems. The same payload is assumed in both cases. The task remains to find the final mass ratios and cost estimates and to determine the particular features of each technology. Each technology has its own virtues and vices: NEP implies orbiting a sizeable nuclear reactor and a power generation system capable of converting thermal into electric power, with minimum mass and volumes compatible with Ariane 5 or the Space Shuttle bay. Issues of safety and launch risks are especially important to public opinion, which is a factor to be reckoned with. Power conversion in space, including thermal cycle efficiency and radiators, is a technical issue in need of attention if power is large, i.e., of order 0.1 MW and above, and so is power conditioning and other ancillary systems. Type of mission, Isp and thrust will ultimately determine a large fraction of the mass to be orbited, as they drive propellant mass. For manned missions, the trade-off also involves consumables and travel time because of exposure to Solar wind and cosmic radiation. Future manned NEP missions will probably need superconducting coils, entailing cryostat technology. The on-board presence of cryogenic propellant (e.g., LH2) may reassure the feasibility of this technology, implying, however, a trade-off between propellant volume to be orbited and reduced thruster mass. SEP is attractive right now in the mind of the public, but also of scientists involved in Solar system exploration. Some of the appeal derives from the hope of reducing propellant mass because of the perceived high Isp of ion engines or future MPD. The comparison, in fact, will show whether the two systems could have the same type of thruster or not, for automatic or for manned missions. The main drawback of SEP is due to

photovoltaics and the total solar cell area required, driving spacecraft mass and orbiting costs up. In addition, the question of using superconducting coils holds also for SEP, while no space radiator is, in principle, needed. These and other factors will be considered in this comparison. The goal is to provide preliminary guidelines in evaluating SEP and NEP that may be useful to suggest closer scrutiny of promising concepts, or even potential solutions. [copyright] 2004 American Institute of Physics
Author (AIP)
Electric Propulsion; Ion Engines; Mars Missions; Nuclear Electric Propulsion; Nuclear Propulsion; Propulsion; Propulsion System Configurations; Propulsion System Performance; Radiation Pressure; Solar Electric Propulsion; Spacecraft

20040020135
Analysis of Fluid Flow and Heat Transfer in a Liquid Hydrogen Storage Vessel for Space Applications
Mukka, Santosh K.; Rahman, Muhammad M.; AIP Conference Proceedings; February 04, 2004; ISSN 0094-243X; Volume 699, no. 1; In English; SPACE TECHNOLOGY and APPLICATIONS INTERNAT. FORUM-STAIF 2004: Conf.on Thermophys.in Microgravity; Commercial/Civil Next Gen.Space Transp.; 21st Symp.Space Nuclear Power & Propulsion; Human Space Explor.; Space Colonization; New Frontiers & Future Concepts, 8-11 February 2004, Albuquerque, New Mexico, USA
Contract(s)/Grant(s): NAG3-2751; Copyright

This paper presents a systematic analysis of fluid flow and heat transfer in a liquid hydrogen storage vessel for both earth and space applications. The study considered a cylindrical tank with elliptical top and bottom. The tank wall is made of aluminum and a multi-layered blanket of cryogenic insulation (MLI) has been attached on the top of the aluminum. The tank is connected to a cryocooler to dissipate the heat leak through the insulation and tank wall into the fluid within the tank. The cryocooler has not been modeled; only the flow in and out of the tank to the cryocooler system has been included. The primary emphasis of this research has been the fluid circulation within the tank for different fluid distribution scenario and for different level of gravity to simulate potential earth and space based applications. The equations solved in the liquid region included the conservation of mass, conservation of energy, and conservation of momentum. For the solid region only the heat conduction equation was solved. The steady-state velocity, temperature, and pressure distributions were calculated for different inlet positions, inlet velocities, and for different gravity values. The above simulations were carried out for constant heat flux and constant wall temperature cases. It was observed that a good flow circulation could be obtained when the cold entering fluid was made to flow in radial direction and the inlet opening was placed close to the tank wall. [copyright] 2004 American Institute of Physics
Author (AIP)
Cryogenics; Design Analysis; Fluid Flow; Fluid Mechanics; Heat Transfer; Liquid Hydrogen; Microgravity; Spaceborne Experiments; Spacecraft; Technology Utilization; Temperature; Weightlessness

20040020131
Flow Pattern Phenomena in Two-Phase Flow in Microchannels
Keska, Jerry K.; Simon, William E.; AIP Conference Proceedings; February 04, 2004; ISSN 0094-243X; Volume 699, no. 1; In English; SPACE TECHNOLOGY and APPLICATIONS INTERNAT. FORUM-STAIF 2004: Conf.on Thermophys.in Microgravity; Commercial/Civil Next Gen.Space Transp.; 21st Symp.Space Nuclear Power & Propulsion; Human Space Explor.; Space Colonization; New Frontiers & Future Concepts, 8-11 February 2004, Albuquerque, New Mexico, USA
Contract(s)/Grant(s): LEQSF(2002-04)DART-2; Copyright

Space transportation systems require high-performance thermal protection and fluid management techniques for systems ranging from cryogenic fluid management devices to primary structures and propulsion systems exposed to extremely high temperatures, as well as for other space systems such as cooling or environment control for advanced space suits and integrated circuits. Although considerable developmental effort is being expended to bring potentially applicable technologies to a readiness level for practical use, new and innovative methods are still needed. One such method is the concept of Advanced Micro Cooling Modules (AMCMs), which are essentially compact two-phase heat exchangers constructed of microchannels and designed to remove large amounts of heat rapidly from critical systems by incorporating phase transition. The development of AMCMs requires fundamental technological advancement in many areas, including: (1) development of measurement methods/systems for flow-pattern measurement/identification for two-phase mixtures in microchannels; (2) development of a phenomenological model for two-phase flow which includes the quantitative measure of flow patterns; and (3) database development for multiphase heat transfer/fluid dynamics flows in microchannels. This paper focuses on the results of experimental research in the phenomena of two-phase flow in microchannels. The work encompasses both an experimental and an analytical approach to incorporating flow patterns for air-water mixtures flowing in a microchannel, which are necessary tools for the optimal design of AMCMs. Specifically, the following topics are addressed: (1) design and construction

of a sensitive test system for two-phase flow in microchannels, one which measures ac and dc components of in-situ physical mixture parameters including spatial concentration using concomitant methods; (2) data acquisition and analysis in the amplitude, time, and frequency domains; and (3) analysis of results including evaluation of data acquisition techniques and their validity for application in flow pattern determination. [copyright] 2004 American Institute of Physics
Author (AIP)
Aerospace Systems; Cryogenic Fluids; Environmental Control; Flow Distribution; Fluid Management; High Temperature; Integrated Circuits; Management Systems; Microgravity; Multiphase Flow; Propulsion System Configurations; Propulsion System Performance; Space Suits; Space Transportation System; Spaceborne Experiments; Spacecraft; Systems Management; Thermal Protection; Two Phase Flow; Water; Weightlessness

20040015253 NASA Goddard Space Flight Center, Greenbelt, MD, USA
On-Orbit Performance of the RHESSI Cryocooler
Boyle, Robert F.; January 1, 2004; In English; No Copyright; Avail: Other Sources; Abstract Only

The Ramaty High Energy Solar Spectroscopic Imager (RHESSI) spacecraft was launched on February 5,2002. With more than a year of operation on-orbit, its Sunpower M77 cryocooler continues to maintain the array of nine germanium detectors at 7% Trends have begun to emerge in cryocooler power and vibration, suggesting that the cooler's operating point is slowly changing. Possible causes are identified and discussed.
Author
Coolers; Cryogenic Cooling; Performance

20040014472
Interferential scanning grating position sensor operating in space at 4 K
Michel, Guy; Dohlen, Kjetil; Martignac, Jerome; Lecullier, Jean-Claude; Levacher, Patrick; Colin, Claude; Applied Optics; November 01, 2003; ISSN 0003-6935; Volume 42, no. 31; In English; Copyright

An interferential position sensor for operation in space at a deep cryogenic temperature (4 K) is derived from a commercial sensor. The application is for the Spectral and Photometric Imaging Receiver submillimetric imaging Fourier-transform spectrometer on the Herschel space telescope. This sensor is used to control the displacement of the interferometer's moving mirrors and to sample the interferograms. This development addresses the following points: minimization of the effects of cooling critical optical parts, introduction of a fully redundant focal plane, selection of optoelectronic components efficient at 4 K, and design of a cryogenic preamplifier. [copyright] 2003 Optical Society of America
Author (AIP)
Artificial Satellites; Cryogenic Temperature; Cryogenics; Fourier Transformation; Interferometry; Photometry; Position (Location); Space Temperature; Spaceborne Telescopes; Spectrometers; Telescopes

20040013449 NASA Goddard Space Flight Center, Greenbelt, MD, USA
AMS-02 Cryocooler Baseline Configuration and Engineering Model Qualification Test Results
Banks, Stuart; Breon, Susan; Shirey, Kimberly; September 2003; In English, 18-19 Sep. 2003, Girdwood, AK, USA
Contract(s)/Grant(s): AMS-02; No Copyright; Avail: Other Sources; Abstract Only

Four Sunpower M87N Stirling-cycle cryocoolers will be used to extend the lifetime of the Alpha Magnetic Spectrometer-02 (AMS-02) experiment. The cryocoolers will be mounted to the AMS-02 vacuum case using a structure that will thermally and mechanically decouple the cryocooler from the vacuum case while providing compliance to allow force attenuation using a passive balancer system. The cryocooler drive is implemented using a 60Hz pulse duration modulated square wave. Details of the testing program, mounting assembly and drive scheme will be presented. AMS-02 is a state-of-the-art particle physics detector containing a large superfluid helium-cooled superconducting magnet. Highly sensitive detector plates inside the magnet measure a particle s speed, momentum, charge, and path. The AMS-02 experiment, which will be flown as an attached payload on the International Space Station, will study the properties and origin of cosmic particles and nuclei including antimatter and dark matter. Two engineering model cryocoolers have been under test at NASA Goddard since November 2001. Qualification testing of the engineering model cryocooler bracket assembly is near completion. Delivery of the flight cryocoolers to Goddard is scheduled for September 2003.
Author
Coolers; Cryogenic Cooling; Performance Tests; Radiation Counters

20040013444 NASA Goddard Space Flight Center, Greenbelt, MD, USA

A 10 Kelvin 3 Tesla Magnet for Space Flight ADR Systems

Tuttle, Jim; Shirron, Peter; Canavan, Edgar; DiPirro, Michael; Riall, Sara; Pourrahimi, Shahin; [2003]; In English, Sep. 2003, Girdwood, AK, USA; Copyright; Avail: Other Sources; Abstract Only

Many future space flight missions are expected to use adiabatic demagnetization refrigerators (ADRs) to reach detector operating temperatures well below one Kelvin. The goal is to operate each ADR with a mechanical cooler as its heat sink, thus avoiding the use of liquid cryogens. Although mechanical coolers are being developed to operate at temperatures of 6 Kelvin and below, there is a large efficiency cost associated with operating them at the bottom of their temperature range. For the multi-stage ADR system being developed at Goddard Space Flight Center, the goal is to operate with a 10 Kelvin mechanical cooler heat sink. With currently available paramagnetic materials, the highest temperature ADR stage in such a system will require a magnetic field of approximately three Tesla. Thus the goal is to develop a small, lightweight three Tesla superconducting magnet for operation at 10 Kelvin. It is important that this magnet have a low current/field ratio. Because traditional NbTi magnets do not operate safely above about six Kelvin, a magnet with a higher Tc is required. The primary focus has been on Nb3Sn magnets. Since standard Nb3Sn wire must be coated with thick insulation, wound on a magnet mandrel and then reacted, standard Nb,Sn magnets are quite heavy and require high currents Superconducting Systems developed a Nb3Sn wire which can be drawn down to small diameter, reacted, coated with thin insulation and then wound on a small diameter coil form. By using this smaller wire and operating closer to the wire s critical current, it should be possible to reduce the mass and operating current of 10 Kelvin magnets. Using this 'react-then-wind' technology, Superconducting Systems has produced prototype 10 Kelvin magnets. This paper describes the development and testing of these magnets and discusses the outlook for including 10 Kelvin magnets on space-flight missions.

Author

Adiabatic Demagnetization Cooling; Space Flight; Space Missions; Superconducting Magnets; Technology Utilization

20040013149 Hextek Corp., Tucson, AZ, USA

Ultra-Lightweight Borosilicate Gas-Fusion Mirror for Cryogenic Testing

Voevodsky, Michael; [2003]; In English; No Copyright; Avail: Other Sources; Abstract Only

Hextek Corporation fabricated a 250 mm diameter ultra-lightweight borosilicate mirror substrate for cryogenic testing at NASA MSFC XRCF facility in Huntsville AL under contract# H-34475D. The objectives of the program were to demonstrate that the Hextek Gas-Fusion technology is capable of meeting the 15kg/sq m areal density target required for future space missions, and to provide a demonstration substrate for NASA MSFC to finish and test at cryogenic temperature. This presentation reviews company background and capabilities, features and benefits of the Gas-Fusion technology, historical data on cryogenic performance of borosilicate glass showing near zero cte at 30-35 degrees Kelvin, design and fabrication results of the 250 mm 15kg/sq m areal density substrate, and finally, projected scaling, lightweighing and fabrication lead-times for meter class segments.

Author

Cryogenic Temperature; Space Missions; Borosilicate Glass; Cryogenics

20040012968 NASA Goddard Space Flight Center, Greenbelt, MD, USA

Continuous Cooling from 10 K to 4 K Using a Toroidal ADR

DiPirro, Michael J.; Canavan, Edgar R.; Shirron, Peter J.; Tuttle, James G.; [2003]; In English, 18-19 Sep. 2003, Girdwood, AK, USA; No Copyright; Avail: Other Sources; Abstract Only

Future large infrared space telescopes will require cooling to 4K to achieve background limited performance for submillimeter wavelengths. These observatories will require lifetimes of many years and will have relatively large cooling requirements making stored helium dewars impractical. We have designed and are building an adiabatic demagnetization refrigerator (ADR) for use in cooling relatively large loads (10- 100 mW) at 4K and rejecting that heat to a cryocooler operating at 1 OK. Cryocoolers below 1 OK have poor thermodynamic efficiency and ADRs can operate in this temperature range with an efficiency of 75% of Carnot or better. Overall, this can save as much as 2/3 of the input power required to operate a 4K cryocooler. The ADR magnet consists of 8 short coils wired in series and arranged in a toroid to provide self shielding of its magnetic field. This will save mass (about 30% of the mass or about 1.5 kg in our small version, higher percentages in higher cooling power, larger versions) that would have been used for passive or active shields in an ordinary solenoid. The toroid has a 100 mm outer diameter and will produce an approximately 3T average field. In the initial demonstration model the toroid coils will be wound with ordinary NbTi wire and operated at 4K. A second version will then use Nb3Sn wire to provide complete 10K operation. As a refrigerant for this temperature range we will use either GdLiF4 or GdF3 crystals, pending tests of these crystals' cooling capacity per field and thermal conductance. Preliminary indications are that these

materials are superior to GGG. We will use gas gap heat switches to alternately connect the toroid to the cold load and the warm heat sink. A small continuous stage will maintain the cold end at 4K while the main toroid is recycled.

Author

Adiabatic Conditions; Coolers; Cryogenic Cooling; Hubble Space Telescope; Infrared Telescopes; Magnetic Cooling; Shielding; Thermodynamic Efficiency

20040012609 NASA Marshall Space Flight Center, Huntsville, AL, USA

High Accuracy Thermal Expansion Measurement at Cryogenic Temperatures

Tucker, Jim; Despit, Gregory; Stallcup, Michael; Presson, Joan; Nein, Max; [2003]; In English; Copyright; Avail: Other Sources; Abstract Only

A new, interferometer-based system for measuring thermal expansion to an absolute accuracy of 20 ppb or better at cryogenic temperatures has been developed. Data from NIST Copper SRM 736 measured from room temperature to 15 K will be presented along with data from many other materials including beryllium, ULE, Zerodur, and composite materials. Particular attention will be given to a study by the Space Optics Manufacturing Technology Center (SOMTC) investigating the variability of ULE and beryllium materials used in the AMSD program Approximately 20 samples of each material, tested from room temperature to below 30 K are compared as a function of billet location.

Author

Cryogenic Temperature; Thermal Expansion; Accuracy; Interferometers

20040009351

A New Capacitance Thermometer with Novel Design for Use at Low Temperatures and High Magnetic Fields

Palm, E. C.; Murphy, T. P.; Peabody, L.; Tozer, S. W.; AIP Conference Proceedings; September 29, 2003; ISSN 0094-243X; Volume 684, no. 1; In English; TEMPERATURE: Its Measurement and Control in Science and Industry; Volume VII; Eighth Temperature Symposium, 21-24 October 2002, Chicago, Illinois, USA; Copyright

A capacitance thermometer made of thin layers of Kapton and copper that is insensitive to high magnetic fields is described. This thermometer can be easily fabricated and the final thermometer is a thin rigid tube that can be easily incorporated into the sample space of most high-field cryogenic systems. We have demonstrated that the minimum in capacitance versus temperature of these thermometers can be moved to progressively lower temperatures even below our base temperature of 20 mK by changing the construction parameters of the devices. We present data demonstrating their lack of magnetic field dependence and their specific sensitivity, and we discuss power dissipation in typical operation. [copyright] 2003 American Institute of Physics

Author (AIP)

Capacitance; Kapton (Trademark); Low Temperature; Magnetic Effects; Magnetic Fields; Thermometers

20040008842 Alabama Univ., Huntsville, AL, USA

Instrument for Measuring Cryo CTE

Vikram, Chandra S.; Hadaway, James B.; [2003]; In English; No Copyright; Avail: Other Sources; Abstract Only

Coefficient of thermal expansion is an integral part of the performance of optical systems, especially for those, which operate at cryogenic temperatures. The measurement of the coefficient of relevant materials has been of continuous interest. Besides commercial measurement sources, development of one-of-a-kind tools have always been of interest due to local needs. This paper describes one such development at the University of Alabama in Huntsville (UAH). The approach involves two vertical rods (one sample and one reference) on a flat platform. A probe bar is held horizontally atop the two samples. A temperature change will generally cause rotation of the probe bar. A mirrored surface on one end of the probe bar is used to measure the rotation using the reflection of an incident laser beam upon it. A position-sensing detector measures the change of the reflected beam spot position. Using other known quantities, the change determines the coefficient of thermal expansion of the sample material as a function of temperature. A parallel measurement of the rotation of the sample support platform is also performed to account for any unwanted background effects. This system has been demonstrated in a cryogenic chamber at the NASA Marshall Space Flight Center X-ray Calibration Facility (XRCF). We present the system details, achievable sensitivity, and up-to-date experimental performance.

Author

Thermal Expansion; Cryogenic Temperature

20040008331 NASA Stennis Space Center, Bay Saint Louis, MS, USA

Nonlinear Modeling and Control of a Propellant Mixer

Barbieri, Enrique; Richter, Hanz; Figueroa, Fernando; June 1, 2003; In English, 4-6 Jun. 2003, Denver, CO, USA

Contract(s)/Grant(s): NASW-99027; NAS13-98033

Report No.(s): SE-2002-08-00056-SSC; No Copyright; Avail: CASI; A03, Hardcopy

A mixing chamber used in rocket engine combustion testing at NASA Stennis Space Center is modeled by a second order nonlinear MIMO system. The mixer is used to condition the thermodynamic properties of cryogenic liquid propellant by controlled injection of the same substance in the gaseous phase. The three inputs of the mixer are the positions of the valves regulating the liquid and gas flows at the inlets, and the position of the exit valve regulating the flow of conditioned propellant. The outputs to be tracked and/or regulated are mixer internal pressure, exit mass flow, and exit temperature. The outputs must conform to test specifications dictated by the type of rocket engine or component being tested downstream of the mixer. Feedback linearization is used to achieve tracking and regulation of the outputs. It is shown that the system is minimum-phase provided certain conditions on the parameters are satisfied. The conditions are shown to have physical interpretation.

Author

Nonlinear Systems; Mimo (Control Systems); Liquid Propellant Rocket Engines; Thermodynamics; Fuel Control

20040001856

Terahertz electroluminescence from boron-doped silicon devices

Adam, T. N.; Troeger, R. T.; Ray, S. K.; Lv, P.-C.; Kolodzey, J.; Applied Physics Letters; September 01, 2003; ISSN 0003-6951; Volume 83, no. 9; In English; Copyright

Terahertz emission was observed from electrically pumped boron-doped p-type silicon structures at cryogenic temperatures. At a current of 1.5 A and temperature of 4.4 K, we achieved a pulsed peak power of 31 [mu]W from a single mesa facet, integrated over three closely spaced spectral lines centered about 8.1 THz. The radiation was slightly transverse magnetically polarized with respect to the plane of the substrate and was still detectable at temperatures as high as 150 K. These findings suggest that moderate power THz sources can be fabricated without epitaxially grown quantum wells using techniques compatible with silicon integrated circuit technology. [copyright] 2003 American Institute of Physics.

Author (AIP)

Boron; Cryogenic Temperature; Doped Crystals; Electroluminescence; Semiconductors (Materials); Silicon

20040001148 Lockheed Martin Space Operations, Bay Saint Louis, MS, USA, NASA Stennis Space Center, Bay Saint Louis, MS, USA

Progress in Valve Modeling at Stennis Space Center

Daines, Russell L.; Woods, Jody L.; Sulyma, Peter; December 04, 2003; In English, 10-11 Dec. 2002, State College, PA, USA; Original contains black and white illustrations

Contract(s)/Grant(s): NAS13-650

Report No.(s): SE-2002-12-00081-SSC; No Copyright; Avail: CASI; A03, Hardcopy

Understanding valve behavior will aid testing of rocket components at Stennis Space Center. The authors of this viewgraph presentation have developed a computational model for a cryogenic liquid control valve, and a gas pressure regulator valve. The model is a compressible/incompressible pressure-based FDNS code from Marshall Space Flight Center (MSFC). It is a k-epsilon turbulence model with wall functions.

CASI

Computational Fluid Dynamics; K-Epsilon Turbulence Model; Valves; Flow Regulators; Pressure Regulators

20040001034 NASA Glenn Research Center, Cleveland, OH, USA

Electrical Devices and Circuits for Low Temperature Space Applications

Patterson, R. L.; Hammond, A.; Dickman, J. E.; Gerber, S.; Overton, E.; Elbuluk, M.; October 2003; In English, 19-20 Jun. 2003, Adelphi, MD, USA

Contract(s)/Grant(s): WBS 22-297-60-17

Report No.(s): NASA/TM-2003-212600; E-14159; NAS 1.15:212600; No Copyright; Avail: CASI; A02, Hardcopy

The environmental temperature in many NASA missions, such as deep space probes and outer planetary exploration, is significantly below the range for which conventional commercial-off-the-shelf electronics is designed. Presently, spacecraft operating in the cold environment of such deep space missions carry a large number of radioisotope or other heating units in order to maintain the surrounding temperature of the on-board electronics at approximately 20 C. Electronic devices and

circuits capable of operation at cryogenic temperatures will not only tolerate the harsh environment of deep space but also will reduce system size and weight by eliminating or reducing the heating units and their associate structures; thereby reducing system development cost as well as launch costs. In addition, power electronic circuits designed for operation at low temperatures are expected to result in more efficient systems than those at room temperature. This improvement results from better behavior in the electrical and thermal properties of some semiconductor and dielectric materials at low temperatures. An on-going research and development program on low temperature electronics at the NASA Glenn Research Center focuses on the development of efficient electrical systems and circuits capable of surviving and exploiting the advantages of low temperature environments. An overview of the program will be presented in this paper. A description of the low temperature test facilities along with selected data obtained from in-house component testing will also be discussed. On-going research activities that are being performed in collaboration with various organizations will also be presented.
Author
Circuits; Cryogenic Temperature; Aerospace Environments; NASA Space Programs; Electrical Properties; Electronics

20040000495 NASA Langley Research Center, Hampton, VA, USA
METAShield: Hot Metallic Aeroshell Concept for RLV/SOV
Scotti, Stephen J.; Poteet, Carl C.; Daryabeigi, Kamran; Nowak, Robert J.; Hsu, Su-Yuen; Schmidt, Irvin H.; Ku, Shih-Huei P.; July 2003; In English
Contract(s)/Grant(s): 23-721-21-51-01
Report No.(s): NASA/TM-2003-212425; L-18310; No Copyright; Avail: CASI; A03, Hardcopy

An innovative fuselage design approach that combines many desirable operational features with a simple and efficient structural approach is being developed by NASA. The approach, named METAShield for MEtallic TransAtmospheric Shield, utilizes lightly loaded, hot aeroshell structures surrounding integral propellant tanks that carry the primary structural loads. The aeroshells are designed to withstand the local pressure loads, transmitting them to the tanks with minimal restraint of thermal growth. No additional thermal protection system protects the METAShield, and a fibrous or multilayer insulation blanket, located in the space between the aeroshell and the tanks, serves as both high temperature and cryogenic insulation for the tanks. The concept is described in detail, and the performance and operational features are highlighted. Initial design results and analyses of the structural, thermal, and thermal-structural performance are described. Computational results evaluating resistance to hypervelocity impact damage, as well as some supporting aerothermal wind tunnel results. are also presented. Future development needs are summarized.
Author
Aeroshells; Thermal Protection; Fuselages; Impact Damage; Multilayer Insulation

20030112192 NASA Marshall Space Flight Center, Huntsville, AL, USA
Nondestructive Inspection Techniques for Friction Stir Weld Verification on the Space Shuttle External Tank
Suits, Michael W.; Leak, Jeffery; Bryson, Craig; [2003]; In English, 13-17 Oct. 2003, Pittsburg, PA, USA; No Copyright; Avail: Other Sources; Abstract Only

Friction Stir Welding (FSW) has gained wide acceptance as a reliable joining process for aerospace hardware as witnessed by its recent incorporation into the Delta Launch vehicle cryotanks. This paper describes the development of nondestructive evaluation methods and techniques used to verify the FSW process for NASA's Space Shuttle.
Author
Nondestructive Tests; Friction Stir Welding; External Tanks

20030111605 Jet Propulsion Lab., California Inst. of Tech., Pasadena, CA, USA
Solar System Observing with the Space Infrared Telescope Facility (SIRTF)
Cleve, J. Van; Meadows, V. S.; Stansberry, J.; Lunar and Planetary Science XXXIV; 2003; In English; Original contains color and black and white illustrations; Copyright; Avail: CASI; A01, Hardcopy; Available from CASI on CD-ROM only as part of the entire parent document

SIRTF is NASA's Space Infrared Telescope Facility. Currently planned for launch on 15 Apr 2003, it is the final element in NASA's Great Observatories Program. SIRTF has an 85 cm diameter f/12 lightweight beryllium telescope, cooled to lekss than 5.5K. It is diffraction-limited at 6.5 microns, and has wavelengthcoverage from 3-180 microns. Its estimated lifetime (limited by cryogen) is 2.5 years at minimum, with a goal of 5+ years. SIRTF has three instruments, IRAC, IRS, and MIPS. IRAC (InfraRed Array Camera) provides simultaneous images at wavelengths of 3.6, 4.5, 5.8, and 8.0 microns. IRS (InfraRed Spectrograph) has 4 modules providing low-resolution (R=60-120) spectra from 5.3 to 40 microns, high-resolution (R=600)

spectra from 10 to 37 microns, and an autonomous target acquisition system (PeakUp) which includes small-field imaging at 15 microns. MIPS (Multiband Imaging Photometer for SIRTF)} does imaging photometry at 24, 70, and 160 m and low-resolution (R=15-25) spectroscopy (SED) between 55 and 96 microns. The SIRTF Guaranteed Time Observers (GTOs) are planning to observe Outer Solar System satellites and planets, extinct comets and low-albedo asteroids, Centaurs and Kuiper Belt Objects, cometary dust trails, and a few active short-period comets. The GTO programs are listed in detail in the SIRTF Reserved Observations Catalog (ROC). We would like to emphasize that there remain many interesting subjects for the General Observers (GO). Proposal success for the planetary observer community in the first SIRTF GO proposal cycle (GO-1) determines expectations for future GO calls and Solar System use of SIRTF, so we would like promote a strong set of planetary GO-1 proposals. Towards that end, we present this poster, and we will convene a Solar System GO workshop 3.5 months after launch.
Derived from text
Solar System; Space Infrared Telescope Facility; NASA Space Programs; Observation; Spacecraft Instruments

20030111195 Jet Propulsion Lab., California Inst. of Tech., Pasadena, CA, USA
Sensor Web in Antarctica: Developing an Intelligent, Autonomous Platform for Locating Biological Flourishes in Cryogenic Environments
Delin, K. A.; Harvey, R. P.; Chabot, N. A.; Jackson, S. P.; Adams, Mike; Johnson, D. W.; Britton, J. T.; Lunar and Planetary Science XXXIV; 2003; In English; Original contains color illustrations
Contract(s)/Grant(s): NAG5-11122; NSF OPP-99-80452; Copyright; Avail: CASI; A01, Hardcopy; Available from CASI on CD-ROM only as part of the entire parent document

The most rigorous tests of the ability to detect extant life will occur where biotic activity is limited by severe environmental conditions. Cryogenic environments are among the most severe-the energy and nutrients needed for biological activity are in short supply while the climate itself is actively destructive to biological mechanisms. In such settings biological activity is often limited to brief flourishes, occurring only when and where conditions are at their most favorable. The closer that typical regional conditions approach conditions that are actively hostile , the more widely distributed biological blooms will be in both time and space. On a spatial dimension of a few meters or a time dimension of a few days, biological activity becomes much more difficult to detect. One way to overcome this difficulty is to establish a Sensor Web that can monitor microclimates over appropriate scales of time and distance, allowing a continuous virtual presence for instant recognition of favorable conditions. A more sophisticated Sensor Web, incorporating metabolic sensors, can effectively meet the challenge to be in ‘the right place in the right time’. This is particularly of value in planetary surface missions, where limited mobility and mission timelines require extremely efficient sample and data acquisition. Sensor Webs can be an effective way to fill the gap between broad scale orbital data collection and fine-scale surface lander science. We are in the process of developing an intelligent, distributed and autonomous Sensor Web that will allow us to monitor microclimate under severe cryogenic conditions, approaching those extant on the surface of Mars. Ultimately this Sensor Web will include the ability to detect and/or establish limits on extant microbiological activity through incorporation of novel metabolic gas sensors. Here we report the results of our first deployment of a Sensor Web prototype in a previously unexplored high altitude East Antarctic Plateau ‘micro-oasis’ at the MacAlpine Hills, Law Glacier, Antarctica.
Derived from text
Antarctic Regions; Autonomy; Cryogenics; Sensors; Microclimatology; Valleys; Activity (Biology)

20030107949 Columbia Accident Investigation Board, Arlington, VA, USA, Federal Aviation Administration, Cambridge, MA, USA, NASA Ames Research Center, Moffett Field, CA, USA, Department of the Navy, Washington, DC, USA
Columbia Accident Investigation Board Report. Volume Four
Gehmann, H. W.; Barry, J. L.; Deal, D. W.; Hallock, J. N.; Hess, K. W.; Oct. 2003; In English
Report No.(s): PB2004-100869; No Copyright; Avail: National Technical Information Service (NTIS)

This is Volume Four of a set of six reports produced by NASA and other organizations which were provided to the Columbia Accident Investigation Board (CAIB) in support of its inquiry into the February 1, 2003 destruction of the Space Shuttle Columbia. The Technical Documents included in this volume are: Appendix F.1 Water Absorption by Foam; Appendix F.2 Follow the TPS; Appendix F.3 MADS Sensor Data; Appendix F.4 ET Cryoinsulation; Appendix F.5 Space Shuttle STS-107 Columbia Accident Investigation, and External Tank Working Group Final Report - Volume 1.
NTIS
Columbia (Orbiter); Accident Investigation

20030107797 NASA Glenn Research Center, Cleveland, OH, USA

Near-Horizontal, Two-Phase Flow Patterns of Nitrogen and Hydrogen at Low Mass Heat and Flux (on CD-ROM)

VanDresar, N. T.; Siegwarth, J. D.; Dec. 2001; In English

Report No.(s): PB2003-500087; NASA-TP-2001-210380-CD; No Copyright; Avail: National Technical Information Service (NTIS)

One reason for NASA's interest in cryogenic two-phase flow with low mass and heat flux is the need to design spacecraft heat exchangers used for vaporizing cryogenic propellants. The CD-ROM provides digitized movies of particular flow patterns observed in experimental work. The movies have been provided in (QuickTime9Trademark) format, encoded at 320w x 240h pixels, 15 fps, using the Sorenson(Trademark) Video Codec for compression. Experiments were conducted to obtain data on the two-phase (liquid and vapor) flow behavior of cryogenic nitrogen and hydrogen under low mass and heat flux conditions. Tests were performed in normal gravity with a 1.5 degree up flow configuration. View ports in the apparatus permitted visual observation of the two-phase flow patterns. Computer codes to predict flow patterns were developed from theoretical/empirical models reported in the literature. Predictions from the computer codes were compared with experimental flow pattern observations. Results are presented employing the traditional two-dimensional flow pattern map format using the liquid and gas superficial velocities as coordinates. In general, the agreement between the experimental results and the analytical predictive methods is reasonably good. Small regions of the flow pattern maps are identified where the models are deficient as a result of neglecting phase change phenomena. Certain regions of the maps were beyond the range of the experiments and could not be completely validated. Areas that could benefit from further work include modeling of the transition from separated flow, collection of additional data in the bubble and annular flow regimes, and collection of experimental data at other inclination angles, tube diameters and high heat flux.

NTIS

Cryogenic Rocket Propellants; Two Phase Flow

20030106617 NASA Marshall Space Flight Center, Huntsville, AL, USA

NASA's In-Space Propulsion Program

Johnson, Les; [2003]; In English, 20-28 Sep. 2003, Lerici, Italy; No Copyright; Avail: CASI; A01, Hardcopy

In order to implement the ambitious science and exploration missions planned over the next several decades, improvements in in-space transportation and propulsion technologies must be achieved. For robotic exploration and science missions, increased efficiencies of future propulsion systems are critical to reduce overall life-cycle costs. Future missions will require 2 to 3 times more total change in velocity over their mission lives than the NASA Solar Electric Technology Application Readiness (NSTAR) demonstration on the Deep Space 1 mission. New opportunities to explore beyond the outer planets and to the stars will require unparalleled technology advancement and innovation. NASA's In-Space Propulsion (ISP) Program is investing in technologies to meet these needs. The ISP technology portfolio includes many advanced propulsion systems. From the next generation ion propulsion system operating in the 5-10 kW range, to advanced cryogenic propulsion, substantial advances in spacecraft propulsion performance are anticipated. Some of the most promising technologies for achieving these goals use the environment of space itself for energy and propulsion and are generically called, propellantless because they do not require on-board fuel to achieve thrust. Propellantless propulsion technologies include scientific innovations such as solar and plasma sails, electrodynamic and momentum transfer tethers, and aeroassist and aerocapture. An overview of both propellantless and propellant-based advanced propulsion technologies, and NASA s plans for advancing them, will be provided.

Author

Spacecraft Propulsion; Technology Assessment

20030088568

Microshutter arrays for near-infrared applications on the James Webb Space Telescope

Zheng, Yun; Li, M. J.; Bier, A.; Fettig, R. K.; Franz, D.; Hu, R.; King, T.; Kutyrev, A. S.; Lynch, B. A.; Moseley, S. H.; Mott, D. B.; Rapchun, D.; Silverberg, R. F.; Smith, W.; Wang, L.; Zinke, C.; Proceedings of SPIE - The International Society for Optical Engineering; 2003; ISSN 0277-786X; Volume 4981; In English; MEMS Components and Applications for Industry, Automobiles, Aerospace, and Communication II, Jan. 28-29, 2003, San Jose, CA, USA; Copyright; Avail: Other Sources

Magnetically actuated MEMS microshutter arrays are being developed at the NASA Goddard Space Flight Center for use in a multi-object spectrometer on the James Webb Space Telescope (JWST), formerly Next Generation Space Telescope (NGST). The microshutter arrays are designed for the selective transmission of light with high efficiency and high contrast. The JWST environment requires cryogenic operation at 45K. Microshutter arrays are fabricated out of silicon-on-insulator (SOI) wafers. Arrays consist of close-packed shutters made on silicon nitride (nitride) membranes with a pixel size of 100 x

100 micron. Individual shutters are patterned with a torsion flexure permitting shutters to open 90 deg, with a minimized mechanical stress concentration. Shutters operated this way have survived fatigue life tests. The mechanical shutter arrays are fabricated using MEMS technologies. The processing includes a multi-layer metal deposition, patterning of shutter electrodes and magnetic pads, reactive ion etching (RIE) of the front side to form shutters in a nitride film, an anisotropic back-etch for wafer thinning, and a deep RIE (DRIE) back-etch, down to the nitride shutter layer, to form support frames and relieve shutters from the silicon substrate. An additional metal deposition and patterning has recently been developed to form electrodes on the vertical walls of the frame. Shutters are actuated using a magnetic force, and latched electrostatically. One-dimensional addressing has been demonstrated.
EI
Electromechanical Devices; Silicon; SOI (Semiconductors); Wafers

20030088178

NASA advanced cryocooler technology development program

Ross, Jr. , R. G.; Boyle, R. F.; Key, R. W.; Coulter, D. R.; Proceedings of SPIE - The International Society for Optical Engineering; 2002; ISSN 0277-786X; Volume 4850, no. 2; In English; IR Space Telescopes and Instruments, Aug. 24-28, 2002, waikoloa, HI, USA; Copyright; Avail: Other Sources

Mechanical cryocoolers represent a significant enabling technology for NASA's Earth and Space Science Enterprises. Over the years, NASA has developed new cryocooler technologies for a wide variety of space missions. Recent achievements include the NCS, AIRS, TES and HIRDLS cryocoolers, and miniature pulse tube coolers at TRW and Lockheed Martin. The largest technology push within NASA right now is in the temperature range of 4 to 10 K. Missions such as the Next Generation Space Telescope (NGST) and Terrestrial Planet Finder plan to use infrared detectors operating between 6-8K, typically arsenic-doped silicon arrays, with IR telescopes from 3 to 6 meters in diameter. Similarly, Constellation-X plans to use X-ray microcalorimeters operating at 50 mK and will require [similar to]6K cooling to precool its multistage 50mK magnetic refrigerator. To address cryocooler development for these next-generation missions, NASA has initiated a program referred to as the Advanced Cryocooler Technology Development Program (ACTDP). This paper presents an overview of the ACTDP program including programmatic objectives and timelines, and conceptual details of the cooler concepts under development.
EI
Brayton Cycle; Cooling; Cryogenic Cooling; Infrared Detectors; Stirling Cycle

20030088171

Ultralow-background large-format bolometer arrays

Benford, Dominic J.; Chervenak, James A.; Irwin, Kent D.; Moseley, S. Harvey; Proceedings of SPIE - The International Society for Optical Engineering; 2002; ISSN 0277-786X; Volume 4850, no. 2; In English; IR Space Telescopes and Instruments, Aug. 24-28, 2002, waikoloa, HI, USA; Copyright; Avail: Other Sources

In the coming decade, work will commence in earnest on large cryogenic far-infrared telescopes and interferometers. All such observatories - for example, SAFIR, SPIRIT, and SPECS - require large format, two dimensional arrays of close-packed detectors capable of reaching the fundamental limits imposed by the very low photon backgrounds present in deep space. In the near term, bolometer array architectures which permit 1000 pixels - perhaps sufficient for the next generation of space-based instruments - can be arrayed efficiently. Demonstrating the necessary performance, with Noise Equivalent Powers (NEPs) of less than 10(sup -20) W/ square root of Hz, will be a hurdle in the coming years. Superconducting bolometer arrays are a promising technology for providing both the performance and the array size necessary. We discuss the requirements for future detector arrays in the far-infrared and submillimeter, describe the parameters of superconducting bolometer arrays able to meet these requirements, and detail the present and near future technology of superconducting bolometer arrays. Of particular note is the coming development of large format planar arrays with absorber-coupled and antenna-coupled bolometers.
EI
Bolometers; Cryogenics; Interferometers; Squid (Detectors); Telescopes

20030088155

Ultra-high resolution, absolute position sensors for cryostatic applications

Leviton, Douglas B.; Frey, Bradley J.; Proceedings of SPIE - The International Society for Optical Engineering; 2002; ISSN 0277-786X; Volume 4850, no. 2; In English; IR Space Telescopes and Instruments, Aug. 24-28, 2002, waikoloa, HI, USA; Copyright; Avail: Other Sources

Recent advances in new technology, optical pattern recognition encoders at NASA have resulted in high speed, reliable, compact position sensors for use in cryostatic space flight mechanisms. New encoder scale patterns and image processing algorithms combine with digital signal processors (DSP) and field programmable gate array (FPGA) logic elements to enable encoders with conversion rates in excess of 1.5 kHz (suitable for high speed servo motion control for mechanisms), linear resolutions of less than 10 nm, and angular resolutions in the single digit milli-arcseconds in relatively compact packages. Fiber optic light guides allow encoders to function in cryostats with extremely low power dissipation. Ambient test data for fiber optic configurations suitable for cryogenic environments are presented. Cryostatic test capabilities under development are discussed. Potential applications exist for NGST and other infrared and sub-millimeter missions, such as fine guidance sensing, attitude control, mirror segment position sensing, and mirror scanning.
EI
Cryostats; Pattern Recognition; Pipes (Tubes); Sensors; Space Flight; Tracking (Position)

20030088119

New cryogenic optical test capability at Marshall space flight center's space optics manufacturing technology center
Kegley, Jeff; Eng, Ron; Engberg, Robert; Hadaway, James; Hogue, William; Reily, Cary; Russell, Kevin; Stahl, Phillip; Wright, Ernie; Proceedings of SPIE - The International Society for Optical Engineering; 2002; ISSN 0277-786X; Volume 4850, no. 1; In English; IR Space Telescopes and Instruments, Aug. 24-28, 2002, Waikoloa, HI, USA; Copyright; Avail: Other Sources

Marshall Space Flight Center (MSFC) has been performing optical wavefront testing at cryogenic temperatures since 1999 in the Space Optics Manufacturing Technology Center's (SOMTC's) X-ray/Cryogenic Facility (XRCF). Recently the cryogenic optical testing capability has been extended to a smaller chamber. This smaller horizontal cylindrical vacuum chamber has been outfitted with a helium-cooled liner that can be connected to the existing helium refrigeration system bringing the kilowatt of refrigeration capacity to bear on a 1 x 2 meter test envelope. Cryogenic cycles to 20 Kelvin, including setup and chamber evacuation/backfill, are now possible in only a few days. Since activation and chamber characterization tests in September 2001, the new chamber has been used to perform a number of proprietary cryogenic tests on mirrors, adhesives, and actuators. A vibration survey has also been performed on the test chamber. Chamber specifications and performance data, vibration environment data, and optical test capability will be discussed.
EI
Cryogenics; Helium; Optics; Refrigerating; Stainless Steels

20030088084

Development of the Space Infrared Telescope Facility (SIRTF)
Gallagher, David B.; Irace, William R.; Werner, Michael W.; Proceedings of SPIE - The International Society for Optical Engineering; 2002; ISSN 0277-786X; Volume 4850, no. 1; In English; IR Space Telescopes and Instruments, Aug. 24-28, 2002, Waikoloa, HI, USA; Copyright; Avail: Other Sources

SIRTF, the Space Infrared Telescope Facility, is to be launched by NASA early in 2003. SIRTF will be an observatory for infrared astronomy from space with an 85cm aperture telescope operating at 5.5K and a 2.5-to-5 year cryogenic lifetime. SIRTF's three instruments with state of the art detector arrays will provide imaging, photometry, and spectroscopy over the 3-180um wavelength range. SIRTF will provide major advances for the study of astrophysical problems from the solar system to the edge of the Universe. SIRTF will complete NASA's family of Great Observatories and serve as a cornerstone of the Origins program. Over 75% of the observing time will be awarded to the general scientific community through the usual proposal and peer review cycle. SIRTF will demonstrate major advances in technology areas critical to future infrared missions. These include lightweight cryogenic optics, sensitive detector arrays, and a high performance thermal system, combining radiative and cryogenic cooling, which allows the telescope to be launched warm and to cool in space. These thermal advances are enabled by the use of an Earth-trailing solar orbit which carries SIRTF to a distance of [similar to]0.6 AU from Earth in 5 years. This paper will provide an overview of the SIRTF mission, telescope, cryostat, instruments, spacecraft, orbit, and operations in preparation for an accompanying set of detailed technical presentations.
EI
Aerospace Sciences; Airborne Equipment; Astronomy; Infrared Radiation; Observatories; Space Infrared Telescope Facility; Telescopes

20030086541

Design of a cryogenic, high accuracy, absolute prism refractometer for infrared through far ultraviolet optical materials

Leviton, Douglas B.; Frey, Bradley J.; Proceedings of SPIE - The International Society for Optical Engineering; 2002; ISSN 0277-786X; Volume 4842; In English; Specialized Optical Developments in Astronomy, Aug. 25-26, 2002, Waikoloa, HI, USA; Copyright; Avail: Other Sources

The next generation of cryogenic, infrared (IR), space optical instrumentation (for NGST and other missions) will require a knowledge of refractive indices for constituent optical materials to a level of accuracy which is not currently attainable. The rationale for and design of a broadband, absolute, prism refractometer for measuring refractive index at cryogenic temperatures to very high absolute accuracy is discussed. The refractometer design also permits similar measurements through the far ultraviolet where accurate refractive index data are scarce for most UV optical materials. The technical challenges in achieving high accuracy in these wavelength regions and at extremely cold temperatures are presented, along with novel solutions under development to meet those challenges.

EI

Cryogenics; Infrared Radiation; Optical Materials; Optics; Prisms; Refractometers

20030086056

Film stress of microshutter arrays for the James Webb Space Telescope

Zheng, Yun; Cheng, Shu-Fan; Fettig, Rainer; Li, Mary; Mott, Brent; Moseley, Harvey; Proceedings of SPIE - The International Society for Optical Engineering; 2002; ISSN 0277-786X; Volume 4935; In English; Smart Structures, Devices, and Systems, Dec. 16-18, 2002, Melbourne, VIC., Australia; Copyright; Avail: Other Sources

The James Webb Space Telescope (JWST), formally Next Generation Space Telescope (NGST), is one of NASA's challenging projects for advancing the exploration of space. The NGST will be equipped with a Multi-Object-Spectrometer (MOS) that covers the wavelength ranging from 0.6 to 5 micron. To selectively direct light rays from different regions of space into the spectrometer, one approach is to use microshutter arrays serving as the slit mask for the spectrometer. A large format (2K x 1K) individually addressable microshutter array with a lateral pixel size of 100 micron x 200 micron is being developed and fabricated using MEMS technologies. The microshutter arrays are close-packed silicon nitride membrane cantilevers. A ferromagnetic Co(sub 90)Fe(sub 10) film is deposited on the membranes to magnetically actuate the microshutters. During deposition a Co(sub 90)Fe(sub 10) film is susceptible to develop large tensile stress that can distort the nitride membranes and affect the contrast of the MOS, especially at cryogenic temperatures. In this paper, we discuss how to minimize the film stress. Stress-test cantilevers are micro machined and used in conjunction with Stoney's formula to determine film stresses. The effects of deposition pressure and power on the Co (sub 90)Fe(sub 10) film, aluminum film and multiple-layer film stress are discussed. It is found that sputter-deposition of Co(sub 90)Fe(sub 10) at low pressure and power results in favor of low tensile stresses in films.

EI

Magnetic Films; Optical Equipment; Silicon Nitrides; Spectrometers

20030082581

Cryogenic thermal design overview of the 30 K passively cooled integrated science instrument module (ISIM) for NASA's next generation space telescope

Parrish, Keith; Thomson, Shaun; Proceedings of SPIE - The International Society for Optical Engineering; 2002; ISSN 0277-786X; Volume 4822; In English; Cryogenic Optical Systems and Instruments IX, Jul. 8, 2002, Seattle, WA, USA; Copyright; Avail: Other Sources

Baseline configurations for NASA's Next Generation Space Telescope (NGST) include a multi-module science instrument package with near-infrared (near-IR) detectors passively cooled to below 30 K. This integrated science instrument model (ISIM) will also house mid-infrared (mid-IR) detectors that are cooled to 6-7 K with a mechanical cooler or stored cryogen. These complex cooling requirements, combined with the NGST concept of a large deployed aperture optical telescope passively cooled to below 40 K, makes NGST one of the most unique and thermally challenging missions flown to date. This paper describes the current status and baseline thermal/cryogenic systems design and analysis approach for the ISIM. The extreme thermal challenges facing the ISIM are presented along with supporting heat maps and analysis results.

EI

Airborne Equipment; Cryogenics; Infrared Detectors; Sun; Telescopes; Thermal Insulation

20030073557 NASA Ames Research Center, Moffett Field, CA, USA

Comet Observations with SIRTF

Cruikshank, Dale P.; Workshop on Cometary Dust in Astrophysics; 2003; In English; No Copyright; Abstract Only; Available from CASI only as part of the entire parent document

Comet observations are included in the programs of the Guaranteed Time Observers (GTO) on the Space Infrared Telescope Facility (SIRTF), scheduled to be in space and operational for five years beginning in late 2003. SIRTF is a cryogenic telescope with three basic instruments for imaging, photometry and spectroscopy from 3.6 m to 160 m. All of these capabilities will be used in studies of comets. The intent is to study the infrared radiation (emission) from comets (and dust tails, where relevant) in all stages of evolution, starting with Kuiper Belt objects and Centaurs (thermal emission at 24,70, and 160 m to derive dimensions and albedos). Active comets will be observed spectroscopically and in deep thermal images. Several known or suspected extinct comets will be observed spectroscopically (5-37 m) for information on their surface compositions. There are opportunities for Guest Observers (GO) to propose additional comet work. .

Author

Comets; Space Infrared Telescope Facility; Imaging Techniques; Cryogenics; Infrared Radiation

20030068241 Boeing Co., USA

Aging Optimization of Aluminum-Lithium Alloy L277 for Application to Cryotank Structures

Sova, B. J.; Sankaran, K. K.; Babel, H.; Farahmand, B.; Cho, A.; [2003]; In English, 9-12 Jun. 2003, Dayton, OH, USA; Copyright; Avail: CASI; A03, Hardcopy

Compared with aluminum alloys such as 2219, which is widely used in space vehicle for cryogenic tanks and unpressurized structures, aluminum-lithium alloys possess attractive combinations of lower density and higher modulus along with comparable mechanical properties and improved damage tolerance. These characteristics have resulted in the successful use of the aluminum-lithium alloy 2195 for the Space Shuttle External Tank, and the consideration of newer U.S. aluminum-lithium alloys such as L277 and C458 for future space vehicles. A design of experiments aging study was conducted for plate and a limited study on extrusions. To achieve the T8 temper, Alloy L277 is typically aged at 290 F for 40 hours. In the study for plate, a two-step aging treatment was developed through a design of experiments study and the one step aging used as a control. Based on the earlier NASA studies on 2195, the first step aging temperature was varied between 220 F and 260 F. The second step aging temperatures was varied between 290 F and 310 F, which is in the range of the single-step aging temperature. For extrusions, two, single-step, and one two-step aging condition were evaluated. The results of the design of experiments used for the T8 temper as well as a smaller set of experiments for the T6 temper for plate and the results for extrusions will be presented.

Derived from text

Aluminum-Lithium Alloys; Aging (Materials); Mechanical Properties; Cryogenics

20030068136 NASA Marshall Space Flight Center, Huntsville, AL, USA

High Accuracy Thermal Expansion Measurement At Cryogenic Temperatures

Stallcup, Michael; Presson, Joan; Tucker, James; Daspit, Gregory; Nein, Max; [2003]; In English, 3-8 Aug. 2003, San Diego, CA, USA

Contract(s)/Grant(s): NASA Order H-35206D; No Copyright; Avail: Other Sources; Abstract Only

A new, interferometer based system for measuring thermal expansion to an absolute accuracy of 20 ppb or better at cryogenic temperatures has been developed. Data from NIST Copper SRM 736 measured from room temperature to 15 K will be presented along with data from many other materials including beryllium, ULE, Zerodur, and composite materials. Particular attention will be given to a study by the Space Optics Manufacturing Technology Center (SOMTC) investigating the variability of ULE and beryllium materials used in the AMSD program. Approximately 20 samples of each material, tested from room temperature to below 30 K are compared as a function of billet location.

Author

Accuracy; Thermal Expansion; Cryogenic Temperature; Interferometers

20030067768 Caen Univ., France

High Sensitivity Magnetometers. Sensors and Applications

Nov. 2002; In English

Contract(s)/Grant(s): F61775-02-W-F077

Report No.(s): AD-A414749; No Copyright; Avail: CASI; A04, Hardcopy

The Final Proceedings for High Sensitivity Magnetometers Sensors and Applications: 4 - 8 November 2002. Magnetic sensors designed to operate both at room temperature and at cryogenic temperatures. Applications of these sensors will also be addressed including non-destructive evaluation of composite materials, magnetic anomaly detection, space magnetism, and geomagnetism.
DTIC
Magnetometers; Conferences; Magnetic Measurement

20030067582 Northrop Grumman Corp., Redondo, CA, USA, NASA Marshall Space Flight Center, Huntsville, AL, USA
Design and Testing of Non-Toxic RCS Thrusters for Second Generation Reusable Launch Vehicle
Calvignac, Jacky; Dang, Lisa; Tramel, Terri; Paseur, Lila; Champion, Robert, Technical Monitor; July 22, 2003; In English; 39th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, 20-23 Jul. 2003, Huntsville, AL, USA
Contract(s)/Grant(s): NAS8-01110; NAG8-0110
Report No.(s): AIAA Paper 2003-4922; Copyright; Avail: CASI; A03, Hardcopy

Under NASA sponsorship, Northrop Grumman Space Technology (NGST) designed, built and tested two non-toxic, reaction control engines, one using liquid oxygen (LOX) and liquid hydrogen (LH2) and the other using liquid oxygen and ethanol. This paper presents the design and testing of the LOX/LH2 thruster. The two key enabling technologies are the coaxial liquid-on-liquid pintle injector and the fuelcooling duct. The workhorse thruster was hotfire tested at the NASA Marshall Space Flight Center Test Stand 500 in March and April of 2002. All tests were performed at sea-level conditions. During the test program, 7 configurations were tested, including 2 combustion chambers, 3 LOX injector pintle tips, and 4 LHp injector settings. The operating conditions surveyed were 70 to 100% thrust levels, mixture ratios from 3.27 to 4.29, and LH2 duct cooling from 18.0 to 25.5% fuel flow. The copper heat sink chamber was used for 16 burns, each burn lasting from 0.4 to 10 seconds, totaling 51.4 seconds, followed by Haynes chamber testing ranging from 0.9 to 120 seconds, totaling 300.9 seconds. The performance of the engine reached 95% C* efficiency. The temperature on the Haynes chamber remained well below established material limits, with the exception of one localized hot spot. These results demonstrate that both the coaxial liquid-on-liquid pintle injector design and fuel duct concepts are viable for the intended application. The thruster headend design maintained cryogenic injection temperatures while firing, which validates the selected injector design approach for minimal heat soak-back. Also, off -nominal operation without adversely impacting the thermal response of the engine showed the robustness of the duct design, a key design feature for this application. By injecting fuel into the duct, the throat temperatures are manageable, yet the split of fuel through the cooling duct does not compromise the overall combstion efficiency, which indicates that, provided proper design refinement, such a concept could be applied to a high-performance version of the thruster.
Author
Aerospace Engineering; Reusable Launch Vehicles; Engine Tests; Combustion Chambers; Combustion Efficiency; Spacecraft Performance; Thrust

20030066229 NASA Marshall Space Flight Center, Huntsville, AL, USA, NASA Marshall Space Flight Center, Huntsville, AL, USA
Evaluation of Impinging Stream Vortex Chamber Concepts for Liquid Rocket Engine Applications
Trinh, Huu; Kopicz, Charles; Bullard, Brad; Michaels, Scott; [2003]; In English, 20-23 Jul. 2003, Huntsville, AL, USA
Report No.(s): AIAA Paper 2003-4476; Copyright; Avail: CASI; A02, Hardcopy

NASA Marshall Space Flight Center (MSFC) and the U. S. Army are jointly investigating vortex chamber concepts for cryogenic oxygen/hydrocarbon fuel rocket engine applications. One concept, the Impinging Stream Vortex Chamber Concept (ISVC), has been tested with gel propellants at AMCOM at Redstone Arsenal, Alabama. A version of this concept for the liquid oxygen (LOX)/hydrocarbon fuel (RP-1) propellant system is derived from the one for the gel propellant. An unlike impinging injector is employed to deliver the propellants to the chamber. MSFC has also designed two alternative injection schemes, called the chasing injectors, associated with this vortex chamber concept. In these injection techniques, both propellant jets and their impingement point are in the same chamber cross-sectional plane. One injector has a similar orifice size with the original unlike impinging injector. The second chasing injector has small injection orifices. The team has achieved their objectives of demonstrating the self-cooled chamber wall benefits of ISVC and of providing the test data for validating computational fluids dynamics (CFD) models. These models, in turn, will be used to design the optimum vortex chambers in the future.
Author
Vortices; Liquid Propellant Rocket Engines; Oxygen-Hydrocarbon Rocket Engines; Cryogenic Equipment; Computational Fluid Dynamics

20030065957 NASA Marshall Space Flight Center, Huntsville, AL, USA

Design and Testing of Non-Toxic RCS Thrusters for Second Generation Reusable Launch Vehicle

Calvignac, Jacky; Tramel, Terri; [2003]; In English, Jul. 2003, Huntsville, AL, USA

Contract(s)/Grant(s): NAS8-01110; No Copyright; Avail: Other Sources; Abstract Only

The current NASA Space Shuttle auxiliary propulsion system utilizes nitrogen tetroxide (NTO) and monomethylhydrazine (MMH), hypergolic propellants. This use of these propellants has resulted in high levels of maintenance and precautions that contribute to costly launch operations. By employing alternate propellant combinations, those less toxic to humans, the hazards and time required between missions can be significantly reduced. Use of alternate propellants can thereby increase the efficiency and lower the cost in launch operations. In support of NASA's Space Launch Initiative (SLI), TRW proposed a three-phase project structured to significantly increase the technology readiness of a high-performance reaction control subsystem (RCS) thruster using non-toxic propellant for an operationally efficient and reusable auxiliary propulsion system (APS). The project enables the development of an integrated primary/vernier thruster capable of providing dual-thrust levels of both 1000-lbf class thrust and 25-lbf thrust. The intent of the project is to reduce the risk associated with the development of an improved RCS flight design that meets the primary NASA objectives of improved safety and reliability while reducing systems operations and maintenance costs. TRW proposed two non-toxic auxiliary propulsion engine designs, one using liquid oxygen and liquid hydrogen and the other using liquid oxygen and liquid ethanol, as candidates to meet the goals of reliability and affordability at the RCS level. Both of these propellant combinations offer the advantage of a safe environment for maintenance, while at the same time providing adequate to excellent performance for a conventional liquid propulsion systems. The key enabling technology incorporated in both TRW thrusters is the coaxial liquid on liquid pintle injector. This paper will concentrate on only the design and testing of one of the thrusters, the liquid oxygen (LOX) and liquid hydrogen (LH2) thruster. The LOX/LH2 thruster design includes a LOX-centered pintle injector, consisting of two rows of slots that create a radial spoke spray pattern in the combustion chamber. The main fuel injector creates a continuous sheet of LH2 originating upstream of the LOX pintle injector. The two propellants impinge at the pintle slots, where the resulting momentum ratio and spray pattern determines the combustion efficiency and thermal effects on the hardware. Another enabling technology used in the design of this thruster is fuel film cooling through a duct, lining the inner wall of the combustion chamber barrel section. The duct is also acts as a secondary fuel injection point. The variation in the amount of LH2 used for the duct allows for adjustments in the cooling capacity for the thruster. The Non-Toxic LOX-LH2 RCS Workhorse Thruster was tested at the NASA Marshall Space Flight Center's Test Stand 500. Hot-fire tests were conducted between March 08, 2002 and April 05, 2002. All testing during the program base period were performed at sea-level conditions. During the test program, 7 configurations were tested, including 2 combustion chambers, 3 LOX injector pintle tips, and 4 LH2 injector stroke settings. The operating conditions that were surveyed varied thrust levels, mixture ratio and LH2 duct cooling flow. The copper heat sink chamber was used for 16 burns, each burn lasting from 0.4 to 10 seconds, totaling 51.4 seconds, followed by Haynes chamber testing ranging from 0.9 to 120 seconds, totaling 300.9 seconds. The total accumulated burn time for the test program is 352.3 seconds. C* efficiency was calculated and found to be within expectable limits for most operating conditions. The temperature on the Haynes combustion chamber remained below established material limits, with the exception of one localized hot spot. The test results demonstrate that both the coaxial liquid-on-liquid pintle injector design and fuel duct concepts are viable for the intended application. The thruster head-e design maintained cryogenic injection temperatures while firing, which validates the concept for minimal heat soak back. By injecting fuel into the duct, the throat temperatures were manageable, yet the split of fuel through the cooling duct does not compromise the overall combustion efficiency, which indicates that, provided proper design refinement, such a concept can be applied to a high-performance version of the thruster. These hot fire tests demonstrate the robustness of the duct design concept and good capability to withstand off-nominal operating conditions without adversely impacting the thermal response of the engine, a key design feature for a cryogenic thruster.

Author

Liquid Rocket Propellants; Thrustors; Ethyl Alcohol; Engine Tests; Aerospace Safety; Hydrogen Fuels; Liquid Hydrogen; Liquid Oxygen

20030065924 NASA Marshall Space Flight Center, Huntsville, AL, USA

Evaluation of Impinging Stream Vortex Chamber Concepts for Liquid Rocket Engine Applications

Trinh, Huu P.; Bullard, Brad; Kopicz, Charles; Michaels, Scott; December 03, 2002; In English, 20-23 Jul. 2003, Huntsville, AL, USA; Copyright; Avail: CASI; A01, Hardcopy

To pursue technology developments for future launch vehicles, NASA/Marshall Space Flight Center (MSFC) is examining vortex chamber concepts for liquid rocket engine applications. Past studies indicated that the vortex chamber schemes potentially have a number of advantages over conventional chamber methods. Due to the nature of the vortex flow,

relatively cooler propellant streams tend to flow along the chamber wall. Hence, the thruster chamber can be operated without the need of any cooling techniques. This vortex flow also creates strong turbulence, which promotes the propellant mixing process. Consequently, the subject chamber concepts not only offer system simplicity, but also enhance the combustion performance. Test results have shown that chamber performance is markedly high even at a low chamber length-to-diameter ratio (LD). This incentive can be translated to a convenience in the thrust chamber packaging. Variations of the vortex chamber concepts have been introduced in the past few decades. These investigations include an ongoing work at Orbital Technologies Corporation (ORBITEC). By injecting the oxidizer tangentially at the chamber convergence and fuel axially at the chamber head end, Knuth et al. were able to keep the wall relatively cold. A recent investigation of the low L/D vortex chamber concept for gel propellants was conducted by Michaels. He used both triplet (two oxidizer orifices and one fuel orifice) and unlike impinging schemes to inject propellants tangentially along the chamber wall. Michaels called the subject injection scheme an Impinging Stream Vortex Chamber (ISVC). His preliminary tests showed that high performance, with an Isp efficiency of 9295, can be obtained. MSFC and the U. S. Army are jointly investigating an application of the ISVC concept for the cryogenic oxygen/hydrocarbon propellant system. This vortex chamber concept is currently tested with gel propellants at AMCOM at Redstone Arsenal, Alabama. A version of this concept for the liquid oxygen (LOX) hydrocarbon fuel (RP-1) system has been derived from the one for the gel propellant. An unlike impinging injector was employed to deliver the propellants to the chamber. MSFC is also conducting an alternative injection scheme, called the chasing injector, associated with this vortex chamber concept. In this injection technique, both propellant jets and their impingement point are in the same chamber cross-sectional plane. Long duration tests (approximately up to 15 seconds) will be conducted on the ISVC to study the thermal effects. This paper will report the progress of the subject efforts at NASA Marshall Space Flight Center. Thrust chamber performance and thermal wall compatibility will be evaluated. The chamber pressures, wall temperatures, and thrust will be measured as appropriate. The test data will be used to validate CFD models, which, in turn, will be used to design the optimum vortex chambers. Measurements in the previous tests showed that the chamber pressures vary significantly with radius. This is due to the existence of the vortices in the chamber flow field. Hence, the combustion efficiency may not be easily determined from chamber pressure. For this project, measured thrust data will be collected. The performance comparison will be in terms of specific impulse efficiencies. In addition to the thrust measurements, several pressure and temperature readings at various locations on the chamber head faceplate and the chamber wall will be made. The first injector and chamber were designed and fabricated based on the available data and experience gained during gel propellant system tests by the U.S. Army. The alternate injector for the ISVC was also fabricated. Hot-fire tests of the vortex chamber are about to start and are expected to complete in February of 2003 at the TS115 facility of MSFC.
Author
Impingement; Vortices; Liquid Propellant Rocket Engines; Thrust Chambers; Performance

20030065050 Boeing Co., USA
Aging Optimization of Aluminum-Lithium Alloy C458 for Application to Cryotank Structures
Sova, B. J.; Sankaran, K. K.; Babel, H.; Farahmand, B.; Rioja, R.; [2003]; In English, 9-12 Jun. 2003, Dayton, OH, USA; Copyright; Avail: Other Sources; Abstract Only

Compared with aluminum alloys such as 2219, which is widely used in space vehicle for cryogenic tanks and unpressurized structures, aluminum-lithium alloys possess attractive combinations of lower density and higher modulus along with comparable mechanical properties. These characteristics have resulted in the successful use of the aluminum-lithium alloy 2195 (Al-1.0 Li-4.0 Cu-0.4 Mg-0.4 Ag-0.12 Zr) for the Space Shuttle External Tank, and the consideration of newer U.S. aluminum-lithium alloys such as L277 and C458 for future space vehicles. These newer alloys generally have lithium content less than 2 wt. % and their composition and processing have been carefully tailored to increase the toughness and reduce the mechanical property anisotropy of the earlier generation alloys such 2090 and 8090. Alloy processing, particularly the aging treatment, has a significant influence on the strength-toughness combinations and their dependence on service environments for aluminum-lithium alloys. Work at NASA Marshall Space Flight Center on alloy 2195 has shown that the cryogenic toughness can be improved by employing a two-step aging process. This is accomplished by aging at a lower temperature in the first step to suppress nucleation of the strengthening precipitate at sub-grain boundaries while promoting nucleation in the interior of the grains. Second step aging at the normal aging temperature results in precipitate growth to the optimum size. A design of experiments aging study was conducted for plate. To achieve the T8 temper, Alloy C458 (Al-1.8 Li-2.7 Cu-0.3 Mg- 0.08 Zr-0.3 Mn-0.6 Zn) is typically aged at 300 F for 24 hours. In this study, a two-step aging treatment was developed through a comprehensive 24 full factorial design of experiments study and the typical one-step aging used as a reference. Based on the higher lithium content of C458 compared with 2195, the first step aging temperature was varied between 175 F and 250 F. The second step aging temperatures was varied between 275 F and 325 F, which is in the range of the single-step aging temperature. The results of the design of experiments used for the T8 temper as well as a smaller set of experiments

for the T6 temper will be presented. The process of selecting the optimum aging treatment, based on the measured mechanical properties at room and cryogenic temperature as well as the observed deformation mechanisms, will be presented in detail. The implications for the use of alloy C458 in cryotanks will be discussed.
Author
Aluminum-Lithium Alloys; Aging (Metallurgy); Optimization; Cryogenic Fluid Storage; Storage Tanks

20030063104 Clark-Atlanta Univ., GA, USA
Characterization of Polyimide Foams for Ultra-Lightweight Space Structures
Meador, Michael, Technical Monitor; Hillman, Keithan; Veazie, David R.; HBCUs/OMUs Research Conference Agenda and Abstracts; February 2003; In English; No Copyright; Abstract Only; Available from CASI only as part of the entire parent document

Ultra-lightweight materials have played a significant role in nearly every area of human activity ranging from magnetic tapes and artificial organs to atmospheric balloons and space inflatables. The application range of ultra-lightweight materials in past decades has expanded dramatically due to their unsurpassed efficiency in terms of low weight and high compliance properties. A new generation of ultra-lightweight materials involving advanced polymeric materials, such as TEEK (TM) polyimide foams, is beginning to emerge to produce novel performance from ultra-lightweight systems for space applications. As a result, they require that special conditions be fulfilled to ensure adequate structural performance, shape retention, and thermal stability. It is therefore important and essential to develop methodologies for predicting the complex properties of ultra-lightweight foams. To support NASA programs such as the Reusable Launch Vehicle (RLV), Clark Atlanta University, along with SORDAL, Inc., has initiated projects for commercial process development of polyimide foams for the proposed cryogenic tank integrated structure (see figure 1). Fabrication and characterization of high temperature, advanced aerospace-grade polyimide foams and filled foam sandwich composites for specified lifetimes in NASA space applications, as well as quantifying the lifetime of components, are immensely attractive goals. In order to improve the development, durability, safety, and life cycle performance of ultra-lightweight polymeric foams, test methods for the properties are constant concerns in terms of timeliness, reliability, and cost. A major challenge is to identify the mechanisms of failures (i.e., core failure, interfacial debonding, and crack development) that are reflected in the measured properties. The long-term goal of the this research is to develop the tools and capabilities necessary to successfully engineer ultra-lightweight polymeric foams. The desire is to reduce density at the material and structural levels, while at the same time maintaining or increasing mechanical and other properties.
Author
Foams; Polyimides; Technology Utilization; Costs; Fabrication

20030063047 NASA Marshall Space Flight Center, Huntsville, AL, USA
Thermal Exposure Effects on Properties of Al-Li Alloy Plate Products
Shah, Sandeep; Wells, Douglas; Wagner, John; Babel, Henry; November 25, 2002; In English, 9-12 Jun. 2003, Dayton, OH, USA; Copyright; Avail: Other Sources; Abstract Only

Aluminum-Lithium (AL-Li) alloys offer significant performance benefits for aerospace structural applications due to their higher specific properties compared with conventional aluminum alloys. For example, the application of an Al-Li alloy to the space shuttle external cryogenic fuel tank contributed to the weight savings that enabled successful deployment of International Space Station components. The composition and heat treatment of this alloy were optimized specifically for strength-toughness considerations for an expendable cryogenic tank. Time dependent properties related to reliability, such as thermal stability, fatigue, and corrosion, will be of significant interest when materials are evaluated for a reusable cryotank structure. As most aerospace structural hardware is weight sensitive, a reusable cryotank will be designed to the limits of the materials mechanical properties. Therefore, this effort was designed to establish the effects of thermal exposure on the mechanical properties and microstructure of one relatively production mature alloy and two developmental alloys C458 and L277. Tensile and fracture toughness behavior was evaluated after exposure to temperatures as high as 3oooF for up to IO00 hrs. Microstructural changes were also evaluated to correlate with the observed data trends. The ambient temperature parent metal data showed an increase in strength and reduction in elongation after exposure at lower temperatures. Strength reached a peak with intermediate temperature exposure followed by a decrease at highest exposure temperature. Characterizing the effect of thermal exposure on the properties of Al-Li alloys is important to defining a service limiting temperature, exposure time, and end-of-life properties.
Author
Aluminum-Lithium Alloys; Temperature Effects; Cryogenic Fluid Storage; Fuel Tanks; Fracture Strength; Structural Design; Thermal Stability

20030062825 Florida Inst. of Tech., FL, USA
Collapsible Cryogenic Storage Vessel Project
Fleming, David C.; 2002 Research Reports: NASA/ASEE Fellowship Program; December 2002; In English; Original contains black and white illustrations; No Copyright; Avail: CASI; A02, Hardcopy

Collapsible cryogenic storage vessels may be useful for future space exploration missions by providing long-term storage capability using a lightweight system that can be compactly packaged for launch. Previous development efforts have identified an ‘inflatable’ concept as most promising. In the inflatable tank concept, the cryogen is contained within a flexible pressure wall comprised of a flexible bladder to contain the cryogen and a fabric reinforcement layer for structural strength. A flexible, high-performance insulation jacket surrounds the vessel. The weight of the tank and the cryogen is supported by rigid support structures. This design concept is developed through physical testing of a scaled pressure wall, and through development of tests for a flexible Layered Composite Insulation (LCI) insulation jacket. A demonstration pressure wall is fabricated using Spectra fabric for reinforcement, and burst tested under noncryogenic conditions. An insulation test specimens is prepared to demonstrate the effectiveness of the insulation when subject to folding effects, and to examine the effect of compression of the insulation under compressive loading to simulate the pressure effect in a nonrigid insulation blanket under the action atmospheric pressure, such as would be seen in application on the surface of Mars. Although pressure testing did not meet the design goals, the concept shows promise for the design. The testing program provides direction for future development of the collapsible cryogenic vessel concept.
Author
Cryogenic Storage; Inflatable Structures; Storage Tanks

20030062263 Boeing Co., Huntington Beach, CA, USA
Thermal-Mechanical Cyclic Test of a Composite Cryogenic Tank for Reusable Launch Vehicles
Messinger, Ross; Pulley, John; [2003]; In English, 7-10 Apr. 2003, Norfolk, VA, USA
Contract(s)/Grant(s): NCC8-39; No Copyright; Avail: CASI; A03, Hardcopy

This viewgraph presentation provides an overview of thermal-mechanical cyclic tests conducted on a composite cryogenic tank designed for reusable launch vehicles. Topics covered include: a structural analysis of the composite cryogenic tank, a description of Marshall Space Flight Center’s Cryogenic Structure Test Facility, cyclic test plans and accomplishments, burst test and analysis and post-testing evaluation.
CASI
Cryogenic Fluid Storage; Storage Tanks; Composite Materials; Destructive Tests; Cryogenic Fluids; Thermal Cycling Tests; Mechanical Properties

20030062194 NASA Marshall Space Flight Center, Huntsville, AL, USA
Development Of A Novel Discontinuously-Reinforced Aluminum For Space Applications
Pandey, A. B.; Shah, S.; Shadoan, M.; [2002]; In English, 9-12 Jun. 2003, Dayton, OH, USA; No Copyright; Avail: Other Sources; Abstract Only

Discontinuously-reinforced aluminum (DRA) has been used in aerospace structures such as Ventral Fins and Fan Exit Guide Vanes owing to its superior specific stiffness, specific strength, wear resistance, and thermal resistance as compared to the unreinforced aluminum alloys. In order to reduce engine weight, DRA materials are now being considered for space applications. Higher specific strength at ambient and cryogenic temperatures is one of the main requirements in certain rocket applications. The commercial DRA materials use 6xxx and 2xxx precipitation hardened aluminum alloys as matrices which have limited strengths. Therefore, an aluminum alloy which can provide significantly higher ambient and cryogenic strengths is required. In this paper, a novel aluminum alloy based on Al-Sc-X composition with improved ambient and cryogenic temperature strengthening capability is proposed. In addition, this alloy showed promise for improved strength at elevated temperature. The monolithic alloy and the composite with 15 volume percent SiC and B4C particles were processed using a powder metallurgy approach. The influence of processing parameters on the microstructures and mechanical properties of the monolithic and composite materials is discussed. The alloy showed very high strength and moderate ductility. The influence of hydrogen on the properties of monolithic and composite materials is discussed. The thermal stability of these materials is also evaluated. The strength of the material is discussed in terms of solid solution strengthening, Orowan strengthening, and antiphase boundary strengthening models.
Author
Composite Materials; Aluminum Alloys; Metal Matrix Composites; Wear Resistance; Thermal Resistance; Thermal Stability

20030062179 Boeing Co., USA

Aging Optimization of Aluminum-Lithium Alloy C458 for Application to Cryotank Structures

Sova, B. J.; Sankaran, K. K.; Babel, H.; Farahmand, B.; Rioja, R.; [2003]; In English, 9-12 Jun. 2003, Dayton, OH, USA
Contract(s)/Grant(s): NAS8-01099; Copyright; Avail: Other Sources; Abstract Only

Compared with aluminum alloys such as 2219, which is widely used in space vehicle for cryogenic tanks and unpressurized structures, aluminum-lithium alloys possess attractive combinations of lower density and higher modulus along with comparable mechanical properties. These characteristics have resulted in the successful use of the aluminum-lithium alloy 2195 (Al-1.0 Li-4.0 Cu-0.4 Mg-0.4 Ag-0.12 Zr) for the Space Shuttle External Tank, and the consideration of newer U.S. aluminum-lithium alloys such as L277 and C458 for future space vehicles. These newer alloys generally have lithium content less than 2 wt. % and their composition and processing have been carefully tailored to increase the toughness and reduce the mechanical property anisotropy of the earlier generation alloys such 2090 and 8090. Alloy processing, particularly the aging treatment, has a significant influence on the strength-toughness combinations and their dependence on service environments for aluminum-lithium alloys. Work at NASA Marshall Space Flight Center on alloy 2195 has shown that the cryogenic toughness can be improved by employing a two-step aging process. This is accomplished by aging at a lower temperature in the first step to suppress nucleation of the strengthening precipitate at sub-grain boundaries while promoting nucleation in the interior of the grains. Second step aging at the normal aging temperature results in precipitate growth to the optimum size. A design of experiments aging study was conducted for plate. To achieve the T8 temper, Alloy C458 (Al-1.8 Li-2.7 Cu-0.3 Mg-0.08 Zr-0.3 Mn-0.6 Zn) is typically aged at 300F for 24hours. In this study, a two-step aging treatment was developed through a comprehensive 2(exp 4) full factorial design of experiments study and the typical one-step aging used as a reference. Based on the higher lithium content of C458 compared with 2195, the first step aging temperature was varied between 175F and 250F. The second step aging temperatures was varied between 275F and 325F, which is in the range of the single-step aging temperature. The results of the design of experiments used for the T8 temper as well as a smaller set of experiments for the T6 temper will be presented. The process of selecting the optimum aging treatment, based on the measured mechanical properties at room and cryogenic temperature as well as the observed deformation mechanisms, will be presented in detail. The implications for the use of alloy C458 in cryotanks will be discussed.
Author

Aluminum-Lithium Alloys; Aging (Metallurgy); Hardening (Materials); Cryogenic Fluid Storage; Storage Tanks; Mechanical Properties; Optimization

20030062118 NASA Marshall Space Flight Center, Huntsville, AL, USA

Polymer Matrix Composites for Propulsion Systems

Nettles, Alan T.; [2003]; In English, 20-26 May 2003, New Orleans, LA, USA; No Copyright; Avail: CASI; A01, Hardcopy

The Access-to-Space study identified the requirement for lightweight structures to achieve orbit with a single-stage vehicle. Thus a task was undertaken to examine the use of polymer matrix composites for propulsion components. It was determined that the effort of this task would be to extend previous efforts with polymer matrix composite feedlines and demonstrate the feasibility of manufacturing large diameter feedlines with a complex shape and integral flanges, (i.e. all one piece with a 90 deg bend), and assess their performance under a cryogenic atmosphere.
Author

Polymer Matrix Composites; Feed Systems; Spacecraft Components; Leakage; Life (Durability); Engine Parts

20030059856

Energy Efficient Cryogenic Transfer Line with Magnetic Suspension

Shu, Quan-Sheng; Cheng, Guangfeng; Yu, Kun; Hull, John R.; Demko, Jonathan A.; Britcher, Colin P.; Fesmire, James E.; Augustynowicz, Stan D.; AIP Conference Proceedings; July 11, 2003; ISSN 0094-243X; Volume 671, no. 1; In English; HYDROGEN IN MATERIALS & VACUUM SYSTEMS: First International Workshop on Hydrogen in Materials and Vacuum Systems, 11-13 November 2002, Newport News, Virginia, USA
Contract(s)/Grant(s): NAS10-01063; Copyright

An energy efficient, cost effective cryogenic distribution system (up to several miles) has been identified as important for spaceport and in-space cryogenic systems. The conduction heat loss from the supports that connect the lines cold mass to the warm support structure is ultimately the most serious heat leak after thermal radiation has been minimized. The use of magnetic levitation by permanent magnets and high temperature superconductors provides support without mechanical contact and thus, the conduction part of the heat leak can be reduced to zero. A stop structure is carefully designed to hold the center tube when the system is warm. The novel design will provide the potential of extending many missions by saving cryogens,

or reducing the overall launch mass to accomplish a given mission. [copyright] 2003 American Institute of Physics
Author (AIP)
Cooling; Cost Effectiveness; Cryogenics; Flux Pinning; Heat Transfer; High Temperature Superconductors; Launching Bases; Magnetic Suspension; Permanent Magnets; Space Transportation

20030055150 NASA Kennedy Space Center, Cocoa Beach, FL, USA
STS-109/Columbia/HST Pre-Launch Activities/Launch On Orbit-Landing-Crew Egress
March 12, 2002; In English; 1 hr, with color and sound; No Copyright; Avail: CASI; V03, Videotape-VHS; B03, Videotape-Beta

The STS-109 Space Shuttle Mission begins with introduction of the seven crew members: Commander Scott D. Altman, pilot Duane G. Carey, payload commander John M. Grunsfeld, mission specialists: Nancy J. Currie, James H. Newman, Richard M. Linnehan, and Michael J. Massimino. Spacewalking NASA astronauts revive the Hubble Space Telescope's (HST) sightless infrared eyes, outfitting the observatory with an experimental refrigerator designed to resuscitate a comatose camera. During this video presentation John Grunsfeld and Rick Linnehan bolt the new cryogenic cooler inside HST and hung a huge radiator outside the observatory and replaces the telescope power switching station. In the video we can see how the shuttle robot arm operator, Nancy Currie, releases the 13-ton HST. Also, the landing of the Space Shuttle Columbia is presented.
CASI
Hubble Space Telescope; Maintenance; Cryogenic Cooling; Infrared Radiation; Cameras; Switching; Refrigerators

20030052770
Development of a gallium-doped germanium far-infrared photoconductor direct hybrid two-dimensional array
Fujiwara, Mikio; Hirao, Takanori; Kawada, Mitsunobu; Shibai, Hiroshi; Matsuura, Shuji; Kaneda, Hidehiro; Patrashin, Mikhail; Nakagawa, Takao; Applied Optics; April 20, 2003; ISSN 0003-6935; Volume 42, no. 12; In English; Copyright

To our knowledge, we are the first to successfully report a direct hybrid two-dimensional (2D) detector array in the far-infrared region. Gallium-doped germanium (Ge:Ga) has been used extensively to produce sensitive far-infrared detectors with a cutoff wavelength of [congruent with]110 [mu]m (2.7 THz). It is widely used in the fields of astronomy and molecular and solid spectroscopy. However, Ge:Ga photoconductors must be cooled below 4.2 K to reduce thermal noise, and this operating condition makes it difficult to develop a large format array because of the need for a warm amplifier. Development of Ge:Ga photoconductor arrays to take 2D terahertz images is now an important target in such research fields as space astronomy. We present the design of a 20 x 3 Ge:Ga far-infrared photoconductor array directly hybridized to a Si p-type metal-oxide-semiconductor readout integrated circuit using indium-bump technology. The main obstacles in creating this 2D array were (1) fabricating a monolithic Ge:Ga 2D array with a longitudinal configuration, (2) developing a cryogenic capacitive transimpedance amplifier, and (3) developing a technology for connecting the detector to the electronics. With this technology, a prototype Ge:Ga photoconductor with a direct hybrid structure has shown a responsivity as high as 14.6 A/W and a minimum detectable power of 5.6 x 10-17 W for an integration time of 0.14 s when it was cooled to 2.1 K. Its noise is limited by the readout circuit with 20 [mu]V/Hz1/2 at 1 Hz. Vibration and cooling tests demonstrated that this direct hybrid structure is strong enough for spaceborne instruments. This detector array will be installed on the Japanese infrared satellite ASTRO-F. [copyright] 2003 Optical Society of America
Author (AIP)
Doped Crystals; Gallium; Germanium; Infrared Detectors; Noise; Photoconductors; Radiation Detectors; Spectrum Analysis; Temperature

20030047459
Safety issues of space liquid-helium and solid-cryogen systems
Mason, Peter V.; AIP Conference Proceedings; May 10, 2002; ISSN 0094-243X; Volume 613, no. 1; In English, 16-20 July 2001, Madison, Wisconsin, USA; Copyright

Safety of hardware and personnel is a major concern in space programs. Space cryogenic systems are particularly prone to risk because of their complexity and because of the potential for overpressurization resulting from blockage of vent paths during the integration and test process. A number of space flight programs with liquid-helium and solid-cryogen systems have had incidents which resulted in risk or actual damage to flight hardware, or in risk to personnel. Since such incidents typically occur late in the development cycle, costs due to delays are extremely high. A second major of area of risk is the use of cooling loops in solid cryogen systems. When cooling is performed, the cryogen contracts and cryogen from warmer locations vaporizes and is deposited in the voids. This can lead to rupture of tankage and plumbing. Risk reduction measures include

two-fault tolerant design, systematic use of burst disks and relief valves, careful analysis of possible risks, detailed and well-reviewed procedures and redundancy of critical systems, such as valves and valve drive circuitry. We will discuss the design and operation of space cryogenics systems from a safety point of view. We will also describe a number of incidents, their causes, the corrective steps taken and lessons learned. [copyright] 2002 American Institute of Physics.
Author (AIP)
Cryogenics; Liquid Helium; Safety; Solid Cryogens; Space Programs

20030047438

Electronic components and systems for cryogenic space applications

Patterson, R. L.; Hammoud, A.; Dickman, J. E.; Gerber, S.; Elbuluk, M. E.; Overton, E.; AIP Conference Proceedings; May 10, 2002; ISSN 0094-243X; Volume 613, no. 1; In English; ADVANCES IN CRYOGENIC ENGINEERING: Proceedings of the Cryogenic Engineering Conference - CEC, 16-20 July 2001, Madison, Wisconsin, USA
Contract(s)/Grant(s): NAS3-00145; Copyright

Electronic components and systems capable of operation at cryogenic temperatures are anticipated in many future NASA space missions such as deep space probes and planetary surface exploration. For example, an unheated interplanetary probe launched to explore the rings of Saturn would reach an average temperature near Saturn of about -183 [deg]C. In addition to surviving the deep space harsh environment, electronics capable of low temperature operation would contribute to improving circuit performance, increasing system efficiency, and reducing payload development and launch costs. Terrestrial applications where components and systems must operate in low temperature environments include cryogenic instrumentation, superconducting magnetic energy storage, magnetic levitation transportation systems, and arctic exploration. An on-going R&D program at the NASA Glenn Research Center focuses on the development of reliable electronic devices and efficient power systems capable of surviving and operating in low temperature environments. An overview of the program will be presented in this paper. A description of the low temperature test facilities along with selected data obtained from in-house electronic component and small system testing will also be discussed. [copyright] 2002 American Institute of Physics.
Author (AIP)
Cryogenic Temperature; Cryogenics; Deep Space; Electronic Equipment Tests; Extraterrestrial Matter; NASA Space Programs; Planetary Surfaces; Space Probes; Superconducting Magnets; Technology Utilization

20030047436

Lightweight multilayer insulation to reduce the self-compression of insulation films

Ohmori, T.; Nakajima, M.; Yamamoto, A.; Takahashi, K.; AIP Conference Proceedings; May 10, 2002; ISSN 0094-243X; Volume 613, no. 1; In English; ADVANCES IN CRYOGENIC ENGINEERING: Proceedings of the Cryogenic Engineering Conference - CEC, 16-20 July 2001, Madison, Wisconsin, USA; Copyright

Heat transfer through the multi-layer insulation (MLI) is governed by the thermal radiation and by the contact heat transfer between the adjacent insulation films at good vacuum condition. If the MLI is well fabricated on a horizontally supported cylindrical cold body to avoid the excess tension in the film, contact pressure between the films is caused by the weight of the MLI itself. Thermal performance of the MLI that does not employ spacer material between the aluminized polyester films has been evaluated experimentally in a guarded cylindrical calorimeter. The experimental condition of the contact pressure is in the range of the MLI that is fabricated in the horizontal cryostat. The test results show that the thermal performance of the MLI is well affected by the contact pressure. Then the thickness of the polyester film is decreased from 12 to 6 micrometer in order to reduce the weight of the MLI. The experimental results show better insulation performance of the MLI that employs the 6-micrometer polyester film. [copyright] 2002 American Institute of Physics.
Author (AIP)
Calorimeters; Compressibility; Cryogenics; Heat Transfer; Multilayer Insulation; Radiative Heat Transfer; Thermal Insulation; Thermal Radiation

20030047435

Analytical modeling of variable density multilayer insulation for cryogenic storage

Hedayat, A.; Hastings, L. J.; Brown, T.; AIP Conference Proceedings; May 10, 2002; ISSN 0094-243X; Volume 613, no. 1; In English; ADVANCES IN CRYOGENIC ENGINEERING: Proceedings of the Cryogenic Engineering Conference - CEC, 16-20 July 2001, Madison, Wisconsin, USA; Copyright

A unique foam/Multilayer Insulation (MLI) combination concept for orbital cryogenic storage was experimentally evaluated at NASA Marshall Space Flight Center (MSFC) using the Multipurpose Hydrogen Test Bed (MHTB). The MLI was

designed for an on-orbit storage period of 45 days and included several unique features such as: a variable layer density and larger but fewer perforations for venting during ascent to orbit. Test results with liquid hydrogen indicated that for similar performance, variable density MLI weight or heat leak is reduced by about half in comparison with standard MLI. The focus of this paper is on analytical modeling of the Variable Density MLI (VD-MLI) on-orbit performance (i.e. vacuum/low pressure environment). The foam/VD-MLI combination model is considered to have five segments. The first segment represents the optional foam layer. The second, third, and fourth segments represent three MLI segments with different layer densities. The last segment is considered to be an environmental boundary or shroud that surrounds the last MLI layer. Two approaches are considered. In the first approach, the variable density MLI is modeled layer by layer while in the second approach, a semi-empirical model is applied. Both models account for thermal radiation between shields, gas conduction, and solid conduction through the layer separator materials. [copyright] 2002 American Institute of Physics.
Author (AIP)
Cryogenics; Foams; Hydrogen; Mathematical Models; Models; Multilayer Insulation; Tests; Thermal Insulation

20030047434

Thermal conductivity measurements of aerogel-impregnated shuttle tile at cryogenic temperatures

Helvensteijn, B. P. M.; Maddocks, J. R.; Salerno, L. J.; Roach, P. R.; Kittel, P.; White, S. M.; AIP Conference Proceedings; May 10, 2002; ISSN 0094-243X; Volume 613, no. 1; In English; ADVANCES IN CRYOGENIC ENGINEERING: Proceedings of the Cryogenic Engineering Conference - CEC, 16-20 July 2001, Madison, Wisconsin, USA; Copyright

New materials are being designed to allow the implementation of innovative concepts in future space transportation vehicles. In present day spacecraft, launch vehicles consist of an overall structure in which the cryogenic propellant tanks are mounted in a framework covered by an aeroshell. In NASA s next generation space transportation vehicles the innovative concept of conformal propellant tanks will be utilized. In addition to containing the propellants the cryogen tanks will serve as part of the main vehicle structure. This concept enables significant reduction in launch mass. Crucial to this approach will be the development of a material that will serve not only as cryogenic insulation on the launchpad and early in flight, but also as a thermal protection system (TPS), protecting the vehicle on re-entry. Prior to selection for this challenging application various material properties are to be assessed. The present paper discusses experimental results on the thermal conductivity of a preliminary candidate material (an aerogel-impregnated shuttle tile) in the presence of helium gas. Data have been taken at room temperature and near 80 K at pressures ranging from 1 atm down to 20 m Torr. The capability to extend the tests down to lower temperatures (4 K) was not utilized considering the noted adsorptive qualities of the open cell structure of the tile. [copyright] 2002 American Institute of Physics.
Author (AIP)
Aerogels; Cryogenic Temperature; Cryogenics; Space Transportation; Thermal Conductivity; Thermal Insulation

20030047421

Quick cooling and filling through a single port for cryogenic transfer operations

Jones, J. R.; Fesmire, J. E.; AIP Conference Proceedings; May 10, 2002; ISSN 0094-243X; Volume 613, no. 1; In English, 16-20 July 2001, Madison, Wisconsin, USA; Copyright

Improved technology for the efficient transfer of cryogens is needed for future on-orbit fueling and remote Lunar/Mars operations. The cooling and filling of a liquid nitrogen (LN(sub 2)) test vessel through a single port were investigated in a series of experiments. A new ‘in-space’ transfer tube design concept was used to demonstrate the ability to quickly cool and load cryogens through a single feed-through connection. Three different fill tube configurations with three different diameters were tested. The tubes providing the quickest cooldown time and the quickest fill time for the test article tank were determined. The results demonstrated a clear trade-off between cooling time and filling time for the optimum tube design. This experimental study is intended to improve technology for future flight tank designs by reducing fill system size, complexity, heat leak rate, and operations time. These results may be applied to Space Shuttle Power Reactant Storage and Distribution (PRSD) System upgrades and other future applications. Further study and experimental analysis for optimization of the fill tube design are in progress. [copyright] 2002 American Institute of Physics.
Author (AIP)
Cooling; Cryogenic Fluids; Cryogenics; Mars (Planet); Remote Sensing; Spacecraft

20030047405

Sloshing of superfluid helium in a viscous damping matrix

Snyder, H. A.; AIP Conference Proceedings; May 10, 2002; ISSN 0094-243X; Volume 613, no. 1; In English, 16-20 July 2001,

Madison, Wisconsin, USA; Copyright

Operational problems may result from sloshing of liquid cryogens on space missions. Sloshing limits the pointing accuracy of spacecraft and the acceleration level of low-g experiments. The resonant frequencies of sloshing in space are low due to the small specific surface tension of cryogens. Cryogens also have small kinematic viscosity. Low frequencies and small viscous forces can result in large sloshing amplitudes at resonance. When a reduction of sloshing will improve a design, two methods are used: baffles and metal or plastic foam. This research presents an analysis of surface waves in a viscous damping matrix such as foam. When viscous forces are included in an analysis of surface waves, the dynamic interaction of the liquid with the gas is important in determining the damping. The velocity fields of the gas and liquid are solved and made compatible with appropriate boundary conditions. For an ordinary fluid, the temperature is constant. For HeII the temperature is a significant variable. Temperature oscillations cause evaporation/condensation at the gas-liquid interface and lead to very complicated boundary conditions. [copyright] 2002 American Institute of Physics.

Author (AIP)

Compressors; Cooling; Cryogenic Fluids; Cryogenics; Helium Isotopes; Liquid Helium; Liquid Helium 2; Liquid Sloshing; Operational Problems; Space Missions; Spacecraft; Superfluidity; Thermodynamic Properties; Viscosity; Viscous Damping

20030047401

Modeling and test data analysis of a tank rapid chill and fill system for the Advanced Shuttle Upper Stage (ASUS) concept

Flachbart, Robin H.; Hedayat, Ali; Holt, Kimberly A.; AIP Conference Proceedings; May 10, 2002; ISSN 0094-243X; Volume 613, no. 1; In English; ADVANCES IN CRYOGENIC ENGINEERING: Proceedings of the Cryogenic Engineering Conference - CEC, 16-20 July 2001, Madison, Wisconsin, USA; Copyright

The Advanced Shuttle Upper Stage (ASUS) concept addresses safety concerns associated with cryogenic stages by launching empty, and filling on ascent. The ASUS employs a rapid chill and fill concept, where a spray bar is used to completely chill the tank before fill. Thus the vent valve can be closed during the fill process. The first tests of this concept, using a flight size (not flight weight) tank, were conducted at Marshall Space Flight Center (MSFC) during the summer of 2000. The objectives of the testing were to: 1. Demonstrate that a flight size tank could be filled in roughly 5 minutes to accommodate the shuttle ascent window, 2. Demonstrate a no-vent fill of the tank, and 3. Gather data to validate analytical models. A total of fourteen tests were conducted. Models of the test facility fill and vent systems, as well as the tank, were constructed. The objective of achieving tank fill in 5 minutes was met during the test series. However, liquid began to accumulate in the tank before it was chilled. Since the tank was not chilled until the end of each test, vent valve closure during fill was not possible. Even though the chill and fill process did not occur as expected, reasonable model correlation with the test data was achieved. [copyright] 2002 American Institute of Physics.

Author (AIP)

Cooling; Cryogenics; Data Processing; Heat Transfer; Models; Safety; Spacecraft

20030047400

Large scale demonstration of liquid hydrogen storage with zero boiloff

Hedayat, A.; Hastings, L. J.; Bryant, C.; Plachta, D. W.; AIP Conference Proceedings; May 10, 2002; ISSN 0094-243X; Volume 613, no. 1; In English; ADVANCES IN CRYOGENIC ENGINEERING: Proceedings of the Cryogenic Engineering Conference - CEC, 16-20 July 2001, Madison, Wisconsin, USA; Copyright

Cryocooler and passive insulation technology advances have substantially improved prospects for zero boiloff (ZBO) cryogenic storage. Therefore, a cooperative effort by NASA's Ames Research Center, Glenn Research Center, and Marshall Space Flight Center (MSFC) has been implemented to develop ZBO concepts for in-space cryogenic storage. Described herein is one program element, a large-scale ZBO demonstration using the MSFC Multipurpose Hydrogen Test Bed (MHTB). A commercial cryocooler is interfaced with the existing MHTB spray-bar mixer and insulation system in a manner that enables a balance between incoming and extracted thermal energy. The testing is scheduled for the summer of 2001. In this paper the test objectives, test set-up, and test procedures are presented. [copyright] 2002 American Institute of Physics.

Author (AIP)

Compressors; Cooling; Cryogenic Cooling; Cryogenics; Hydrogen; Infrared Detectors; Liquid Hydrogen; Refrigerators; Spacecraft

20030047398

Performance, reliability and life issues for components of the Planck sorption cooler

Bowman, R. C., Jr.; Prina, M.; Schmelzel, M. E.; Lindensmith, C. A.; Barber, D. S.; Bhandari, P.; Loc, A.; Morgante, G.; AIP Conference Proceedings; May 10, 2002; ISSN 0094-243X; Volume 613, no. 1; In English; ADVANCES IN CRYOGENIC

ENGINEERING: Proceedings of the Cryogenic Engineering Conference - CEC, 16-20 July 2001, Madison, Wisconsin, USA; Copyright

Continuous-duty hydrogen sorption cryocoolers are being developed for the European Space Agency (ESA) Planck mission. To achieve an acceptable level of performance and robust operation with these hydride refrigerators during flight, detailed investigations have been performed on the sorbent materials and on critical hardware components. The sorbent longevity has been verified for both the compressor alloy and the gas gap actuator alloy. Check valves that isolate the high- and low-pressure sides within the sorption compressor are potential single-point failures as internal leaks would short circuit hydrogen flow to the Joule-Thomson (J-T) expander. Check valves were operated using hydrogen gas for over 43,000 pressure cycles at various orientations and temperatures without leaks or other changes. The filters that will be used to protect check valves and J-T expander from particles were tested. The temperature gradients along the tubular heater elements for the compressor beds were evaluated to assess their impact on the dynamics of compressor element heating and hydrogen desorption. The durability and reliability of low-power heaters used for the gas gap actuators were determined by accelerated temperature cycling. [copyright] 2002 American Institute of Physics.

Author (AIP)

Adsorption; Compressors; Cooling; Cryogenic Cooling; Cryogenics; European Space Agency; Hydrogen; Joule-Thomson Effect; Metal Surfaces; Refrigerators; Space Missions

20030047397

A cryogenic platform for space-borne instruments with nanoKelvin stability

Holmes, W.; Bamford, R.; Chui, T. C. P.; Craig, J.; Elliott, S.; Galloway, S.; Gannon, J.; Park, S.; Rentz, P.; Thomassen, J.; AIP Conference Proceedings; May 10, 2002; ISSN 0094-243X; Volume 613, no. 1; In English; ADVANCES IN CRYOGENIC ENGINEERING: Proceedings of the Cryogenic Engineering Conference - CEC, 16-20 July 2001, Madison, Wisconsin, USA; Copyright

We describe the design and test of a modular probe structure to allow nK control of \h8 kg space borne instruments operated at liquid helium temperatures for the Low Temperature Microgravity Physics Program. The probe consists of a 25.4 cm diameter plate on which is attached a 24.8 cm high 3-stage truss. This assembly is inserted into an evacuated instrument space in a liquid helium cryostat. Germanium resistance thermometers with standard voltage readout and heater servo are used to control stages 1 and 2, the closest to the plate, to [mu]K stability. Paramagnetic thermometers with DC SQUID readouts are used to control stage 3 to \h1 nK. A room temperature random vibration test at 7.7 g(sub rms) verified that the probe supports a 6.2 kg mock instrument mounted on stage 3 under launch load for the Japanese HII-A rocket or the shuttle. The measured lateral stiffness is 1.8 MegaN/m. Thermal tests at T\h7 K show that for helium bath temperature drifts \h0.1 K, stage 3 can be maintained within 1 nK of a set temperature. [copyright] 2002 American Institute of Physics.

Author (AIP)

Compressors; Cooling; Cryogenics; Gravitation; Liquid Helium; Low Temperature Physics; Models; Refrigerators; Resistance Thermometers; Satellite-Borne Instruments; Space Temperature; Spacecraft; Squid (Detectors)

20030047396

Operational cryogenic experience with the Gravity Probe B payload

Taber, M. A.; Murray, D. O.; Maddocks, J. R.; Burns, K. M.; AIP Conference Proceedings; May 10, 2002; ISSN 0094-243X; Volume 613, no. 1; In English; ADVANCES IN CRYOGENIC ENGINEERING: Proceedings of the Cryogenic Engineering Conference - CEC, 16-20 July 2001, Madison, Wisconsin, USA

Contract(s)/Grant(s): NAS-8-39225; Copyright

The Gravity Probe B Relativity Mission is a satellite-based experimental test of two predictions of Einstein's General Theory of Relativity. The experimental design makes substantial use of cryogenic technology. The flight payload, which includes the dewar, the cryostat probe, and the science instrument, is now in final test in preparation for integration with the spacecraft. We review the unique aspects of the cryogenic subsystem and discuss the implications they have for cryogenic operations. We also review cryogenic performance of the payload and compare it to thermal model predictions. [copyright] 2002 American Institute of Physics.

Author (AIP)

Cooling; Cryogenics; Gravitation Theory; Gravity Probe B; Refrigerators; Relativity; Spacecraft

20030047394

Low-power, zero-vibration 5 K sorption coolers for astrophysics instruments

Wade, L. A.; Lindensmith, C. A.; AIP Conference Proceedings; May 10, 2002; ISSN 0094-243X; Volume 613, no. 1; In English; ADVANCES IN CRYOGENIC ENGINEERING: Proceedings of the Cryogenic Engineering Conference - CEC,

16-20 July 2001, Madison, Wisconsin, USA; Copyright

Many space missions now in development in Europe (e.g., Planck, Darwin) and the USA (e.g., SIRTF, NGST, TPF) will fly in orbits which enable passive cooling to \h50 K. In such an environment it is possible to greatly reduce the cooling requirements of cryogenic instruments such as infrared cameras. Missions such as SIRTF serve as proof that such a strategy can be successfully implemented to hugely reduce the spacecraft resources required for instrument cooling. Three novel sorption cooler concepts are described in this paper. These coolers derive maximum benefit from passive radiative precooling. All coolers considered herein are sized to provide 2 mW of net refrigeration at 5 K and 10 mW at 16.5 K. The concept designs, performance modeling and the development status of these coolers are described. [copyright] 2002 American Institute of Physics.

Author (AIP)

Adsorption; Artificial Satellites; Cooling; Cryogenics; Infrared Detectors; Metal Surfaces; Refrigerators; Space Missions; Spaceborne Telescopes; Spacecraft; Telescopes

20030047386

Optimization of cold head for miniature Stirling cryocooler

Agrawal, H. K.; Narayankhedkar, K. G.; AIP Conference Proceedings; May 10, 2002; ISSN 0094-243X; Volume 613, no. 1; In English; ADVANCES IN CRYOGENIC ENGINEERING: Proceedings of the Cryogenic Engineering Conference - CEC, 16-20 July 2001, Madison, Wisconsin, USA; Copyright

Small capacity Stirling cryocoolers for space-borne applications generally use linear electromagnetic drives (also called linear motors) for long life, maintenance free operation and high reliability. Such motors are normally of moving coil type. The performance prediction of such miniature Stirling cryocoolers is very critical and is governed by principal design parameters. The performance of a cryocooler depends on various losses such as loss due to regenerator ineffectiveness, temperature swing loss, shuttle conduction loss, P-V loss, etc. In this paper, the optimization of a cold head for a given opposed piston compressor has been carried out considering above losses using cyclic simulation and with COP and refrigerating effect as optimization parameters for a cold head temperature of 70 K. [copyright] 2002 American Institute of Physics.

Author (AIP)

Compressors; Cooling; Cryogenic Cooling; Cryogenics; Electric Motors; Refrigerators; Spacecraft; Stirling Cycle

20030047384

Technical diagnostics of linear split Stirling cryocooler through the analysis of self-induced forces

Riabzev, S. V.; Veprik, A. M.; Pundak, N.; AIP Conference Proceedings; May 10, 2002; ISSN 0094-243X; Volume 613, no. 1; In English; ADVANCES IN CRYOGENIC ENGINEERING: Proceedings of the Cryogenic Engineering Conference - CEC, 16-20 July 2001, Madison, Wisconsin, USA; Copyright

The effective operation of a linear split Stirling cryogenic cooler with pneumatically driven expander relies primarily on the matched sinusoidal motion of the compressor piston and displacer. The measurement of magnitudes and relative phase shift is required not only at cryocooler development and refinement, but also throughout the manufacturing process for the purposes of on-line diagnostics. Presently practiced methods of motion measurement are based on using different sensors, which are typically mounted directly on the moving parts inside the hermetic gas space. The technical problems associated with the application of these methods are evident. The authors present a novel approach to the indirect measurement of the motion of the internal components of the linear split Stirling cryocoolers through the measurement of their self-induced forces. This approach is based on the simple fact that self-induced forces developed both by the linear compressor and expander are proportional to the accelerations of corresponding moving parts. The authors describe the experimental test apparatus comprising a multiaxial piezoceramic dynamometer and data acquisition system. The test apparatus is successfully used at RICOR’s R&D Department and in the manufacturing line as a part of the diagnostic system. [copyright] 2002 American Institute of Physics.

Author (AIP)

Compressors; Cooling; Cryogenic Cooling; Cryogenics; Dynamometers; Heat Exchangers; Sine Waves; Spacecraft; Stirling Cycle

20030047376

High efficiency cryocooler

Tward, E.; Chan, C. K.; Colbert, R.; Jaco, C.; Nguyen, T.; Orsini, R.; Raab, J.; AIP Conference Proceedings; May 10, 2002; ISSN 0094-243X; Volume 613, no. 1; In English; ADVANCES IN CRYOGENIC ENGINEERING: Proceedings of the

Cryogenic Engineering Conference - CEC, 16-20 July 2001, Madison, Wisconsin, USA; Copyright

The High Efficiency Cryocooler (HEC) is a highly reliable, \g10 year life, space cryocooler. Design goals included very high capacity with low mass. The HEC achieved its 10 W at 95 K load while rejecting to 300 K with considerable margin and a flight configured mass of 4 Kg. This flight cooler design is being fabricated for a number of payloads. This paper describes the cooler, its measured performance, and its flight qualification. [copyright] 2002 American Institute of Physics.

Author (AIP)

Compressors; Cooling; Cryogenic Cooling; Cryogenics; Refrigerators; Spacecraft

20030047374

A low temperature turbo-Brayton cryocooler for space applications

Swift, W. L.; McCormick, J. A.; Zagarola, M. V.; AIP Conference Proceedings; May 10, 2002; ISSN 0094-243X; Volume 613, no. 1; In English; ADVANCES IN CRYOGENIC ENGINEERING: Proceedings of the Cryogenic Engineering Conference - CEC, 16-20 July 2001, Madison, Wisconsin, USA; Copyright

Large, advanced space telescopes are being planned by NASA to extend the exploration of the universe into far infrared and X-ray wavelengths. The detectors for these telescopes will require active, long-life, vibration free refrigeration at temperatures of 10 K and below. Smaller, more efficient, lower temperature mechanical cryocoolers will be needed to support these missions. Technology is being developed to reduce the size and power for turbo-Brayton cryocoolers in order to address the unique requirements of these advanced instruments. Key features in a turbo-Brayton cooler include miniature, gas-bearing turbomachines and very high effectiveness heat exchangers. At reduced temperatures, these components must incorporate increasingly smaller geometric features in order to achieve the needed levels of efficiency. Developmental plans include radical reductions in the sizes of some of these machines, the development of a miniature cryogenic compressor, and interfacing a turbo-Brayton cooler with lower temperature cooling stages to achieve temperatures in the millikelvin range. This paper discusses several system arrangements that are being considered to address these new applications. Key cryocooler developments will be described, and the results from recent tests will be presented. [copyright] 2002 American Institute of Physics.

Author (AIP)

Brayton Cycle; Cooling; Cryogenic Cooling; Cryogenics; Far Infrared Radiation; Hubble Space Telescope; Infrared Detectors; Infrared Spectra; Low Temperature; Spaceborne Telescopes; Spacecraft; Technology Utilization; Telescopes; X Rays

20030047373

TES cryocooler system design and development

Collins, S. A.; Rodriguez, J. I.; Ross, R. G., Jr.; AIP Conference Proceedings; May 10, 2002; ISSN 0094-243X; Volume 613, no. 1; In English; ADVANCES IN CRYOGENIC ENGINEERING: Proceedings of the Cryogenic Engineering Conference - CEC, 16-20 July 2001, Madison, Wisconsin, USA; Copyright

JPL’s Tropospheric Emission Spectrometer (TES) instrument is typical of recent NASA cryogenic instruments that take advantage of mechanical cryocoolers to enable the acquisition of important science data using cryogenic focal plane arrays. TES is a high-resolution infrared imaging Fourier transform spectrometer with spectral coverage of 3.2 to 15.4 microns and is under development at JPL for flight on NASA’s EOS-Aura spacecraft in the 2003 timeframe. The instrument contains four focal plane arrays in two separate housings that are cooled to 65 K by a pair of TRW pulse tube cryocoolers. The instrument also includes a two-stage passive radiator to cool the optical bench to 180 K. The cryocooler system design is tightly coupled with the overall thermal control design to maximize performance of the TES instrument. This paper describes the cryogenic system design including the cryogenic loads, thermal performance margins, and performance properties for the cryocoolers. Test results are presented from recent integration activities that focused on the critical interface between the cryocoolers and the focal plane subsystem. [copyright] 2002 American Institute of Physics.

Author (AIP)

Cryogenic Cooling; Cryogenics; Focal Plane Devices; Infrared Spectrometers; Refrigerators; Spacecraft; Systems Engineering; Troposphere

20030047372

The Ball 12 K Stirling cryocooler

Gully, W. J.; Glaister, D.; AIP Conference Proceedings; May 10, 2002; ISSN 0094-243X; Volume 613, no. 1; In English, 16-20 July 2001, Madison, Wisconsin, USA

Contract(s)/Grant(s): NAS-5 99239; Copyright

At Ball we have been making progress towards the creation of a 12 K Space Stirling mechanical cryocooler. We describe our work in which we modified a 35 K cooler for use at lower temperatures. With this hardware we have attained temperatures below 14 K, and can provide 100 mW of cooling capacity at 16 K for less than 80 watts of input power. As part of our development effort we have measured the thermal regenerator loss associated with different versions of our key low temperature regenerator and report our findings. Our work extends the two stage Stirling investigations of Bradshaw [et al.] [1], and contrasts with the low frequency low temperature GM pulse tube work of Satoh [et al.] [2]. [copyright] 2002 American Institute of Physics.

Author (AIP)

Cooling; Cryogenic Cooling; Cryogenics; Rare Earth Compounds; Refrigerators; Spacecraft; Stirling Cycle

20030047369

High temperature superconducting magnetic refrigeration

Blumenfeld, P. E.; Prenger, F. C.; Sternberg, A.; Zimm, C.; AIP Conference Proceedings; May 10, 2002; ISSN 0094-243X; Volume 613, no. 1; In English; ADVANCES IN CRYOGENIC ENGINEERING: Proceedings of the Cryogenic Engineering Conference - CEC, 16-20 July 2001, Madison, Wisconsin, USA; Copyright

A near-room temperature active magnetic regenerative refrigerator (AMRR) was designed and built using a high-temperature superconducting (HTS) magnet in a charge-discharge cycle and a gadolinium-packed regenerative bed as the magnetocaloric component. Current to the HTS magnet was ramped periodically from zero to 100 amperes, which generated a ramp in field strength from zero to 1.7 tesla. Water was moved periodically through the bed and through hot and cold heat exchangers to accomplish a continuous refrigeration cycle. Cycle periods as short as 30 seconds were realized. Refrigerator performance was measured in terms of cooling capacity as a function of temperature span and in terms of efficiency expressed as a percentage of maximum obtainable (Carnot) efficiency. A three-watt cooling capacity was measured over a temperature span of 15 degrees C between hot and cold end temperatures of 25 degrees C and 10 degrees C. This experiment is directed to two possible applications for magnetic refrigeration: a no-moving part cryogenic refrigerator for space applications, and a compact permanent magnet refrigerator for commercial and consumer applications. [copyright] 2002 American Institute of Physics.

Author (AIP)

Cryogenics; Heat Exchangers; High Temperature; High Temperature Superconductors; Magnetic Cooling; Magnetic Properties; Refrigerators; Room Temperature; Superconducting Magnets

20030047329

Flexure bearing cryocoolers at Thales Cryogenics

Meijers, M.; Benschop, A. A. J.; Mullie, J. C.; AIP Conference Proceedings; May 10, 2002; ISSN 0094-243X; Volume 613, no. 1; In English; ADVANCES IN CRYOGENIC ENGINEERING: Proceedings of the Cryogenic Engineering Conference - CEC, 16-20 July 2001, Madison, Wisconsin, USA; Copyright

Thales Cryogenics (NL) and Thales Cryogenie (F), formerly known as Signal Usfa and Cryotechnologies, closely co-operate in the field of production and development of linear and rotary cryocoolers. Over the past years, Thales Cryogenics has developed a complete range of Stirling cryocoolers with flexure bearings. In this paper the main design features of the flexure bearing compressor are explained. With these flexure bearing cryocoolers, which are available in slip-on configuration as well as IDCA (Integrated Detector Cooler Assembly), up to 6 W @80 K cooling power can be obtained. Also a pulse tube cryocooler with a specified cooling power of 500 mW @80 K has been developed. Two specific production machines have been developed and introduced in the production line. With this equipment Thales Cryogenics has been able to further improve the quality and reproducibility of its coolers. Up to now, several flexure bearing cryocoolers have been built and integrated in various new commercial and military applications requiring long life cryocoolers. Besides this, Thales Cryogenics is active in several space applications in co-operation with Air Liquide/DTA. [copyright] 2002 American Institute of Physics.

Author (AIP)

Compressors; Cryogenic Cooling; Cryogenics; Cryostats; Magnetic Bearings; Refrigerators; Superconducting Magnets

20030046964

ELISA: A small balloon Experiment for a Large Scale Survey in the Sub-millimeter

Bernard, J.-Ph.; Ristorcelli, I.; Stepnik, B.; Abergel, A.; Boulanger, F.; Giard, M.; Lagache, G.; Lamarre, J. M.; Meny, C.; Torre, J. P.; AIP Conference Proceedings; March 27, 2002; ISSN 0094-243X; Volume 609, no. 1; In English; ASTROPHYSICAL POLARIZED BACKGROUNDS: Workshop on Astrophysical Polarized Backgrounds, 9-12 October

2001, Bologna, Italy; Copyright

This paper presents the technical aspects and scientific objectives of the balloon-borne Experiment for Large Infrared Survey Astronomy (ELISA). The emphasis is put upon the synergies existing between the ELISA project and future space missions, both with respect to technical and scientific aspects. ELISA is a small balloon project for an experiment dedicated to measure the Far-Infrared to Sub-millimeter continuum emission of dust over a large fraction of the sky, with unprecedented sensitivity and angular resolution. The primary mirror of the telescope, similar to the one used for the Top-Hat mission, will have a diameter of 1 m, ensuring an angular resolution of about 3. 5(sup ‘). PACS-type bolometer arrays will be used in four photometric bands centered at 170, 240, 400, and 650 [mu]m and providing a 22(sup ‘) x45(sup ‘) instantaneous field of view per channel. A liquid He cryostat will host the cold optics, including the secondary mirror of the telescope, as well as the detectors, which will be cooled to 0.3 K using an He3 close-cycle fridge. Mapping of the sky will be accomplished by rotating the gondola over a large azimuth range (up to 60 degree amplitude). The pointing of the experiment will be maintained to a constant elevation during the azimuth scans through a feed back loop using the signal from a large format, fast stellar sensor, operating day and night. The scientific goal of the experiment is to map the diffuse Sub-millimeter emission along a large fraction of the Milky Way. The astronomical data obtained will be used to derive the emission properties of the dust grains in the Interstellar Medium (ISM), such as their temperature and emissivity. It will also allow to systematically measure the polarization of the dust emission. It should also lead to the detection of a few thousand point sources such as newly formed stars and distant galaxies. In addition to these goals, the ELISA project will serve as a test bed for the detector technology that will be used for the HERSCHEL and the PLANCK space missions to be launched in 2007. The ELISA data will also be usable to help calibrate the observations of HERSCHEL and PLANCK and to plan the large-scale surveys to be undertaken with HERSCHEL. Owing to these objectives, 3 flights of the ELISA experiment, including one from Southern hemisphere, are foreseen in the period from 2004 to 2006. The ELISA project is carried out by an international collaboration including France (CESR, IAS, CEA, CNES), Netherlands (SSD/ESTEC), Denmark (DSRI), England (QMW), USA (JPL/Caltech), Italy (ASI). [copyright] 2002 American Institute of Physics.

Author (AIP)

Astrophysics; Balloons; Cosmic Dust; Galaxies; Infrared Astronomy; Interstellar Matter; Polarization; Radio Astronomy; Submillimeter Waves; Surveys

20030046941

The advanced technology development center (ATDC)

Clements, Gregory R.; AIP Conference Proceedings; January 14, 2002; ISSN 0094-243X; Volume 608, no. 1; In English, 3-6 Feb 2002, Albuquerque, New Mexico, USA; Copyright

NASA is building the Advanced Technology Development Center (ATDC) to provide a ‘national resource’ for the research, development, demonstration, testing, and qualification of Spaceport and Range Technologies. The ATDC will be located at Space Launch Complex 20 (SLC-20) at Cape Canaveral Air Force Station (CCAFS) in Florida. SLC-20 currently provides a processing and launch capability for small-scale rockets: this capability will be augmented with additional ATDC facilities to provide a comprehensive and integrated in situ environment. Examples of Spaceport Technologies that will be supported by ATDC infrastructure include densified cryogenic systems, intelligent automated umbilicals, integrated vehicle health management systems, next-generation safety systems, and advanced range systems. The ATDC can be thought of as a prototype spaceport where industry, government, and academia, in partnership, can work together to improve safety of future space initiatives. The ATDC is being deployed in five separate phases. Major ATDC facilities will include a Liquid Oxygen Area (Phase 1); a Liquid Hydrogen Area, a Liquid Nitrogen Area, and a multipurpose Launch Mount (Phase 2); ‘Iron Rocket’ Test Demonstrator (Phase 3); a Processing Facility with a Checkout and Control System (Phase 4); and Future Infrastructure Developments (Phase 5). Initial ATDC development will be completed in 2006. [copyright] 2002 American Institute of Physics.

Author (AIP)

Aerospace Industry; Launching Bases; Research and Development; Research Management; Rockets; Safety; Space Transportation; Spacecraft; Test Facilities

20030046936

Potential use of high temperature superconductors in satellite power transmission and distribution systems

Powell, James; Paniagua, John; Maise, George; AIP Conference Proceedings; January 14, 2002; ISSN 0094-243X; Volume 608, no. 1; In English; SPACE TECHNOLOGY and APPLICATIONS INTERNATIONAL FORUM- STAIF 2002, 3-6 Feb 2002, Albuquerque, New Mexico, USA; Copyright

In Space Solar Power Satellites (SSP), gigawatts of electrical power would be collected from 100’s of thousands of m2

of solar panels, carried by multi-kilometer long transmission lines, distributed for distances of 100’s of meters over a microwave transmitter, and beamed down to Earth. SSP’s using conventional conductor transmission/-distribution (T/D) systems must operate at high voltages ([approx]100 kilovolts) and require heavy power conversion equipment to match the high voltage T/D system to the low voltage (e.g., 100’s of volts DC) solar panels and microwave transmitter. In contrast, superconducting (SC) T/D systems operate at low voltages and high DC currents, eliminating the heavy power conversion units. Moreover, they can operate with many massively parallel independent circuits, enabling greater reliability and reducing the risk of failure. A T/D system for the Sun Tower SSP that uses existing superconducting and cryogenic technology is described. Low voltage ([approx]100 volts) DC power is collected and conveyed over several hundred parallel circuits to the microwave transmitter. The SC T/D system utilizes high temperature superconductors (HTS) for power distribution on the solar panels and the microwave transmitter, and low temperature superconductors (LTS) for power transmission from the panels to the transmitter. While HTS power lines are attractive because they would operate at a temperature of [approx]70 K, their current density (A/cm2) is too low by a factor of 10 to meet weight goals for the long transmission distance (e.g., [approx]5 kilometers) in Sun Tower. Instead, the transmission lines use LTS superconductors (Nb(sub 3)Al or Nb(sub 3)Sn) at 6 K, which operate at a current densities than HTS conductor. Insulation and refrigeration for the T/D lines is simpler than on Earth, due to the absence of an atmosphere. With a 70 K thermal radiation shield, the thermal refrigeration load is only a few watts for a 5 Km long transmission line at 6 K. [copyright] 2002 American Institute of Physics.
Author (AIP)
Artificial Satellites; Critical Current; Cryogenics; Current Density; Electric Generators; Electronic Equipment; High Current; High Temperature Superconductors; Microwave Power Beaming; Refrigerating; Satellite Power Transmission; Solar Cells; Solar Energy Conversion; Solar Power Satellites; Superconductivity; Transmission Lines

20030046915

Outgassing and vaporization considerations in milliwatt generators designed for 20-year missions

Hiller, Nathan; Allen, Daniel; Elsner, Norbert; Bass, J. C.; Moore, J. Peyton; AIP Conference Proceedings; January 14, 2002; ISSN 0094-243X; Volume 608, no. 1; In English; SPACE TECHNOLOGY and APPLICATIONS INTERNATIONAL FORUM- STAIF 2002, 3-6 Feb 2002, Albuquerque, New Mexico, USA; Copyright

Ongoing experimental work and theoretical models indicate that milliwatt thermoelectric generators that operate in a sealed-off vacuum environment will be useful for long-term operation, such as the PASCAL 20 year Mars mission and the CryoScout mission. Considerations for long-term operation include out gassing of the multifoil vacuum insulation before pinch off and vaporization of the (Bi, Sb)(sub 2)(Se, Te)(sub 3) thermoelectric materials during long-term operation. Tests underway indicate the multi-foil insulation can be pre-outgassed before assembly so further outgassing in the sealed generator is minimized. Experimental data and vaporization models for a Th of 250 [deg]C thus far indicate that the small amount of vaporization of materials used in the thermoelectric module do not significantly effect the generator vacuum or the module power output. These tests and models indicate that both potential modes of degradation can be controlled and minimized. Although performance data on the generator materials only extend for several hundred hours, the good performances in a limited time, combined with an understanding of the materials behavior, indicate that milliwatt generator holds promise for providing sufficient and reliable power for space missions lasting up to 20 years. [copyright] 2002 American Institute of Physics.
Author (AIP)
Electric Generators; Insulation; Mars Missions; Mathematical Models; Outgassing; Pascal (Programming Language); Thermoelectric Generators; Thermoelectric Power Generation; Thermoelectricity; Vacuum; Vaporizing

20030046852

Development and design of a zero-G liquid quantity gauge for a solar thermal vehicle

Dodge, Franklin T.; Green, Steven T.; Petullo, Steven P.; Van Dresar, Neil T.; AIP Conference Proceedings; January 14, 2002; ISSN 0094-243X; Volume 608, no. 1; In English; SPACE TECHNOLOGY and APPLICATIONS INTERNATIONAL FORUM- STAIF 2002, 3-6 Feb 2002, Albuquerque, New Mexico, USA; Copyright

The development and design of a cryogenic liquid quantity gauge for zero-g applications is described. The gauge, named the Compression Mass Gauge (CMG), operates on the principle of slightly changing the volume of the tank by an oscillating bellows. The resulting pressure change is measured and used to predict the volume of vapor in the tank, from which the volume of liquid is computed. For each gauging instance, pressures are measured for several different bellows frequencies to enable minor real-gas effects to be quantified and thereby to obtain a gauging accuracy of [plus-or-minus]1% of tank volume. Southwest Research Institute[trademark] and NASA-GRC have developed several previous breadboard and engineering development gauges and tested them in cryogenic hydrogen and nitrogen to establish the gauge capabilities, to resolve several

design issues, and to formulate data processing algorithms. The CMG has been selected by NASA's Future X program for a flight demonstration on the USAF/Boeing Solar Thermal Vehicle Space Experiment (SOTVSE). This paper reviews the design trade studies needed to satisfy the SOTVSE limitations on CMG power, volume, and mass, and describes the mechanical design of the CMG. [copyright] 2002 American Institute of Physics.
Author (AIP)
Cryogenics; Measuring Instruments; Pressure Measurement; Solar Radiation; Spacecraft; Vapor Pressure; Weightlessness

20030045419

A small volume, rapid translation cryostat insert constructed from commercial components for the detection of ultrafast optical signals

Larsen, Delmar S.; Review of Scientific Instruments; March 2002; ISSN 0034-6748; Volume 73, no. 3; In English; Copyright

A linear motion device was designed and built to move small sample cells within the confined space of a liquid nitrogen Dewar cryostat. Instead of the often-used methods of flowing or rotating samples to generate motion, this cryostat insert simply translates the sample cell while maintaining atmospheric isolation. Accurate, repeatable and rapid translation over a 5 cm range with peak linear velocities of 1 m/s is attainable. The insert is constructed mainly from commercially available components and can be built with minimal effort. Another benefit is that the cryostat insert uses commercially available sample cells, allowing for maximal flexibility in satisfying pathlength and volume requirements and the cells can be easily replaced during the duration of the experiment. The motion device system can be easily installed into existing experimental apparatuses with confined volumes with minor modifications and can be used with liquid helium cryostats or for use in high vacuum applications. This motion is demonstrated by collecting temperature dependent ultrafast signals from the laser dye Rhodamine 640 in viscous glycerol at 170 and 293 K. [copyright] 2002 American Institute of Physics.
Author (AIP)
Cryogenic Equipment; Cryostats; Liquid Nitrogen; Optical Communication; Signal Detection

20030045407

The toroid cavity autoclave for high-pressure and variable-temperature in situ nuclear magnetic resonance studies

Niessen, Heiko G.; Trautner, Peter; Wiemann, Sabine; Bargon, Joachim; Woelk, Klaus; Review of Scientific Instruments; March 2002; ISSN 0034-6748; Volume 73, no. 3; In English; Copyright

The toroid cavity autoclave (TCA) is a coaxial nuclear magnetic resonance (NMR) resonator and high-pressure autoclave for in situ NMR studies, which combines the advantages of a toroid NMR detector with the features of a cylindrical metal pressure vessel. It is designed to fit within the limited space of a standard NMR narrow-bore cryomagnet and allows for recording high resolution NMR spectra during chemical reactions under high pressure. Compounds that, for example, initiate a reaction can be injected into the reactor through a nonreturn valve even if the TCA is already pressurized. The TCA is heated by a resistive, coaxial heating arrangement that does not generate any stray magnetic field in the sample volume. Current pressure and temperature capabilities are 0-300 bar and room temperature to 150 [deg]C, respectively. With standard 200 MHz (sup 1)H NMR experiments, signal resolution of 0.55 Hz and signal-to-noise ratios comparable to those of standard NMR probes were achieved. In a further development, the TCA is optimized for gas/liquid reactions in which gaseous components are vigorously mixed with the liquid to obtain maximum reaction rates. Applications to parahydrogen induced polarization are shown, in which the nuclear spin polarization patterns show pairwise addition of hydrogen in both liquid organic solvents and in supercritical CO(sub 2). [copyright] 2002 American Institute of Physics.
Author (AIP)
Cavity Resonators; Chemical Reactions; Cylindrical Bodies; High Pressure; Metal Shells; Nuclear Magnetic Resonance; Polarization (Spin Alignment); Pressure Vessels; Resistance Heating; Spectrometers

20030045010

Towards low-temperature electrostatic accelerometry

Lafargue, Laurent; Rodrigues, Manuel; Touboul, Pierre; Review of Scientific Instruments; January 2002; ISSN 0034-6748; Volume 73, no. 1; In English; Copyright

Ultrasensitive accelerometers with electrostatic suspension use a technology allowing operation at ambient temperature. However, their resolution is theoretically limited to around 10(sup -12) m s(sup -2)/Hz(sup 1/2) by thermal noise. To overcome this limit, and in the perspective of future space missions, an electrostatic sensor compatible with operation at cryogenic temperatures is currently under development. It should ultimately reduce thermodynamic noise and improve the instrument characteristics. The perspectives for a rectangular proof mass electrostatically suspended with six degrees of freedom at

liquid-helium temperature are presented and discussed, as are tests and test data. [copyright] 2002 American Institute of Physics.
Author (AIP)
Accelerometers; Ambient Temperature; Electrostatics; Low Temperature

20030033913 Air Force Research Lab., Edwards AFB, CA, USA
First Principles Calculations of Nitro Compounds with the A1 (111) Surface. DoD UGC, 10-14 Jun 02, Austin, TX
Boatz, Jerry; June 14, 2002; In English
Report No.(s): AD-A410652; AFRL-PR-ED-VG-2002-116; No Copyright; Avail: CASI; A03, Hardcopy

The objective of the research is to identify, develop and transition new propellants and advanced concepts for propulsion applications, such as hydrocarbon fuels for liquid boost, liquid and solid oxidizers for boost and upper stages, monopropellants for spacecraft and upper stages, cryogenic propellants for upper stages and laser light craft for microsatellite and other applications.
DTIC
Nitrogen Compounds; Spacecraft Propulsion; Propellants

20030032188 NASA Langley Research Center, Hampton, VA, USA
Thermal/Mechanical Response of a Polymer Matrix Composite at Cryogenic Temperatures
Whitley, Karen S.; Gates, Thomas S.; March 2003; In English, Apr. 2002, Denver, CO, USA; Original contains black and white illustrations
Contract(s)/Grant(s): 721-21-10-01
Report No.(s): NASA/TM-2003-212171; L-18269; NAS 1.15:212171; No Copyright; Avail: CASI; A03, Hardcopy

In order for polymeric-matrix composites to be considered for use as structural materials in the next generation of space transportation systems, the mechanical behavior of these materials at cryogenic temperatures must be investigated. This paper presents experimental data on the residual mechanical properties of a carbon-fiber polymeric composite, IM7/PETI-5, both before and after aging. Both tension and compression modulus and strength were measured at room temperature, -196C, and -269 C on five different laminate configurations. One set of specimens was aged isothermally for 576 hours at -184 C in an unconstrained state. Another set of corresponding specimens was aged under constant uniaxial strain for 576 hours at -184 C. Based on the experimental data presented, it is shown that trends in stiffness and strength that result from changes in temperature are not always smooth and consistent. Moreover, it is shown that loading mode and direction are significant for both stiffness and strength, and aging at cryogenic temperature while under load can alter the mechanical properties of pristine, un-aged laminates made of IM7/PETI-5 material.
Author
Temperature Effects; Polymer Matrix Composites; Cryogenic Temperature; Compressive Strength

20030020786 NASA Goddard Space Flight Center, Greenbelt, MD, USA
Progress Toward a Compact 0.05 K Magnet Refrigerator Operating from 10 K
Canavan, Edgar; Shirron, Peter; DiPirro, Micheal; Tuttle, James; Jackson, Michael; King, Todd; Numazawa, Takenori; January 07, 2003; In English; No Copyright; Avail: Other Sources; Abstract Only

Much of the most interesting information regarding our universe is hidden in the sub-millimeter, infrared, and x-rays bands of the spectrum, to which our atmosphere is largely opaque. Thus, missions exploring these bands are a very important part of NASA s Space Science program. Coincidentally, the most sensitive detectors in these spectral regions operate at extremely low temperatures, typically 0.05 - 0.10 K. Generally these temperatures will be achieved using magnetic refrigerators, also know as Adiabatic Demagnetization Refrigerators, or ADRs. Current ADRs, such as the one used in the XRS-II instrument on the Astro-E2 satellite, use a single-stage to cool detectors from 1.3 K to 0.06 K. The ADR is designed so that it can absorb the heat on the detector stage for at least 24 hours before it must stop, warm up to the helium bath temperature (1.3 K), and dump the accumulated heat. Future detector arrays will be much larger and will have higher heat dissipation. Furthermore, future missions will use mechanical cryocoolers to provide upper stage cooling, but they can only reach 4 - 10 K. Trying to scale heavy (-15 kg) single stage ADRs up to the higher heat loads and higher heat rejection temperatures required leads to unacceptably large systems. The GSFC Cryogenics Branch has developed the Continuous ADR (CADR) to solve this problem. The CADR consists of a series of ADR stages that sequentially pass heat from the load up to the high temperature heat sink. The stage connected to the load remains at a constant temperature. The continuous stage effectively decouples detector operation from ADR operation, allowing the ADR stages to be cycled much more rapidly. Rapid

cycling leads to higher cooling power density. The cascading, multistage arrangement allows the magnetic refrigerant of each stage to be optimized for its own temperature swing. In the past year, we have made good progress toward a 0.05 to 10K system. A four-stage system that operates from 4.2 K was demonstrated. Magnetic shielding was added to eliminate inter-stage coupling. Improvements were made to superconducting and passive gas-gap heat switches. A second type of passive gas gap switch, one meant for use at higher temperature, was demonstrated. The presentation will focus primarily on these recent design improvements, and on the challenges that remain on the progress toward a system that will operate from 10 K or higher.
Author
Low Temperature; Magnetic Cooling; Refrigerators; Operating Temperature; Cryogenics

20030019225 Energy Research Consultants, Inc., Laguna Hills, CA USA
The Behavior of Cryogenic Shear Layers under Supercritical Conditions
Chehroudi, Bruce; Cohn, R.; Talley, Doug; Jun. 29, 2001; In English
Contract(s)/Grant(s): AF Proj. 2308
Report No.(s): AD-A409825; AFRL-PR-ED-TP-2000-173; No Copyright; Avail: CASI; A01, Hardcopy

As combustion chamber pressures increase in order to realize higher performance and efficiency in a wide range of propulsion applications, the injected fluid may experience ambient pressures which exceed the critical pressure of the injected propellants. For example, in the cryogenic liquid hydrogen/liquid oxygen Space Shuttle main engine, the thrust chamber pressure is more than 4 times larger then the critical pressure of oxygen. In these applications, the initial temperature of the injected oxygen can initially be below the critical temperature, and then undergo a transition to a supercritical temperature as the oxygen is mixed and burned in the combustion chamber.
DTIC
Liquid Propellant Rocket Engines; Supercritical Flow; Cryogenic Rocket Propellants; Shear Layers

20030016689 NASA Glenn Research Center, Cleveland, OH USA
Electronic Components and Circuits for Extreme Temperature Environments
Patterson, Richard L.; Hammoud, Ahmad; Dickman, John E.; Gerber, Scott; January 2003; In English, 8-15 Mar. 2003, Big Sky, MT, USA
Contract(s)/Grant(s): RTOP 297-60-05
Report No.(s): NASA/TM-2003-212079; NAS 1.15:212079; E-13732; Copyright; Avail: CASI; A03, Hardcopy; Distribution as joint owner in the copyright

Planetary exploration missions and deep space probes require electrical power management and control systems that are capable of efficient and reliable operation in very low temperature environments. Presently, spacecraft operating in the cold environment of deep space carry a large number of radioisotope heating units in order to maintain the surrounding temperature of the on-board electronics at approximately 20 C. Electronics capable of operation at cryogenic temperatures will not only tolerate the hostile environment of deep space but also reduce system size and weight by eliminating or reducing the radioisotope heating units and their associate structures; thereby reducing system development as well as launch costs. In addition, power electronic circuits designed for operation at low temperatures are expected to result in more efficient systems than those at room temperature. This improvement results from better behavior and tolerance in the electrical and thermal properties of semiconductor and dielectric materials at low temperatures. The Low Temperature Electronics Program at the NASA Glenn Research Center focuses on research and development of electrical components, circuits, and systems suitable for applications in the aerospace environment and deep space exploration missions. Research is being conducted on devices and systems for reliable use down to cryogenic temperatures. Some of the commercial-off-the-shelf as well as developed components that are being characterized include switching devices, resistors, magnetics, and capacitors. Semiconductor devices and integrated circuits including digital-to-analog and analog-to-digital converters, DC/DC converters, operational amplifiers, and oscillators are also being investigated for potential use in low temperature applications. An overview of the NASA Glenn Research Center Low Temperature Electronic Program will be presented in this paper. A description of the low temperature test facilities along with selected data obtained through in-house component and circuit testing will also be discussed. Ongoing research activities that are being performed in collaboration with various organizations will also be presented.
Author
Aerospace Environments; Cryogenic Temperature; Electrical Properties; Electronic Equipment Tests; Low Temperature Environments; Low Temperature Tests; Thermodynamic Properties

20030014941 NASA Glenn Research Center, Cleveland, OH USA

Cryogenic Evaluation of an Advanced DC/DC Converter Module for Deep Space Applications

Elbuluk, Malik E.; Hammoud, Ahmad; Gerber, Scott S.; Patterson, Richard; January 2003; In English, 13-17 Oct. 2002, Pittsburgh, PA, USA

Contract(s)/Grant(s): NAS3-00145; RTOP 297-60-05

Report No.(s): NASA/TM-2003-212085; NAS 1.15:212085; E-13738; Copyright; Avail: CASI; A03, Hardcopy; Distribution as joint owner in the copyright

DC/DC converters are widely used in power management, conditioning, and control of space power systems. Deep space applications require electronics that withstand cryogenic temperature and meet a stringent radiation tolerance. In this work, the performance of an advanced, radiation-hardened (rad-hard) commercial DC/DC converter module was investigated at cryogenic temperatures. The converter was investigated in terms of its steady state and dynamic operations. The output voltage regulation, efficiency, terminal current ripple characteristics, and output voltage response to load changes were determined in the temperature range of 20 to -140 C. These parameters were obtained at various load levels and at different input voltages. The experimental procedures along with the results obtained on the investigated converter are presented and discussed.
Author

Voltage Converters (DC to DC); Cryogenic Temperature; Technology Utilization; Spacecraft Power Supplies; Electric Potential; Deep Space

20030012840 Arizona State Univ., Tempe, AZ USA

Thermal/Mechanical Response and Damage Growth in Polymeric Matrix Composites at Cryogenic Temperatures

Zhu, Han; 2001 NASA-ODU American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program; December 2002; In English; No Copyright; Abstract Only; Available from CASI only as part of the entire parent document

The next generation of space transportation systems may require both reusable launch vehicles (RLVs) and expendable launch vehicles (ELVs) to satisfy mission requirements. Regardless of the vehicle type, these new space transportation vehicles will require advances in lightweight structural materials and design to meet the increased demands on performance. One potential source for significant structura1 weight reduction is the replacement of traditional metallic cryogenic fuel tanks with new designs for polymeric matrix composite (PMC) tanks. The research is undertaken to help understand this problem of damage development in cryogenic environments and relate this data to material permeability. Specifically, the experimental results provide data on the residual mechanical properties and damage state of a high-performance PMC tested at cryogenic temperatures and pre-conditioned using combinations of mechanical and thermal loading. This data was then used as both input to and verification of a thermal/mechanical analysis of composite laminates for a range of loading conditions and laminate configurations. The study presented here then aims to correlate changes in material properties with the development of microcracks in a PMC material subjected to an extreme environment. Materials characterization and the development of data that leads to an understanding of the damage mechanisms of PMC's at cryogenic temperatures requires the appropriate test methods suitable for extreme environments. One method, for example, is to load coupons in tension while undergoing a temperature change from room temperature to -269 C. The test program evaluated residual stiffness and strength properties as a function of both cryogenic test temperatures and pre-test cryogenic aging conditions and damage, as measured by microcrack density, was quantified at each stage of the test program. The test specimens were made of a carbon fiber polymeric matrix composite, IM7/PETI-5, and five different specimen ply lay-ups were chosen for study. It was recognized that a broad spectrum of factors influence the development of damage in PMC's including material selection, composite fabrication and handling, aging or preconditioning, specimen preparation, laminate layup, test procedures, etc. This study will focus on preconditioning methods and laminate configuration as the primary test variables. Coupon specimens are isothermally aged first and then received the mechanical load till they fail. Matrix cracks are optically observed in those coupons, and the crack density is evaluated by counting crack numbers over per inch length. The information of crack density will provide the understanding and quantification of how the temperature and mechanical load may change the performance of composites iq a cryogenic environment.
Author

Polymer Matrix Composites; Cryogenic Temperature; Mechanical Properties; Reusable Launch Vehicles; Space Transportation; Isothermal Processes

20030012727 Air Force Research Lab., Edwards AFB, CA USA

Investigation of the Unique Cryogenic Pumping System of the CHAFF-IV spacecraft-Thruster Interaction Facility

Ketsdever, Andrew D.; Young, Marcus P.; Jamison, Andrew; Eccles, Brian; Muntz, E. P.; Jul. 09, 2000; In English; Original contains color images

Report No.(s): AD-A409037; No Copyright; Avail: CASI; A02, Hardcopy

Chamber -IV of the Collaborative High Altitude Flow Facility was designed to obtain high fidelity spacecraft- thruster interaction data. CHAFF-IV uses a total chamber pumping concept by lining the entire chamber with an array of cryogenically cooled, radial fins. Details of Monte Carlo numerical simulation and experimental investigation of the radial fin target array pumping efficiency are presented.
DTIC
Cryogenics; Aerospace Vehicles; Pumps; Rocket Engines

20030011546 Air Force Research Lab., Edwards AFB, CA USA
Electronic Spectroscopy of B Atoms and B2 Molecules Isolated in Para-H2, Normal-D2, Ne, Ar, Kr, and Xe Matrices
Tam, Simon; Macler, Michel; DeRose, Michelle E.; Fajardo, Mario E.; May 15, 2000; In English
Contract(s)/Grant(s): AF Proj. 2303
Report No.(s): AD-A408930; AFRL-PR-ED-TP-2000-114; No Copyright; Avail: CASI; A03, Hardcopy

We report spectroscopic observations on B atoms isolated in cryogenic parahydrogen (pH2), normal deuterium (nD2), Ne, Ar, Kr, and Xe matrices, and of B2 molecules in Ne, Ar, Kr, and Xe matrices. The 2s(sup 2)3s((sup 2)S) left arrow 2s(sup 2)2p((sup 2)P) B atom Rydberg absorption suffers large gas-to-matrix blue shifts, increasing from +3000 to +7000/cm in the host sequence: Xe less than Kr less than Ar approx. = Ne approx. =nD(2) approx. = pH2. Much smaller shifts are observed for the 2s2p(sup 2)((sup 2)D) left arrow 2s(sup 2)2p((sup 2)P) B atom core-to-valence transition. We assign pairs of absorption peaks spaced by approx. 10 nm in the 315 to 355 nm region to the B2 (A (sup 3)Sigma (sub u)(-) left arrow X (sup 3)Sigma(sub g)(-)) Douglas-Herzberg transition. We assign a much weaker progression in the 260 to 300 nm region to the B2 (2) (sup 3)Pi(sub u) left arrow X (sup 3)Sigma(sub g)(-) transition. We report a novel progression of strong peaks in the 180 to 200 nm region which we suspect may be due to B2 molecules, but which remains unassigned. Ultraviolet (UV) absorption spectra of B/pH2 solids show two strong peaks at 216.6 and 208.9 nm, which we assign to the matrix perturbed 2s(sup 2)3s((sup 2)S) left arrow 2s(sup 2)2p((sup 2)P) and 2s2p(sup 2)((sup 2)D) left arrow 2s(sup 2)2p((sup 2)P) B atom absorptions, respectively. Laser induced fluorescence emission spectra of B/pH2 solids show a single line at 249.6 nm, coincident with the gas phase wavelength of the 2s(sup 2)3s((sup 2)S) right arrow 2s(sup 2)2p((sup 2)P) B atom emission. The UV laser irradiation results in photobleaching of the B atom emission and absorptions, accompanied by the formation of B2H6.
DTIC
Absorption Spectra; Boron; Spectroscopy

20030007417
Dielectric relaxation and strain behavior of 95.5% Pb(Zn(sub 1/3)Nb(sub 2/3))O(sub 3)-4.5% PbTiO(sub 3) single crystals at cryogenic temperatures
Yu, Zhi; Ang, Chen; Furman, E.; Cross, L. E.; Applied Physics Letters; February 03, 2003; ISSN 0003-6951; Volume 82, no. 5; In English; Copyright

The dielectric behavior of 95.5% Pb(Zn(sub 1/3)Nb(sub 2/3))O(sub 3)-4.5% PbTiO(sub 3) single crystals oriented along \h001\g direction with and without dc electric field has been studied at cryogenic temperatures. A pronounced low-temperature dielectric relaxation process was observed below 200 K; the relaxation rate follows the Arrhenius law ([tau](sub 0)=[approx]1.0 x10(sup -15) s and U=0.24 eV). An additional dielectric anomaly showed up around 250 K at 10 kHz under a dc electric field. These results indicate rather complicated polarization mechanisms at cryogenic temperatures which clearly need more detailed study. The strain levels at cryogenic temperatures suggest that this material is very promising for space applications, in which the performance at cryogenic temperatures is critical. [copyright] 2003 American Institute of Physics.
Author (AIP)
Cryogenic Temperature; Dielectric Polarization; Dielectric Properties; Dielectrics; Ferroelectric Materials; Lead Compounds; Permittivity; Piezoelectricity; Polarization; Single Crystals

20030006828
Developments in Turbo-Brayton Power Converters
Zagarola, Mark V.; Crowley, Christopher J.; Swift, Walter L.; AIP Conference Proceedings; January 28, 2003; ISSN 0094-243X; Volume 654, no. 1; In English; SPACE TECHNOLOGY and APPLICATIONS INT.FORUM-STAIF 2003: Conf.on Thermophysics in Microgravity; Commercial/Civil Next Generation Space Transportation; Human Space Exploration, 2-5 February 2003, Albuquerque, New Mexico, USA
Contract(s)/Grant(s): NAS3-02038; Copyright

Design studies show that a Brayton cycle power unit is an extremely attractive option for thermal-to-electric power conversion on long-duration, space missions. At low power levels (50 to 100 We), a Brayton system should achieve a conversion efficiency between 20% and 40% depending on the radiative heat sink temperature. The expected mass of the converter for these power levels is about 3 kg. The mass of the complete system consisting of the converter, the electronics, a radiator, and a single general purpose heat source should be about 6 kg. The system is modular and the technology is readily scalable to higher power levels (to greater than 10 kWe) where conversion efficiencies of between 28% and 45% are expected, the exact value depending on sink temperature and power level. During a recently completed project, key physical features of the converter were determined, and key operating characteristics were demonstrated for a system of this size. The key technologies in these converters are derived from those which have been developed and successfully implemented in miniature turbo-Brayton cryogenic refrigerators for space applications. These refrigerators and their components have been demonstrated to meet rigorous requirements for vibration emittance and susceptibility, acoustic susceptibility, electromagnetic interference and susceptibility, environmental cycling, and endurance. Our progress in extending the underlying turbo-Brayton cryocooler technologies to thermal-to-electric power converters is the subject of this paper. [copyright] 2003 American Institute of Physics
Author (AIP)
Brayton Cycle; Cryogenics; Electric Generators; Heat Exchangers; Long Duration Space Flight; Power Converters; Spacecraft Power Supplies; Thermoelectric Power Generation; Turbogenerators

20030006785
Across-Gimbal and Miniaturized Cryogenic Loop Heat Pipes
Bugby, D.; Marland, B.; Stouffer, C.; Kroliczek, E.; AIP Conference Proceedings; January 28, 2003; ISSN 0094-243X; Volume 654, no. 1; In English; SPACE TECHNOLOGY and APPLICATIONS INT.FORUM-STAIF 2003: Conf.on Thermophysics in Microgravity; Commercial/Civil Next Generation Space Transportation; Human Space Exploration, 2-5 February 2003, Albuquerque, New Mexico, USA; Copyright
This paper describes the development status of three advanced cryogenic loop heat pipes (CLHP) for solving important problems in cryogenic integration. The three devices described herein are: (1) an across-gimbal CLHP; (2) a short transport length miniaturized CLHP; and (3) a long transport length miniaturized CLHP. The across-gimbal CLHP, which is baselined for operation from 80-100 K with nitrogen, provides a low weight, low torque, high conductance solution for gimbaled cryogenic systems wishing to mount their cryocoolers off-gimbal. The short transport length miniaturized CLHP, which is baselined for operation near 35 K with neon, combines localized thermal transport, flexibility, and thermal switching into one device that can be directly mounted to a cryocooler cold head and a cryogenic component just a short distance (10-20 cm) away. The long transport length miniaturized CLHP, which is also baselined for operation near 35 K with neon, adds to the capabilities of the short transport length miniaturized CLHP by increasing the transport length to over 250 cm to meet cryogenic heat transport device requirements of future NASA and DoD spacecraft. [copyright] 2003 American Institute of Physics
Author (AIP)
Cryogenics; Heat Pipes; Heat Transfer; Spacecraft; Vibration Isolators

20030005612 Saskatchewan Univ., Saskatoon, Saskatchewan Canada
An Observation of Film Thickness and Local Pressure in Upward and Downward Annular and Two-Phase Flow in Microgravity, Hypergravity and Normal Gravity
Gabriel, Kamiel S.; Manz, Devon L.; Sixth Microgravity Fluid Physics and Transport Phenomena Conference: Exposition Topical Areas 1-6; November 2002; Volume 2; In English; Original contains color illustrations; No Copyright; Avail: CASI; A02, Hardcopy
The phenomenon of two-phase flow in a near weightless environment (or microgravity) is becoming increasingly important. Two-phase flow loops are used in advanced spacecraft thermal management systems and also occur during the transfer of cryogenic propellants. On earth, twophase annular flow is common in power plants and many chemical processing plants. The liquid film along the tube wall plays a large role in mass and momentum transfer, featuring a complex wave structure. It is the wave structure phenomenon relating to the pressure and film thickness time trace that is the current interest in this investigation.
Author
Film Thickness; Gravitation; Microgravity; Two Phase Flow; Annular Flow; Pressure Distribution

20030002688 NASA Marshall Space Flight Center, Huntsville, AL USA

New Cryogenic Optical Test Capability at Marshall Space Flight Center's Space Optics Manufacturing Technology Center

Kegley, Jeff; Burdine, Robert V., Technical Monitor; [2002]; In English; SPIE Astronomy Conference, 22-28 Aug. 2002, Waikoloa, HI, USA; No Copyright; Avail: Other Sources; Abstract Only

A new cryogenic optical testing capability exists at Marshall Space Flight Center's Space Optics Manufacturing Technology Center (SOMTC). SOMTC has been performing optical wavefront testing at cryogenic temperatures since 1999 in the X-ray Cryogenic Test Facility's (XRCF's) large vacuum chamber. Recently the cryogenic optical testing capability has been extended to a smaller vacuum chamber. This smaller horizontal cylindrical vacuum chamber has been outfitted with a helium-cooled liner that can be connected to the facility's helium refrigeration system bringing the existing kilowatt of refrigeration capacity to bear on a 1 meter diameter x 2 meter long test envelope. Cryogenic environments to less than 20 Kelvin are now possible in only a few hours. SOMTC's existing instruments (the Instantaneous Phase-shifting Interferometer (IPI) from ADE Phase-Shift Technologies and the PhaseCam from 4D Vision Technologies) view the optic under test through a 150 mm clear aperture BK-7 window. Since activation and chamber characterization tests in September 2001, the new chamber has been used to perform a cryogenic (less than 30 Kelvin) optical test of a 22.5 cm diameter x 127 cm radius of curvature Si02 mirror, a cryogenic survival (less than 30 Kelvin) test of an adhesive, and a cryogenic cycle (less than 20 Kelvin) test of a ULE mirror. A vibration survey has also been performed on the test chamber. Chamber specifications and performance data, vibration environment data, and limited test results will be presented.

Author

Research Facilities; Cryogenics; Vacuum Chambers; Cryogenic Temperature

20030001044 NASA Marshall Space Flight Center, Huntsville, AL USA

Effects of Thermal Exposure on Properties of Al-Li Alloys

Shah, Sandeep; Wells, Douglas; Stanton, William; Lawless, Kirby; Russell, Carolyn; Wagner, John; Domack, Marcia; Babel, Henry; Farahmand, Bahram; Schwab, David; Munafo, Paul M., Technical Monitor, et al.; [2002]; In English; AMPET, 16-18 Sep. 2002, Huntsville, AL, USA; No Copyright; Avail: Other Sources; Abstract Only

Aluminum-Lithium (Al-Li) alloys offer significant performance benefits for aerospace structural applications due to their higher specific properties compared with conventional Al alloys. For example, the application of Al-Li alloy 2195 to the space shuffle external cryogenic fuel tank resulted in weight savings of over 7,000 lb, enabling successful deployment of International Space Station components. The composition and heat treatment of 2195 were optimized specifically for strength-toughness considerations for an expendable cryogenic tank. Time-dependent properties related to reliability, such as thermal stability, fatigue, and corrosion, will be of significant interest when materials are evaluated for a reusable cryotank structure. Literature surveys have indicated that there is limited thermal exposure data on Al-Li alloys. The effort reported here was designed to establish the effects of thermal exposure on the mechanical properties and microstructure of Al-Li alloys C458, L277, and 2195 in plate gages. Tensile, fracture toughness, and corrosion resistance were evaluated for both parent metal and friction stir welds (FSW) after exposure to temperatures as high as 300 F for up to 1000 hrs. Microstructural changes were evaluated with thermal exposure in order to correlate with the observed data trends. The ambient temperature parent metal data showed an increase in strength and reduction in elongation after exposure at lower temperatures. Strength reached a peak with intermediate temperature exposure followed by a decrease at highest exposure temperature. Friction stir welds of all alloys showed a drop in elongation with increased length of exposure. Understanding the effect of thermal exposure on the properties and microstructure of Al-Li alloys must be considered in defining service limiting temperatures and exposure times for a reusable cryotank structure.

Author

Aluminum-Lithium Alloys; Temperature Effects; Exposure; Mechanical Properties; Microstructure

20030000999 NASA Marshall Space Flight Center, Huntsville, AL USA

Characterization of Carbon Nanotube Reinforced Nickel

Gill, Hansel; Hudson, Steve; Bhat, Biliyar; Munafo, Paul M., Technical Monitor; [2002]; In English; AMPET, 16-18 Sep. 2002, Huntsville, AL, USA; No Copyright; Avail: Other Sources; Abstract Only

Carbon nanotubes are cylindrical molecules composed of carbon atoms in a regular hexagonal arrangement. If nanotubes can be uniformly dispersed in a supporting matrix to form structural materials, the resulting structures could be significantly lighter and stronger than current aerospace materials. Work is currently being done to develop an electrolyte-based self-assembly process that produces a Carbon Nanotube/Nickel composite material with high specific strength. This process is expected to produce a lightweight metal matrix composite material, which maintains it's thermal and electrical

conductivities, and is potentially suitable for applications such as advanced structures, space based optics, and cryogenic tanks.
Author
Carbon Nanotubes; Nickel; Electrolytes; Self Assembly; Metal Matrix Composites

20030000994 NASA Langley Research Center, Hampton, VA USA
Thermal/Mechanical Response and Damage Growth in Polymeric Composites at Cryogenic Temperatures
Whitley, Karen S.; Gates, Thomas S.; [2002]; In English, 22-25 Apr. 2002, Denver, CO, USA
Report No.(s): AIAA Paper 2002-1416; Copyright; Avail: CASI; A03, Hardcopy; Distribution under U.S. Government purpose rights

In order to increase the reliability of the next generation of space transportation systems, the mechanical behavior of polymeric matrix composite (PMC) materials at cryogenic temperatures must be investigated. This paper presents experimental data on the residual mechanical properties of a carbon fiber polymeric composite, IM7/PETI-5 both before and after aging at cryogenic temperatures. Tension modulus and strength were measured at room temperature, -196 C, and -269 C on five different specimen ply lay-ups, [0](sub 12), [90](sub 12), [+/-45](sub 3S), [+/-25](sub 3s) and [45,90(sub 3),-45,0(sub 3),-45,90(sub 3),45]. Specimens were preconditioned with one set of coupons being isothermally aged for 555 hours at -184 C in an unloaded state. Another set of corresponding coupons were mounted in constant displacement fixtures such that a constant uniaxial strain was applied to the specimens for 555 hours at -184 C. The measured lamina level properties indicated that cryogenic temperatures have an appreciable influence on behavior, and residual stress calculations based on lamination theory showed that the transverse tensile ply stresses could be quite high for cryogenic test temperatures. Microscopic examination of the surface morphology showed evidence of degradation along the exposed edges of the material due to aging at cryogenic temperatures.
Author
Polymer Matrix Composites; Cryogenic Temperature; Carbon Fibers; Modulus of Elasticity

20030000980 NASA Marshall Space Flight Center, Huntsville, AL USA
Manufacturing Process Simulation of Large-Scale Cryotanks
Babai, Majid; Phillips, Steven; Griffin, Brian; Munafo, Paul M., Technical Monitor; [2002]; In English; AMPET, 16-18 Sep. 2002, Huntsville, AL, USA; No Copyright; Avail: Other Sources; Abstract Only

NASA's Space Launch Initiative (SLI) is an effort to research and develop the technologies needed to build a second-generation reusable launch vehicle. It is required that this new launch vehicle be 100 times safer and 10 times cheaper to operate than current launch vehicles. Part of the SLI includes the development of reusable composite and metallic cryotanks. The size of these reusable tanks is far greater than anything ever developed and exceeds the design limits of current manufacturing tools. Several design and manufacturing approaches have been formulated, but many factors must be weighed during the selection process. Among these factors are tooling reachability, cycle times, feasibility, and facility impacts. The manufacturing process simulation capabilities available at NASA's Marshall Space Flight Center have played a key role in down selecting between the various manufacturing approaches. By creating 3-D manufacturing process simulations, the varying approaches can be analyzed in a virtual world before any hardware or infrastructure is built. This analysis can detect and eliminate costly flaws in the various manufacturing approaches. The simulations check for collisions between devices, verify that design limits on joints are not exceeded, and provide cycle times which aid in the development of an optimized process flow. In addition, new ideas and concerns are often raised after seeing the visual representation of a manufacturing process flow. The output of the manufacturing process simulations allows for cost and safety comparisons to be performed between the various manufacturing approaches. This output helps determine which manufacturing process options reach the safety and cost goals of the SLI.
Author
Reusable Launch Vehicles; Manufacturing; Feasibility; Cryogenic Fluid Storage; Fuel Tanks; Simulation

20030000767 NASA Marshall Space Flight Center, Huntsville, AL USA
Thermal Examination of an Orbiting Cryogenic Fuel Depot
Hull, Patrick V.; Canfield, Steven L.; Carrington, Connie; Fikes, John; Twelfth Thermal and Fluids Analysis Workshop; July 2002; In English; Original contains color illustrations; No Copyright; Avail: CASI; A02, Hardcopy

For many years NASA has been interested in the storage and transfer of cryogenic fuels in space. Lunar, L2 and other chemical propulsive space vehicle missions now have staged refueling needs that a fuel depot would satisfy. The depot considered is located in lower earth orbit. Many considerations must go into designing and building such a station. Multi-layer

insulation systems, thermal shielding and low conductive structural supports are the principal means of protecting the system from excessive heat loss due to boiloff. This study focuses on the thermal losses associated with storing LH2 in a passively cooled fuel depot in a lower earth equatorial orbit. The corresponding examination looks at several configurations of the fuel depot. An analytical model has been developed to determine the thermal advantages and disadvantages of three different fuel depot configurations. Each of the systems consists of three Boeing rocket bodies arranged in various configurations. The first two configurations are gravity gradient stabilized while the third one is a spin-stabilized concept. Each concept was chosen for self-righting capabilities as well as the fuel settling capabilities, however the purpose of this paper is to prove which of the three concepts is the most efficient passively cooled system. The specific areas to be discussed are the heating time from the fusion temperature to the vaporization temperature and the amount of boiloff for a specific number of orbits. Each of the previous points is compared using various sun exposed surface areas of the tanks.
Author
Cryogenics; Mathematical Models; Cryogenic Fluid Storage; Equatorial Orbits; Heat of Vaporization; Thermodynamics

20020090943 Portland State Univ., OR USA
Analysis of Tank PMD Rewetting Following Thrust Resettling
Weislogel, M. M.; Sala, M. A.; Collicott, S. H.; Rame, Enrique, Technical Monitor; October 2002; In English
Contract(s)/Grant(s): NAS3-00126; RTOP 101-13-0B
Report No.(s): NASA/CR-2002-211974; NAS 1.26:211974; E-13618; No Copyright; Avail: CASI; A03, Hardcopy

Recent investigations have successfully demonstrated closed-form analytical solutions of spontaneous capillary flows in idealized cylindrical containers with interior corners. In this report, the theory is extended and applied to complex containers modeling spacecraft fuel tanks employing propellant management devices (PMDs). The specific problem investigated is one of spontaneous rewetting of a typical partially filled liquid fuel/cryogen tank with PMD after thrust resettling. The transients of this flow impact the logistics of orbital maneuvers and potentially tank thermal control. The general procedure to compute the initial condition (mean radius of curvature for the interface) for the closed-form transient flows is first outlined then solved for several 'complex' cylindrical tanks exhibiting symmetry. The utility and limitations of the technique as a design tool are discussed in a summary, which also highlights comparisons with NASA flight data of a model propellant tank with PMD.
Author
Propellant Tanks; Capillary Flow; Liquid Fuels; Fuel Tanks

20020088421 NASA Glenn Research Center, Cleveland, OH USA
Development and Design of Zero-g Liquid Quantity Gauge for Solar Thermal Vehicle
Dodge, Franklin T.; Green, Steven T.; Petullo, Steven P.; VanDresar, Neil T.; November 2002; In English; Original contains color illustrations
Contract(s)/Grant(s): RTOP 721-26-CF
Report No.(s): NASA/TP-2002-211595; NAS 1.60:211595; E-13367; No Copyright; Avail: CASI; A03, Hardcopy

The development and design of a cryogenic liquid quantity gauge for zero-gravity (zero-g) applications are described. The gauge, named the compression mass gauge (CMG), operates on the principle of slightly changing the volume of the tank by an oscillating bellows. The resulting pressure change is measured and used to predict the volume of vapor in the tank, from which the volume of liquid is computed. For each gauging instance, pressures are measured for several different bellows frequencies to enable minor real-gas effects to be quantified and thereby to obtain a gauging accuracy of 11 percent of tank volume. The CMG has been selected by NASA's Future-X program for a flight demonstration on the USA Air Force-Boeing Solar Orbit Transfer Vehicle Space Experiment (SOTVSE). This report reviews the design trade studies needed for the CMG to satisfy the SOTVSE limitations on its power, volume, and mass and also describes the mechanical design of the CMG.
Author
Measuring Instruments; Manufacturing; Design Analysis; Cryogenic Fluids; Microgravity

20020081281 NASA Goddard Space Flight Center, Greenbelt, MD USA
Space Flight Qualification Program for the AMS-2 Commercial Cryocoolers
Shirey, K. A.; Banks, I. S.; Breon, S. R.; Boyle, R. F.; Krebs, Carolyn A., Technical Monitor; June 2002; In English; 12th International Cryocooler Conference (ICC-12), 18-20 Jun. 2002, Cambridge, MA, USA; No Copyright; Avail: CASI; A02, Hardcopy

The Alpha Magnetic Spectrometer-02 (AMS-02) experiment is a state-of-the-art particle physics detector containing a large superfluid helium-cooled superconducting magnet. Highly sensitive detector plates inside the magnet measure a

particle’s speed, momentum, charge, and path. The AMS-02 experiment will study the properties and origin of cosmic particles and nuclei including antimatter and dark matter. AMS-02 will be installed on the International Space Station on Utilization Flight-4. The experiment will be run for at least three years. To extend the life of the stored cryogen and minimize temperature gradients around the magnet, four Stirling-cycle Sunpower M87N cryocoolers will be integrated with AMS-02. The cryocooler cold tip will be connected via a flexible strap to the outer vapor cooled shield of the dewar. Initial thermal analysis shows the lifetime of the experiment is increased by a factor of 2.8 with the use of the cryocooler. The AMS-02 project selected the Sunpower M87 cryocoolers and has asked NASA Goddard to qualify the cryocoolers for space flight use. This paper describes the interfaces with the cryocoolers and presents data collected during testing of the two engineering model cryocoolers. Tests include thermal performance characterization and launch vibration testing. Magnetic field compatibility testing will be presented in a separate paper at the conference.
Author
Alpha Magnetic Spectrometer; Cryogenic Cooling; Space Flight; Particle Theory; Detectors

20020081035 NASA Goddard Space Flight Center, Greenbelt, MD USA
Final Qualification and Early On-Orbit Performance of the HESSI Cryocooler
Boyle, R. F.; Banks, I. S.; Shirey, K.; June 2002; In English, 27 Jul. 2001, Madison, WI, USA; No Copyright; Avail: CASI; A02, Hardcopy

The High Energy Solar Spectroscopic Imager (HESSI) spacecraft was launched on February 5, 2002. It now observes the Sun with the finest angular and energy resolutions ever achieved from a few keV to hundreds of keV, using an array of nine germanium detectors operating at 75K. The spacecraft was originally scheduled for launch in July 2000, but a vibration facility mishap damaged the primary structure of the spacecraft, along with the cryocooler, This paper describes issues in the qualification of a replacement for the original flight cooler, and describes early on-orbit performance.
Author
Cryogenic Cooling; Vibration; Germanium; Angular Resolution; Coolers

20020080839 NASA Goddard Space Flight Center, Greenbelt, MD USA
Operation of A Sunpower M87 Cryocooler In A Magnetic Field
Breon, S. R.; Shirey, K. A.; Banks, I. S.; Warner, B. A.; Boyle, R. F.; Mustafi, S.; Krebs,Carolyn A., Technical Monitor; [2002]; In English; 12th International Cryocooler Conference, 17-20 Jun. 2002, Cambridge, MA, USA; No Copyright; Avail: CASI; A02, Hardcopy

The Alpha Magnetic Spectrometer-02 (AMS-02) is an experiment that will be flown as an attached payload on the International Space Station to detect dark matter and antimatter. It uses large superconducting magnets cooled with superfluid helium to bend the path of cosmic particles through a series of detectors, which then measure the mass, speed, charge, and direction of the particles. Four Sunpower M87N Stirling-cycle cryocoolers are used to extend the mission life by cooling the outer vapor-cooled shield of the dewar. The main magnet coils are separated by a distance of approximately 1 m and the coolers are located approximately 1.5 m from the center line of the magnet, where the field is as high as 925 gauss perpendicular to the cryocooler axis and 400 gauss along the cryocooler axis. Interactions between the applied magnetic field and the linear motor may result in additional forces and torques on the compressor piston. Motion of the compressor arid displacer pistons through the magnetic field spatial gradients will generate eddy currents. Additional eddy currents are created during magnet charge, discharge, and quench by the time-varying magnetic field. The results of tests to determine the magnitude of the forces, torques, and heating effects, as well as the need for additional magnetic shielding, are presented.
Author
Cryogenic Cooling; Magnetic Fields; Payloads; Dark Matter; Antimatter; Superconducting Magnets

20020072846 NASA Glenn Research Center, Cleveland, OH USA
Comprehensive Evaluation of Power Supplies at Cryogenic Temperatures for Deep Space Applications
Patterson, Richard L.; Gerber, Scott; Hammoud, Ahmad; Elbuluk, Malik E.; Lyons, Valerie, Technical Monitor; [2002]; In English
Contract(s)/Grant(s): NAS3-00145; RTOP 297-60-10; No Copyright; Avail: CASI; A03, Hardcopy

The operation of power electronic systems at cryogenic temperatures is anticipated in many future space missions such as planetary exploration and deep space probes. In addition to surviving the space hostile environments, electronics capable of low temperature operation would contribute to improving circuit performance, increasing system efficiency, and reducing development and launch costs. DC/DC converters are widely used in space power systems in the areas of power management,

conditioning, and control. As part of the on-going Low Temperature Electronics Program at NASA, several commercial-off-the-shelf (COTS) DC/DC converters, with specifications that might fit the requirements of specific future space missions have been selected for investigation at cryogenic temperatures. The converters have been characterized in terms of their performance as a function of temperature in the range of 20 C to - 180 C. These converters ranged in electrical power from 8 W to 13 W, input voltage from 9 V to 72 V and an output voltage of 3.3 V. The experimental set-up and procedures along with the results obtained on the converters' steady state and dynamic characteristics are presented and discussed.
Author
Spacecraft Power Supplies; Cryogenic Temperature; Deep Space; Space Exploration; Voltage Converters (DC to DC); Low Temperature; Electric Potential

20020071075 NASA Goddard Space Flight Center, Greenbelt, MD USA
Ultralow-Background Large-Format Bolometer Arrays
Benford, Dominic; Chervenak, Jay; Irwin, Kent; Moseley, S. Harvey; Oegerle, William, Technical Monitor; [2002]; In English; SPIE Workshop, 22-28 Aug. 2002, Waikoloa, HI, USA; No Copyright; Avail: Other Sources; Abstract Only

In the coming decade, work will commence in earnest on large cryogenic far-infrared telescopes and interferometers. All such observatories - for example, SAFIR, SPIRIT, and SPECS - require large format, two dimensional arrays of close-packed detectors capable of reaching the fundamental limits imposed by the very low photon backgrounds present in deep space. In the near term, bolometer array architectures which permit 1000 pixels - perhaps sufficient for the next generation of space-based instruments - can be arrayed efficiently. Demonstrating the necessary performance, with Noise Equivalent Powers (NEPs) of order 10-20 W/square root of Hz, will be a hurdle in the coming years. Superconducting bolometer arrays are a promising technology for providing both the performance and the array size necessary. We discuss the requirements for future detector arrays in the far-infrared and submillimeter, describe the parameters of superconducting bolometer arrays able to meet these requirements, and detail the present and near future technology of superconducting bolometer arrays. Of particular note is the coming development of large format planar arrays with absorber-coupled and antenna-coupled bolometers.
Author
Bolometers; Product Development; Design Analysis; Satellite-Borne Instruments; Wavelength Division Multiplexing

20020070863 NASA Glenn Research Center, Cleveland, OH USA
Development and Design of a Zero-G Liquid Quantity Gauge for a Solar Thermal Vehicle
Dodge, Franklin T.; Green, Steven T.; Petullo, Steven P.; VanDresar, Neil T.; Taylor, William J., Technical Monitor; Feb. 01, 2002; In English; Space Technology and Applications International Forum (STAIF), 3-7 Feb. 2002, Albuquerque, NM, USA
Contract(s)/Grant(s): NAS3-99152; RTOP 721-26-CF; No Copyright; Avail: CASI; A02, Hardcopy

The development and design of a cryogenic liquid quantity gauge for zero-g applications is described. The gauge, named the Compression Mass Gauge (CMG), operates on the principle of slightly changing the volume of the tank by an oscillating bellows. The resulting pressure change is measured and used to predict the volume of vapor in the tank, from which the volume of liquid is computed. For each gauging instance, pressures are measured for several different bellows frequencies to enable minor real-gas effects to be quantified and thereby to obtain a gauging accuracy of +/- 1% of tank volume. Southwest Research Institute (Tm) and NASA-GRC (Glenn Research Center) have developed several previous breadboard and engineering development gauges and tested them in cryogenic hydrogen and nitrogen to establish the gauge capabilities, to resolve several design issues, and to formulate data processing algorithms. The CMG has been selected by NASA's Future X program for a flight demonstration on the USAF (USA Air Force) / Boeing Solar Thermal Vehicle Space Experiment (SOTVSE). This paper reviews the design trade studies needed to satisfy the SOTVSE limitations on CMG power, volume, and mass, and describes the mechanical design of the CMG.
Author
Measuring Instruments; Weightlessness; Cryogenic Fluids; Storage Tanks

20020070802 NASA Goddard Space Flight Center, Greenbelt, MD USA
A Mechanical Cryogenic Cooler for the Hubble Space Telescope
Jedrich, Nicholas; Zimbelman, Darell; Swift, Walter; Dolan, Francis; Brumfield, Mark, Technical Monitor; [2002]; In English; No Copyright; Avail: CASI; A02, Hardcopy

This paper presents a description of the Hubble Space Telescope (HST) Near-Infrared Camera and Multi-Object Spectrometer (NICMOS) Cryo Cooler (NCC), the cutting edge technology involved, its evolution, performance, and future space applications. The NCC is the primary hardware component of the NICMOS Cooling System comprised of the NCC,

an Electronics Support Module, a Capillary Pumped Loop/Radiator, and associated interface harnessing. The system will be installed during extravehicular activities on HST during Servicing Mission 3B scheduled for launch in February 2002. The NCC will be used to revive the NICMOS instrument, which experienced a reduced operational lifetime due to an internal thermal short in its dewar structure, and restore HST scientific infrared capability to operational status. The NCC is a state-of-the-art reverse Turbo-Brayton cycle cooler employing gas bearing micro turbo machinery, driven by advanced power conversion electronics, operating at speeds up to 7300 revolutions per second (rps) to remove heat from the NICMOS instrument.
Author
Cameras; Spectrometers; Cryogenic Equipment; Cryogenic Cooling; Hubble Space Telescope

20020068101 Alabama Univ., Huntsville, AL USA
Ultrasonic Characterization of Fatigue Cracks in Composite Materials
Workman, Gary L.; Watson, Jason; Johnson, Devin; Walker, James; Russell, Sam; Thom, Robert, Technical Monitor; [2002]; In English; 11th International Symposium on Nondestructive Characterization of Materials, 24-28 Jun. 2002, Berlin, Germany
Contract(s)/Grant(s): NAG8-1548; No Copyright; Avail: Other Sources; Abstract Only

Microcracking in composite structures due to combined fatigue and cryogenic loading can cause leakage and failure of the structure and can be difficult to detect in-service. In aerospace systems, these leaks may lead to loss of pressure/propellant, increased risk of explosion and possible cryo-pumping. The success of nondestructive evaluation to detect intra-ply microcracking in unlined pressure vessels fabricated from composite materials is critical to the use of composite structures in future space systems. The work presented herein characterizes measurements of intraply fatigue cracking through the thickness of laminated composite material by means of correlation with ultrasonic resonance. Resonant ultrasound spectroscopy provides measurements which are sensitive to both the microscopic and macroscopic properties of the test article. Elastic moduli, acoustic attenuation, and geometry can all be probed. The approach is based on the premise of half-wavelength resonance. The method injects a broadband ultrasonic wave into the test structure using a swept frequency technique. This method provides dramatically increased energy input into the test article, as compared to conventional pulsed ultrasonics. This relative energy increase improves the ability to measure finer details in the materials characterization, such as microcracking and porosity. As the microcrack density increases, more interactions occur with the higher frequency (small wavelength) components of the signal train causing the spectrum to shift toward lower frequencies. Several methods are under investigation to correlate the degree of microcracking from resonance ultrasound measurements on composite test articles including self organizing neural networks, chemometric techniques used in optical spectroscopy and other clustering algorithms.
Author
Algorithms; Composite Materials; Fatigue (Materials); Ultrasonic Radiation; Ultrasonics; Microcracks

20020068002 NASA Marshall Space Flight Center, Huntsville, AL USA
New Cryogenic Optical Test Capability at Marshall Space Flight Center's Space Optics Manufacturing Technology Center
Kegley, Jeff; Stahl, H. Philip, Technical Monitor; [2002]; In English; 2nd Annual Technology Days, 22-24 May 2002, Huntsville, AL, USA; No Copyright; Avail: Other Sources; Abstract Only

A new cryogenic optical testing capability exists at Marshall Space Flight Center's Space Optics Manufacturing Technology Center (SOMTC). SOMTC has been performing optical wavefront testing at cryogenic temperatures since 1999 in the X-ray Cryogenic Test Facility's (XRCF's) large vacuum chamber. Recently the cryogenic optical testing capability has been extended to a smaller vacuum chamber. This smaller horizontal cylindrical vacuum chamber has been outfitted with a helium-cooled liner that can be connected to the facility's helium refrigeration system bringing the existing kilowatt of refrigeration capacity to bear on a 1 meter diameter x 2 meter long test envelope. Cryogenic environments to less than 20 Kelvin are now possible in only a few hours. SOMTC's existing instruments (the Instantaneous Phase-shifting Interferometer (IPI) from ADE Phase-Shift Technologies and the PhaseCam from 4D Vision Technologies) view the optic under test through a 150 mm clear aperture BK-7 window. Since activation and chamber characterization tests in September 2001, the new chamber has been used to perform a cryogenic (less than 30 Kelvin) optical test of a 22.5 cm diameter x 127 cm radius of curvature SiO2 mirror, a cryogenic survival (less than 30 Kelvin) test of an adhesive, and a cryogenic cycle (less than 20 Kelvin) test of a ULE mirror. A vibration survey has also been performed on the test chamber. Chamber specifications and performance data, vibration environment data, and limited test results will be presented.
Author
Cryogenic Temperature; Cryogenics; Optical Materials; Manufacturing; Vacuum Chambers

20020067446 NASA Marshall Space Flight Center, Huntsville, AL USA

COI NMSD Hybrid Mirror

Mehle, Greg; Stahl, Phil, Technical Monitor; [2002]; In English; 2nd Annual Technology Days, 22-24 May 2002, Huntsville, AL, USA

Contract(s)/Grant(s): NAS8-97310; No Copyright; Avail: Other Sources; Abstract Only

This presentation provides an overview of the development of the 1.6 meter hybrid mirror demonstrator for the NGST Mirror System Demonstrator (NMSD) program. The COI design approach for the NGST program combines the optical performance of glass, with the high specific stiffness capabilities of composite materials The foundation technologies being exploited in the development of the hybrid mirror focus upon precision Composite Materials for cryogenic operation, and non-contact optical processing (ion figuring) of the lightweight mirror surface. The NGST Mirror System Demonstrator (NMSD) has been designed and built by Composite Optics, Inc. (COI) with optical processing performed by SAGEM (REOSC). The sponsors of these efforts are the NASA Marshall and Goddard Space Flight Centers.

Author

Mirrors; Optical Materials; Cryogenics; Proving

20020067399 NASA Marshall Space Flight Center, Huntsville, AL USA

Interferometer for Testing in Vibration Environments

Eng, Ron; Freischlad, Klaus; Hadaway, James; Stahl, H. Philip, Technical Monitor; [2002]; In English; SPIE's 47th Annual Meeting: International Symposium on Optical Science and Technology, 7-11 Jul. 2002, Seattle, WA, USA; No Copyright; Avail: Other Sources; Abstract Only

Temporal phase shifting interferometers require a stable environment during the data acquisition, so that well controlled phase steps can be introduced between successively acquired interferograms. In contrast, single-frame interferometers need to acquire only one interferogram to provide a phase map with very good precision at high spatial resolution. Thus these interferometers are well suited for the interferometric testing of large optics with long radius of curvature for which vibration isolation is difficult, eg. testing astronomical telescope mirrors in a test tower, or testing space optics inside a cryogenic vacuum chamber. This paper describes the Instantaneous Phase Interferometer (IPI) by ADE Phase Shift, together with measurement results at NASA. The IPI consists of a polarization Twyman-Green interferometer operating at 632.8 nm, with single-frame data acquisition based on a spatial carrier technique. The spatial carrier fringes are generated by introducing large amount of tilt between the test beam and the reference beam. The phase information of the optical surface under test is encoded in the straightness of the interference fringes, which can be detected in a single frame with spatial sampling of 1000 x 1000 pixels. Measurements taken at the NASA Marshall Space Flight Cater in support of the characterization of developmental optics for the Next Generation Space Telescope are presented. Such tests consist of a mirror placed inside a cryogenic vacuum chamber, with the IPI placed outside the test chamber without any additional vibration isolation.

Author

Interferometers; Interferometry; Vibration; Performance Tests

20020066738 NASA Goddard Space Flight Center, Greenbelt, MD USA

The Fourier-Kelvin Stellar Interferometer Mission Concept

Danchi, W. C.; Allen, R.; Benford, D.; Gezari, D.; Leisawitz, D.; Mundy, L.; Oegerle, William, Technical Monitor; [2002]; In English; SPIE Conference, 22-28 Aug. 2002, Waikoloa, HI, USA; No Copyright; Avail: Other Sources; Abstract Only

The Fourier-Kelvin Stellar Interferometer (FKSI) is a mission concept for an imaging interferometer for the mid-infrared spectral region (5-30 microns). FKSI is conceived as a scientific and technological precursor to TPF as well as Space Infrared Interferometric Telescope (SPIRIT), Submillimeter Probe Evolution of Cosmic Structure (SPECS), and Single Aperture for Infrared Observatory (SAFIR). It will also be a high angular resolution system complementary to Next Generation Space Telescope (NGST). The scientific emphasis of the mission is on the evolution of protostellar systems, from just after the collapse of the precursor molecular cloud core, through the formation of the disk surrounding the protostar, the formation of planets in the disk, and eventual dispersal of the disk material. FKSI will also search for brown dwarfs and Jupiter mass and smaller planets, and could also play a very powerful role in the investigation of the structure of active galactic nuclei and extra-galactic star formation. We are in the process of studying alternative interferometer architectures and beam combination techniques, and evaluating the relevant science and technology tradeoffs. Some of the technical challenges include the development of the cryocooler systems necessary for the telescopes and focal plane array, light and stiff but well-damped truss systems to support the telescopes, and lightweight and coolable optical telescopes. The goal of the design study is to determine if a mid-infrared interferometry mission can be performed within the cost and schedule requirements of a Discovery class mission. At the present time we envision the FKSI as comprised of five one meter diameter telescopes arranged along a truss

structure in a linear non-redundant array, cooled to 35 K. A maximum baseline of 20 meters gives a nominal resolution of 26 mas at 5 microns. Using a Fizeau beam combination technique, a simple focal plane camera could be used to obtain both Fourier and spectral data simultaneously for a given orientation of the array. The spacecraft will be rotated to give sufficient Fourier data to reconstruct complex images of a broad range of astrophysical sources.
Author
Astrophysics; Imaging Techniques; Interferometers; Fourier Transformation; Protostars; Stellar Evolution; Space Missions

20020066590 Cornerstone Research Group, Inc., USA
Conformal Membrane Reflectors for Deployable Optics
Hood, Patrick J.; Keys, Andrew S., Technical Monitor; May 20, 2002; In English; 2nd Annual Technology Days, 22-24 May 2002, Huntsville, AL, USA
Contract(s)/Grant(s): NAS8-01115; No Copyright; Avail: Other Sources; Abstract Only

This presentation reports the Phase I results on NASA's Gossamer Spacecraft Exploratory Research and Technology Program. Cornerstone Research Group, Inc., the University of Rochester, and International Photonics Consultants collaborated to investigate the feasibility of free-standing, liquid-crystal-polymer (LCP) reflectors for integration into space-based optical systems. The goal of the program was to achieve large-diameter, broadband. reflective membranes that are resistant to the effects of space, specifically cryogenic environments and gamma-ray irradiation. Additionally, we assessed the applicability of utilizing the technology as tight sails, since, by their very nature, these films offer high-reflectivity at specified wavelengths. Previous research programs have demonstrated all-polymer, narrow-band Specular reflectors and diffuse membrane reflectors. The feasibility of fabricating an all-polymer broadband specular reflector and a narrow-band specular membrane reflector was assessed in the Phase I Gossamer program. In addition, preliminary gamma irradiation studies were conducted to determine the stability of the polymer reflectors to radiation. Materials and process technology were developed to fabricate coupon-scale reflectors of both broad- and narrow-band specular reflectors in Phase 1. This presentation will report the results of these studies, including, the performance of a narrow-band specular membrane. Gamma irradiation exposures indicate limited impact on the optical performance although additional exposure studies are warranted. Plans to scale up the membrane fabrication process will be presented.
Author
Membranes; Reflectors; Sails; Spacecraft Propulsion; Space Flight

20020066585 NASA Marshall Space Flight Center, Huntsville, AL USA
MSFC/Ball Space-Act Test Results of SBMD
Hadaway, James; Brown, Bob; Eng, Ron; Stahl, Phil; [2002]; In English, 22-24 May 2002, Huntsville, AL, USA
Contract(s)/Grant(s): NCC2-800; No Copyright; Avail: Other Sources; Abstract Only

The results of two cryo tests of the SBMD that were funded by Ball Aerospace through a Space-Act Agreement with MSFC will be discussed. These tests followed the formal completion of the SBMD program. The PhaseCam interferometer, rather than the Wavescope Shack-Hartmann sensor, was used during these tests.
Author
Cryogenics; Aerospace Systems; Sensors; Performance Tests

20020062212 PROSystems, Inc., Sharpsburg, MD USA
Hollow Retroreflectors Offer Solid Benefits
Spinoff 2001: Special Millennium Feature; 2001; In English; Original contains color illustrations; No Copyright; Avail: CASI; E99, Hardcopy; There is no charge for this publication. Shipping and handling charges may apply.

A technician who lead a successful team of scientists, engineers, and other technicians in the design, fabrication, and characterization of cryogenic retroreflectors for the NASA Cassini/Composite Infrared Spectrometer (CIRS) mission to Saturn, developed a hollow retroreflector technology while working at NASA Goddard Space Flight Center. With 16 years of NASA experience, the technician teamed up with another NASA colleague and formed PROSystems, Inc., of Sharpsburg, Maryland, to provide the optics community with an alternative source for precision hollow retroreflectors. The company's hollow retroreflectors are front surface glass substrates assembled to provide many advantages over existing hollow retroreflectors and solid glass retroreflectors. Previous to this new technology, some companies chose not to use hollow retroreflectors due to large seam widths and loss of signal. The 'tongue and groove' facet design of PROSystems's retroreflector allows for an extremely small seam width of .001 inches. Feedback from users is very positive regarding this characteristic. Most of PROSystems's primary customers mount the hollow retroreflectors in chrome steel balls for laser

tracker targets in applications such as automobile manufacturing and spacecraft assembly.
Author
Fabrication; Flat Surfaces; Glass; Infrared Spectrometers; Retroreflectors

20020061297 NASA Glenn Research Center, Cleveland, OH USA
Preliminary Evaluation of Polyarylate Dielectric Films for Cryogenic Applications
Patterson, Richard L.; Hammoud, Ahmad; Fialla, Peter; April 2002; In English
Contract(s)/Grant(s): NAS3-00145; RTOP 297-60-10
Report No.(s): NASA/TM-2002-211382; NAS 1.15:211382; E-13210; No Copyright; Avail: CASI; A02, Hardcopy

Polymeric materials are used extensively on spacecraft and satellites in electrical power and distribution systems, as thermal blankets and optical surface coatings, as well as mechanical support structures. The reliability of these systems when exposed to the harsh environment of space is very critical to the success of the mission and the safety of the crew in manned-flight ventures. In this work, polyarylate films were evaluated for potential use as capacitor dielectrics and wiring insulation for cryogenic applications. Two grades of the film were characterized in terms of their electrical and mechanical properties before and after exposure to liquid nitrogen (-196 C). The electrical characterization consisted of capacitance and dielectric loss measure Cents in the frequency range of 50 Hz to 100 kHz, and volume and surface resistivities. The mechanical measurements performed included changes in tensile (Young's modulus, elongation-at-break, and tensile strength) and structural properties (dimensional change, weight, and surface morphology). The preliminary results, which indicate good stability of the polymer after exposure to liquid nitrogen, are presented and discussed.
Author
Electrical Properties; Dielectric Loss; Capacitors; Cryogenics; Thin Films; Thermal Insulation; Reliability; Antireflection Coatings

20020060462 NASA Goddard Space Flight Center, Greenbelt, MD USA
Cryo Cooler Induced Micro-Vibration Disturbances to the Hubble Space Telescope
Jedrich, Nick; Zimbelman, Darrell; Turczyn, Mark; Sills, Joel; Voorhees, Carl; Clapp, Brian; Brumfield, Mark, Technical Monitor; [2002]; In English; No Copyright; Avail: CASI; A02, Hardcopy

This paper presents an overview of the Hubble Space Telescope (HST) Near Infrared Camera and Multi-Object Spectrometer (NICMOS) Cryo Cooler (MCC) system, a description of the micro-vibration characterization testing performed, and a discussion of the simulated performance. The NCC is a reverse Brayton cycle system that employs micro turbo-machinery to provide cooling to the NICMOS instrument. Extensive testing was conducted to quantify the expected on-orbit disturbances caused by the micro turbo-machinery and provide input to a flexible-body dynamic simulation to demonstrate compliance with the HST 7 milli-arcsecond root mean square jitter requirement.
Author
Hubble Space Telescope; Spectrometers; Satellite Instruments; Cooling Systems

20020054211 NASA Ames Research Center, Moffett Field, CA USA
Specification and Design of the SBRC-190: A Cryogenic Multiplexer for Far Infrared Photoconductor Detectors
Erickson, E. F.; Young, E. T.; Wolf, J.; Asbrock, J. F.; Lum, N.; DeVincenzi, D., Technical Monitor; [2002]; In English; SPIE Conference on Astronomical Telescope and Instrumentation, 22-28 Aug. 2002, HI, USA
Contract(s)/Grant(s): RTOP 263-10-30; No Copyright; Avail: Other Sources; Abstract Only

Arrays of far-infrared photoconductor detectors operate at a few degrees Kelvin and require electronic amplifiers in close proximity. For the electronics, a cryogenic multiplexer is ideal to avoid the large number of wires associated with individual amplifiers for each pixel, and to avoid adverse effects of thermal and radiative heat loads from the circuitry. For low background applications, the 32 channel CRC 696 CMOS device was previously developed for SIRTF, the cryogenic Space Infrared Telescope Facility. For higher background applications, we have developed a similar circuit, featuring several modifications: (a) an AC coupled, capacitive feedback transimpedence unit cell, to minimize input offset effects, thereby enabling low detector biases, (b) selectable feedback capacitors to enable operation over a wide range of backgrounds, and (c) clamp and sample & hold output circuits to improve sampling efficiency, which is a concern at the high readout rates required. We describe the requirements for and design of the new device.
Author
Amplifiers; Cryogenics; Far Infrared Radiation; Multiplexing; Photoconductors; Specifications

20020051004 NASA Marshall Space Flight Center, Huntsville, AL USA

Evaluation of Impinging Stream Vortex Chamber Concepts for Liquid Rocket Engine Applications

Trinh, Huu P.; Bullard, Brad; Kopicz, Charles; Michaels, Scott; Turner, James, Technical Monitor; Dec. 14, 2001; In English; JANNAF CS/APS/PSHS/MSS Joint Meeting, 8-12 Apr. 2002, Destin, FL, USA; No Copyright; Avail: Other Sources; Abstract Only

To pursue technology developments for future launch vehicles, NASA/Marshall Space Flight Center (MSFC) is examining vortex chamber concepts for liquid rocket engine applications. Past studies indicated that the vortex chamber schemes potentially have a number of advantages over conventional chamber methods. Due to the nature of the vortex flow, relatively cooler propellant streams tend to flow along the chamber wall. Hence, the thruster chamber can be operated without the need of any cooling techniques. This vortex flow also creates strong turbulence, which promotes the propellant mixing process. Consequently, the subject chamber concepts not only offer the system simplicity, but they also would enhance the combustion performance. The test results showed that the chamber performance was markedly high even at a low chamber length-to-diameter ratio (L/D). This incentive can be translated to a convenience in the thrust chamber packaging. Variations of the vortex chamber concepts have been introduced in the past few decades. These investigations include an ongoing work at Orbital Technologies Corporation (ORBITEC). By injecting the oxidizer tangentially at the chamber convergence and fuel axially at the chamber head end, Knuth et al. were able to keep the wall relatively cold. A recent investigation of the low L/D vortex chamber concept for gel propellants was conducted by Michaels. He used both triplet (two oxidizer and one fuel orifices) and unlike impinging schemes to inject propellants tangentially along the chamber wall. Michaels called the subject injection scheme as Impinging Stream Vortex Chamber (ISVC). His preliminary tests showed that high performance, with an Isp efficiency of 92%, can be obtained. MSFC and the U.S. Army are jointly investigating an application of the ISVC concept for the cryogenic oxygen/hydrocarbon propellant system. This vortex chamber concept is currently tested with gel propellants at AMCOM at Redstone Arsenal, Alabama. A version of this concept for the liquid oxygen (LOX)/hydrocarbon fuel (RPM) system has been derived from the one for the gel propellant.

Author

Combustion; Liquid Propellant Rocket Engines; Streams; Vortices; Thrust Chambers

20020050395 NASA Marshall Space Flight Center, Huntsville, AL USA

Zero Gravity Cryogenic Vent System Concepts for Upper Stages

Flachbart, Robin H.; Holt, James B.; Hastings, Leon J.; The Tenth Thermal and Fluids Analysis Workshop; July 2001; In English; Original contains color illustrations; No Copyright; Avail: CASI; A03, Hardcopy

The capability to vent in zero gravity without resettling is a technology need that involves practically all uses of sub-critical cryogenics in space, and would extend cryogenic orbital transfer vehicle capabilities. However, the lack of definition regarding liquid/ullage orientation coupled with the somewhat random nature of the thermal stratification and resulting pressure rise rates, lead to significant technical challenges. Typically a zero gravity vent concept, termed a thermodynamic vent system (TVS), consists of a tank mixer to destratify the propellant, combined with a Joule-Thomson (J-T) valve to extract thermal energy from the propellant. Marshall Space Flight Center's (MSFC's) Multipurpose Hydrogen Test Bed (MHTB) was used to test both spray-bar and axial jet TVS concepts. The axial jet system consists of a recirculation pump heat exchanger unit. The spray-bar system consists of a recirculation pump, a parallel flow concentric tube heat exchanger, and a spray-bar positioned close to the longitudinal axis of the tank. The operation of both concepts is similar. In the mixing mode, the recirculation pump withdraws liquid from the tank and sprays it into the tank liquid, ullage, and exposed tank surfaces. When energy extraction is required, a small portion of the recirculated liquid is passed sequentially through the J-T expansion valve, the heat exchanger, and is vented overboard. The vented vapor cools the circulated bulk fluid, thereby removing thermal energy and reducing tank pressure. The pump operates alone, cycling on and off, to destratify the tank liquid and ullage until the liquid vapor pressure reaches the lower set point. At that point, the J-T valve begins to cycle on and off with the pump. Thus, for short duration missions, only the mixer may operate, thus minimizing or even eliminating boil-off losses.

Author

Cryogenics; Vents; Heat Exchangers; Pressure Reduction; Tube Heat Exchangers; Vapor Pressure; Weightlessness

20020050200 Micromega Dynamics S.A., Angleur, Belgium

MABE: High-Precision Tip/Tilt Mechanism Based on Magnetic Bearing Technology

Loix, N.; Verschueren, J. P.; Scolamiero, L.; Proceedings of the 36th Aerospace Mechanisms Symposium; April 2002; In English; No Copyright; Avail: CASI; A02, Hardcopy

This paper presents a three degrees-of-freedom long-stroke, high-resolution tip/tilt mechanism for space interferometric

mission applications based on magnetic bearing technology. A breadboard model of the mechanism has been developed and successfully passed environmental and functional tests. The translational and rotational resolutions are respectively 1 nm (over a 5-mm stroke) and 10 nrad (over the two 5 mrad rotation ranges). Thanks to the innovative magnetic bearing design, the power dissipation in the mechanism (under gravity compensated conditions) is less than 1 mW, which makes it a good candidate for infrared interferometric applications in a cryogenic environment where dissipated power has to be minimized. An in-orbit test demonstration of a proto-flight mechanism model is currently under preparation, and is to be flown on board the Space Shuttle GAS canister carrier. The presented activity has been performed within the ESA GSTP research program.
Author
Attitude (Inclination); Breadboard Models; Magnetic Bearings

20020048545 Lockheed Martin Michoud Space Systems, New Orleans, LA USA
FSW Implementation on the Space Shuttle's External Tank
Hartley, Paula J.; Hartley, David E.; McCool, Alex, Technical Monitor; [2002]; In English; Edison Welding Institute/Navy Joint Center Workshop, 14-15 May 2002, Columbus, OH, USA
Contract(s)/Grant(s): NAS8-00016; No Copyright; Avail: CASI; A03, Hardcopy

The Friction Stir Welding process developed by The Welding Institute (TWI) has found application throughout the transportation industry. This technique has proven to be a viable joining process for aluminum alloys, producing virtually defect free welds with improved mechanical properties as compared to conventional fusion welding. Lockheed Martin Space Systems - Michoud Operations has been developing this technology for application on aluminum 2219 and 2195 cryogenic tankage since 1995. This effort will come to fruition with implementation on the longitudinal welds of the External Fuel Tank (ET) of the Shuttle. To this end, sub-and full-scale demonstration programs coupled with process development and optimization have been complete. Full size ET tool has been designed, fabricated and are being installed at the Michoud Assembly Facility. Upon completion of the tooling certification and materials allowables testing, production will commence. This implementation will result in increased reliability and safety of flight for the Shuttle.
Author
External Tanks; Friction Welding; Reliability; Space Shuttles; Welded Joints; Aluminum Alloys

20020045499 Dayton Univ. Research Inst., OH USA
Polymer Matrix Composite (PMC) Damage Tolerance and Repair Technology
Kim, Ran Y.; Apr. 2001; In English; Original contains color images
Contract(s)/Grant(s): F33615-95-D-5029; AF Proj. 4347
Report No.(s): AD-A400690; UDR-TR-2001-00041; AFRL-ML-WP-TR-2001-4176; No Copyright; Avail: CASI; A03, Hardcopy

The application of composites in space structures such as reusable launch vehicles requires a detailed understanding of their mechanical behavior and damage resistance in the service environment. Experimental and analytical studies were conducted on IM7/977-3, a graphite-toughened epoxy, to characterize the influence of cryogenic service temperatures on the strength, modulus, and fracture of this material system, and on transverse crack initiation in cross-ply laminates at 23, -129, and -196 deg C. Transverse tensile and shear strengths and moduli increased at the cryogenic test temperatures while strain to failure decreased, denoting increased brittleness. The stress for the onset of transverse cracking decreased substantially at cryogenic temperatures, due primarily to an increase in the curing residual stresses. Laminated plate theory, in conjunction with maximum stress criteria, appears to overestimate the onset of the transverse cracking in this laminate.
DTIC
Composite Materials; Cryogenic Temperature; Large Space Structures; Modulus of Elasticity; Damage; Tolerances (Mechanics)

20020039696 NASA Kennedy Space Center, Cocoa Beach, FL USA, DYNACS Engineering Co., Inc., Cocoa Beach, FL USA
Heat Transfer Study for HTS Power Transfer Cables
Augustynowicz, S.; Fesmire, J.; [2002]; In English, 15-19 Apr. 2002, Prague, Czechoslovakia
Contract(s)/Grant(s): NAS10-98001; No Copyright; Avail: CASI; A01, Hardcopy

Thermal losses are a key factor in the successful application of high temperature superconducting (HTS) power cables. Existing concepts and prototypes rely on the use of multilayer insulation (MLI) systems that are subject to large variations in actual performance. The small space available for the thermal insulation materials makes the application even more difficult

because of bending considerations, mechanical loading, and the arrangement between the inner and outer piping. Each of these mechanical variables affects the heat leak rate. These factors of bending and spacing are examined in this study. Furthermore, a maintenance-free insulation system (high vacuum level for 20 years or longer) is a practical requirement. A thermal insulation system simulating a section of a flexible FITS power cable was constructed for test and evaluation on a research cryostat. This paper gives experimental data for the comparison of ideal MLI, MLI on rigid piping, and MLI between flexible piping. A section of insulated flexible piping was tested under cryogenic vacuum conditions including simulated bending and spacers.
Author
Heat Transfer; High Temperature; Superconductivity; Power Lines; Cryogenics; Thermal Insulation

20020038972 Jet Propulsion Lab., California Inst. of Tech., Pasadena, CA USA
Novel Multiplexing Technique for Detector and Mixer Arrays
Karasik, Boris S.; McGrath, William R.; Proceedings of the Twenlfth International Symposium on Space Terahertz Technology; December 2001; In English; No Copyright; Avail: CASI; A02, Hardcopy

Future submillimeter and far-infrared space telescopes will require large-format (many 1000's of elements) imaging detector arrays to perform state-of-the-art astronomical observations. A crucial issue related to a focal plane array is a readout scheme which is compatible with large numbers of cryogenically-cooled (typically \h 1 K) detectors elements. When the number of elements becomes of the order of thousands, the physical layout for individual readout amplifiers becomes nearly impossible to realize for practical systems. Another important concern is the large number of wires leading to a 0.1-0.3 K platform. In the case of superconducting transition edge sensors (TES), a scheme for time-division multiplexing of SQUID read-out amplifiers has been recently demonstrated. In this scheme the number of SQUIDs is equal to the number (N) of the detectors, but only one SQUID is turned on at a time. The SQUIDs are connected in series in each column of the array, so the number of wires leading to the amplifiers can be reduced, but it is still of the order of N. Another approach uses a frequency domain multiplexing scheme of the bolometer array. The bolometers are biased with ac currents whose frequencies are individual for each element and are much higher than the bolometer bandwidth. The output signals are connected in series in a summing loop which is coupled to a single SQUID amplifier. The total number of channels depends on the ratio between the SQUID bandwidth and the bolometer bandwidth and can be at least 100 according to the authors. An important concern about this technique is a contribution of the out-of-band Johnson noise which multiplies by factor N(exp 1/2) for each frequency channel. We propose a novel solution for large format arrays based on the Hadamard transform coding technique which requires only one amplifier to read out the entire array of potentially many 1000's of elements and uses approximately 10 wires between the cold stage and room temperature electronics. This can significantly reduce the complexity of the readout circuits.
Derived from text
Bolometers; Squid (Detectors); Wire; Readout

20020033232 NASA Goddard Space Flight Center, Greenbelt, MD USA
Dynamic Response Assessment for the MEMS Accelerometer Under Severe Shock Loads
Fan, Mark S.; Shaw, Harry C.; October 2001; In English
Report No.(s): NASA/TP-2001-209978; Rept-2002-01008-0; NAS 1.60:209978; No Copyright; Avail: CASI; A04, Hardcopy

NASA Goddard Space Flight Center (GSFC) has evaluated the dynamic response of a commercial-off-the-shelf (COTS) microelectromechanical systems (MEMS) device made by Analog Device, Inc. The device is designated as ADXL250 and is designed mainly for sensing dynamic acceleration. It is also used to measure the tilting angle of any system or component from its original level position. The device has been in commercial use (e.g., in automobile airbag deployment system as a dual-axial accelerometer and in the electronic game play-station as a tilting sensor) with success, but NASA needs an in-depth assessment of its performance under severe dynamic shock environments. It was realized while planning this evaluation task that two assessments would be beneficial to NASA's missions: (1) severe dynamic shock response under nominal thermal environments; and (2) general dynamic performance under cryogenic environments. The first evaluation aims at obtaining a good understanding of its micromachined structure within a framework of brittle fracture dynamics, while the second evaluation focuses on the structure integrity under cryogenic temperature conditions. The information we gathered from the manufacturer indicated that the environmental stresses under NASA's evaluation program have been far beyond what the device has experienced with commercial applications, for which the device was designed. Thus NASA needs the outcome of this evaluation in order to make the selection for possible use for its missions. This paper provides details of the first evaluation

the dynamic response under severe multi-axial single-pulse shock load. It was performed using finite element tools with nonlinear dynamics procedures.
Author
Accelerometers; Commercial Off-the-Shelf Products; Dynamic Response; Microelectromechanical Systems; Finite Element Method

20020030761 NASA Marshall Space Flight Center, Huntsville, AL USA
Artificial Aging Effects on Cryogenic Fracture Toughness of the Main Structural Alloy for the Super Lightweight Tank
Chen, P. S.; Stanton, W. P.; February 2002; In English
Report No.(s): NASA/TM-2002-211546; M-1041; NAS 1.15:211546; No Copyright; Avail: CASI; A03, Hardcopy

In 1996, Marshall Space Flight Center developed a multistep heating rate-controlled (MSRC) aging technique that significantly enhanced cryogenic fracture toughness (CFT) and reduced the statistical spread of fracture toughness values in alloy 2195 by controlling the location and size of strengthening precipitate T1. However, it could not be readily applied to flight-related hardware production, primarily because large-scale production furnaces are unable to maintain a heating rate of 0.6 C (1 F)/hr. In August 1996, a new program was initiated to determine whether the MSRC aging treatment could be further modified to facilitate its implementation to flight hardware production. It was successfully redesigned into a simplified two-step aging treatment consisting of 132 C (270 F)/20 hr + 138 C (280 F)/40 hr. Results indicated that two-step aging can achieve the same yield strength levels as those produced by conventional aging while providing greatly improved ductility. Two-step aging proved to be very effective at enhancing CFT, enabling previously rejected materials to meet simulated service requirements. Cryogenic properties are improved by controlling T1 nucleation and growth so that they are promoted in the matrix and suppressed in the subgrain boundaries.
Author
Fracture Strength; Aging (Metallurgy); Heat Treatment; Precipitation Hardening; Aluminum-Lithium Alloys; Copper Alloys

20020030745 NASA Marshall Space Flight Center, Huntsville, AL USA
Cryogenic Fracture Toughness Improvement for the Super Lightweight Tank's Main Structural Alloy
Chen, P. S.; Stanton, W. P.; February 2002; In English
Report No.(s): NASA/TM-2002-211547; M-1042; NAS 1.15:211547; No Copyright; Avail: CASI; A03, Hardcopy

Marshall Space Flight Center has developed a two-step (TS) artificial aging technique that can significantly enhance cryogenic fracture toughness and resistance to stress corrosion cracking (SCC) in aluminum-copper-lithium alloy 2195. The new TS aging treatment consists of exposures at 132 C (270 F)/20 hr + 138 C (280 F)/42 hr, which can be readily applied to flight hardware production. TS aging achieves the same yield strength levels as conventional aging, while providing much improved ductility in the short transverse direction. After TS aging, five previously rejected lots of alloy 2195 (lots 950M029B, 960M030F, 960M030J, 960M030K, and 960M030L) passed simulated service testing for use in the super lightweight tank program. Each lot exhibited higher fracture toughness at cryogenic temperature than at ambient temperature. Their SCC resistance was also enhanced. All SCC specimens passed the minimum 10-day requirement in 3.5-percent sodium chloride alternate immersion at a stress of 45 ksi. The SCC lives ranged from 57 to 83 days, with an average of 70 days.
Author
Cryogenics; Fracture Strength; Aging (Metallurgy); Mechanical Properties; High Strength Alloys; Stress Corrosion Cracking

20020027352 NASA Ames Research Center, Moffett Field, CA USA
Performance Testing of a Lightweight, High Efficiency 95 K Cryocooler
Salerno, Lou; Kittel, P.; Kashani, A.; Helvensteijn, B. P. M.; Tward, E.; Arnold, Jim A., Technical Monitor; [2001]; In English; Nineteenth International Cryogenic Engineering Conference, 22-26 Jul. 2002, Grenoble, France; No Copyright; Avail: Other Sources; Abstract Only

Performance data are presented for a flight-like, lightweight, high efficiency pulse tube cryogenic cooler. The cooler has a mass of less than 4.0 kg, and an efficiency of 12 W/W, which is 18% of Carnot at 95 K, nearly double the efficiency of previous cooler designs, The mass of the cooler has been reduced by approximately a factor of three. The design point cooling power is 10 watts at 95 K at a heat rejection temperature of 300 K. The no-load temperature is 45 K. The compressor is built by Hymatic Engineering, UK, and is of a horizontally opposed piston design using flexure bearings. The vertical pulse tube is built by TRW with the heat exchanger or cold block located approximately mid-way along the tube. The final assembly and integration is also performed by TRW. The inertance tube and dead volume are contained within one of the compressor end caps. The cooler was developed by TRW under a joint NASA-DOD program, and has a goal of 10 yr operating lifetime.

Potential NASA applications will focus on using coolers of this type in Zero boil off (ZBO) cryogen storage topologies for next generation launch vehicles. Zero boil off systems will feature significant reductions in tank size and Initial Mass to Low Earth Orbit (IMLEO), thereby significantly reducing the cost of access to space, and enabling future missions. The coolers can be used directly in liquid oxygen (LOx) or liquid methane ZBO systems, as shield coolers in liquid hydrogen tanks, or as first stage coolers in two-stage liquid hydrogen (LH2) ZBO cooler systems. Finally, the coolers could find applications in exploration missions where either propellants or breathable oxygen are extracted from the planetary atmosphere using a Sabatier or similar process. The gases could then be liquefied for storage either directly in return vehicle propellant tanks or on the planetary surface. Data presented were taken with the cooler operating in a vacuum of 10 (exp -5) torr, at controlled rejection temperatures from 300 K down to 275 K using a cold water heat exchanger bolted to the cooler. Heat loads were varied between 0.5 W and 15 W by supplying current to a 50 omega resistor mounted on a copper cold plate which was bolted to the cooler cold block. Silicon diodes mounted on both the cold plate and the heat exchanger provided accurate temperature measurement to within plus or minus 0.25 K and plus or minus 0.5 K respectively, up to 100 K with plus or minus 1% accuracy above 100 K. Input power to the compressor was limited to 180 W, corresponding to a maximum stroke of 80%.
Author
Cryogenic Cooling; Performance Tests; Planetary Atmospheres; Cooling Systems

20020022179 NASA Marshall Space Flight Center, Huntsville, AL USA
Autofrettage to Counteract Coefficient of Thermal Expansion Mismatch in Cryogenic Pressurized Pipes with Metallic Liners
Wen, Ed; Barbero, Ever; Tygielski, Phlip; Turner, James E., Technical Monitor; [2001]; In English; No Copyright; Avail: CASI; A03, Hardcopy

Composite feedlines with metal liners have the potential to reduce weight/cost while providing the same level of permeation resistance and material compatibility of all-metal feedlines carrying cryogenic propellants in spacecraft. The major technical challenges are the large difference in Coefficient of Thermal Expansion between the liner and the composite, and the manufacturing method required to make a very thin liner with the required strength and dimensional tolerance. This study investigates the use of autofrettage (compressive preload) to counteract Coefficient of Thermal Expansion when pre-pressurization procedures cannot be used to solve this problem. Promising materials (aluminum 2219, Inconel 718, nickel, nickel alloy) and manufacturing techniques (chemical milling, electroplating) are evaluated to determine the best liner candidates. Robust, autofrettaged feedlines with a low Coefficient of Thermal Expansion liner (Inconel 718 or nickel alloy) are shown to successfully counteract mismatch at LOX temperature. A new concept, autofrettage by temperature, is introduced for high Coefficient of Thermal Expansion materials (aluminum and pure nickel) where pressure cannot be used to add compressive preload.
Author
Cryogenics; Feed Systems; Linings; Pipes (Tubes); Thermal Expansion; Fretting

20020021915 NASA Glenn Research Center, Cleveland, OH USA
Low Temperature Testing of a Radiation Hardened CMOS 8-Bit Flash Analog-to-Digital (A/D) Converter
Gerber, Scott S.; Hammoud, Ahmad; Elbuluk, Malik E.; Patterson, Richard L.; Overton, Eric; Ghaffarian, Reza; Ramesham, Rajeshuni; Agarwal, Shri G.; July 2001; In English, 29 Jul. - 2 Aug. 2001, Savannah, GA, USA
Contract(s)/Grant(s): RTOP 755-A4-12
Report No.(s): NASA/TM-2001-211074; NAS 1.15:211074; E-12913; IECEC2001-AT-31; No Copyright; Avail: CASI; A03, Hardcopy

Power processing electronic systems, data acquiring probes, and signal conditioning circuits are required to operate reliably under harsh environments in many of NASA’s missions. The environment of the space mission as well as the operational requirements of some of the electronic systems, such as infrared-based satellite or telescopic observation stations where cryogenics are involved, dictate the utilization of electronics that can operate efficiently and reliably at low temperatures. In this work, radiation-hard CMOS 8-bit flash A/D converters were characterized in terms of voltage conversion and offset in the temperature range of +25 to -190 C. Static and dynamic supply currents, ladder resistance, and gain and offset errors were also obtained in the temperature range of +125 to -190 C. The effect of thermal cycling on these properties for a total of ten cycles between +80 and -150 C was also determined. The experimental procedure along with the data obtained are reported and discussed in this paper.
Author
Radiation Hardening; CMOS; Analog to Digital Converters; Cryogenics

20020021910 NASA Marshall Space Flight Center, Huntsville, AL USA

Structural Analysis of a 50 cm Diameter Open-back Triangular Cell Beryllium Mirror in a Cryogenic Environment

Craig, Larry; Smithers, Martin; Nein, Max; Hadaway, James; Throckmorton, D. A., Technical Monitor; [2001]; In English; SPIE International Symposium on Optical Science and Technology, 29 Jul. - 3 Aug. 2001, San Diego, CA, USA; No Copyright; Avail: CASI; A03, Hardcopy

This paper discusses NASTRAN structural analysis of the Sub-Scale Beryllium Mirror Demonstrator (SBMD), which has been developed by Ball Aerospace as an experimental design concept for the Next Generation Space Telescope (NGST). The mirror was repeatedly subjected to 35 K environment in the large cryogenic test chamber at Marshall Space Flight Center. Deformations on the mirror surface were measured optically. The surface distortions predicted by NASTRAN are analyzed optically for comparison with the measured values. Model results compare favorably with measured results for ambient temperature validation cases. For the cryogenic environment case the influence of geometry and material property variations is being investigated to obtain closer correlation.

Author

Mirrors; Structural Analysis; Computerized Simulation

20020018141 Thomas Jefferson National Accelerator Facility, Newport News, VA USA

Design of the SNS Cryomodule

Schneider, W.; Daly, E.; Hogan, J.; Hiatt, T.; Kneisel, P.; Jun. 01, 2001; In English

Report No.(s): DE2001-783617; JLAB-ACE-01-05; DOE/ER/40150-1870; No Copyright; Avail: Department of Energy Information Bridge

Plans are underway to develop a medium beta (0.61) and a high beta (0.81) cryomodule for the super-conducting portion of the Spallation Neutron Source (SNS). This paper describes the design of these cryomodules that provide a significant portion of the total acceleration to the proton beam. The design minimizes the effect of losses on cavity performance by preserving cavity cleanliness, maintaining high vacuum and shielding the cavity from the earth's magnetic field. A modal analysis was performed to maintain resonance by minimizing cavity microphonics and provide cavity tuning. The cryomodule design optimizes the cryostat heat load to the refrigerator on the primary (2 K), secondary (5 K) and shield (50 K) circuits and facilitates production of multiple modules (thirty-two maximum) at a reasonable cost. The paper describes the two types of cavities, the helium vessel, the tuner, the magnetic shields, the thermal shield, the power couplers, the space frame, the vacuum tank and the end cans that make up the medium and high beta cryomodules.

NTIS

Superconducting Devices; Neutron Sources; Cryogenics; Spallation; Particle Acceleration

20020017750 Sverdrup Technology, Inc., Huntsville, AL USA

Analytical Modeling of Variable Density Multilayer Insulation for Cryogenic Storage

Hedayat, A.; Hastings, L. J.; Brown, T.; Cruit, Wendy, Technical Monitor; [2001]; In English; Cryogenic Engineering Conference, 16-20 Jul. 2001, Madison, WI, USA

Contract(s)/Grant(s): NAS8-00187; No Copyright; Avail: CASI; A02, Hardcopy

A unique foam/Multilayer Insulation (MLI) combination concept for orbital cryogenic storage was experimentally evaluated at NASA Marshall Space Flight Center (MSFC) using the Multipurpose Hydrogen Test Bed (MHTB). The MLI was designed for an on-orbit storage period of 45 days and included several unique features such as: a variable layer density and larger but fewer perforations for venting during ascent to orbit. Test results with liquid hydrogen indicated that the MLI weight or heat leak is reduced by about half in comparison with standard MLI. The focus of this paper is on analytical modeling of the Variable Density MLI (VD-MLI) on-orbit performance (i.e. vacuum/low pressure environment). The foam/VD-MLI combination model is considered to have five segments. The first segment represents the optional foam layer. The second, third, and fourth segments represent three MLI segments with different layer densities. The last segment is considered to be a shroud that surrounds the last MLI layer. Two approaches are considered. In the first approach, the variable density MLI is modeled layer by layer while in the second approach, a semi-empirical model is applied. Both models account for thermal radiation between shields, gas conduction, and solid conduction through the layer separator materials.

Author

Mathematical Models; Density (Mass/Volume); Multilayer Insulation; Foams

20020017748 NASA Marshall Space Flight Center, Huntsville, AL USA

Cryogenic Propellant Long-Term Storage With Zero Boil-Off

Hedayat, Ali; Hastings, L. J.; Bryant, C.; Plachta, D. W.; Cruit, Wendy, Technical Monitor; [2001]; In English; Cryogenic Engineering Conference, 16-20 Jul. 2001, Madison, WI, USA

Contract(s)/Grant(s): NAS8-00187; No Copyright; Avail: CASI; A01, Hardcopy

Significant boil-off losses from cryogenic propellant storage systems in long-duration space mission applications result in additional propellant and larger tanks. The potential propellant mass loss reductions with the Zero Boil-off (ZBO) concept are substantial; therefore, further exploration through technology programs has been initiated within NASA. A large-scale demonstration of the ZBO concept has been devised utilizing the Marshall Space Flight Center (MSFC) Multipurpose Hydrogen Test Bed (MHTB) along with a cryo-cooler unit. The ZBO concept consists of an active cryo-cooling system integrated with traditional passive thermal insulation. The cryo-cooler is interfaced with the MHTB and spraybar recirculation/mixer system in a manner that enables thermal energy removal at a rate that equals the total tank heat leak. The liquid hydrogen (LH2) is withdrawn from the tank, passed through a heat exchanger, and then the chilled liquid is sprayed back into the tank through a spraybar. The test series will be performed over a 20-30 day period. Tests will be conducted at multiple fill levels to demonstrate concept viability and to provide benchmark data to be used in analytical model development. In this paper the test set-up and test procedures are presented.

Author

Cryogenics; Propellant Storage; Propellant Tanks; Heat Exchangers; Leakage

20020016967 NASA Marshall Space Flight Center, Huntsville, AL USA

Space Resource Requirements for Future In-Space Propellant Production Depots

Smitherman, David; Fikes, John; Roy, Stephanie; Henley, Mark W.; Potter, Seth D.; Howell, Joe T., Technical Monitor; [2001]; In English; Space Resources Utilization Roundtable III, 24-26 Oct. 2001, Golden, CO, USA

Contract(s)/Grant(s): RTOP 905-22-00; No Copyright; Avail: CASI; A03, Hardcopy

In 2000 and 2001 studies were conducted at the NASA Marshall Space Flight Center on the technical requirements and commercial potential for propellant production depots in low Earth orbit (LEO) to support future commercial, NASA, and other Agency missions. Results indicate that propellant production depots appear to be technically feasible given continued technology development, and there is a substantial growing market that depots could support. Systems studies showed that the most expensive part of transferring payloads to geosynchronous orbit (GEO) is the fuel. A cryogenic propellant production and storage depot stationed in LEO could lower the cost of missions to GEO and beyond. Propellant production separates water into hydrogen and oxygen through electrolysis. This process utilizes large amounts of power, therefore a depot derived from advanced space solar power technology was defined. Results indicate that in the coming decades there could be a significant demand for water-based propellants from Earth, moon, or asteroid resources if in-space transfer vehicles (upper stages) transitioned to reusable systems using water based propellants. This type of strategic planning move could create a substantial commercial market for space resources development, and ultimately lead toward significant commercial infrastructure development within the Earth-Moon system.

Derived from text

Low Earth Orbits; Propellant Storage; Geosynchronous Orbits

20020016025 NASA Marshall Space Flight Center, Huntsville, AL USA

An Overview of NASA Efforts on Zero Boiloff Storage of Cryogenic Propellants

Hastings, Leon J.; Plachta, D. W.; Salerno, L.; Kittel, P.; Haynes, Davy, Technical Monitor; [2001]; In English; 2001 Space Cryogenics Workshop, 12-20 Jul. 2001, Milwaukee, WI, USA; No Copyright; Avail: CASI; A03, Hardcopy

Future mission planning within NASA has increasingly motivated consideration of cryogenic propellant storage durations on the order of years as opposed to a few weeks or months. Furthermore, the advancement of cryocooler and passive insulation technologies in recent years has substantially improved the prospects for zero boiloff storage of cryogenics. Accordingly, a cooperative effort by NASA's Ames Research Center (ARC), Glenn Research Center (GRC), and Marshall Space Flight Center (MSFC) has been implemented to develop and demonstrate 'zero boiloff' concepts for in-space storage of cryogenic propellants, particularly liquid hydrogen and oxygen. ARC is leading the development of flight-type cryocoolers, GRC the subsystem development and small scale testing, and MSFC the large scale and integrated system level testing. Thermal and fluid modeling involves a combined effort by the three Centers. Recent accomplishments include: 1) development of 'zero boiloff' analytical modeling techniques for sizing the storage tankage, passive insulation, cryocooler, power source mass, and radiators; 2) an early subscale demonstration with liquid hydrogen 3) procurement of a flight-type 10 watt, 95 K pulse tube cryocooler for liquid oxygen storage and 4) assembly of a large-scale test article for an early demonstration of the integrated

operation of passive insulation, destratification/pressure control, and cryocooler (commercial unit) subsystems to achieve zero boiloff storage of liquid hydrogen. Near term plans include the large-scale integrated system demonstration testing this summer, subsystem testing of the flight-type pulse-tube cryocooler with liquid nitrogen (oxygen simulant), and continued development of a flight-type liquid hydrogen pulse tube cryocooler.
Author
Cryogenic Cooling; Cryogenic Rocket Propellants; Mathematical Models; Evaporation; Storable Propellants; NASA Programs

20020012427 NASA Glenn Research Center, Cleveland, OH USA
Performance of High-Speed PWM Control Chips at Cryogenic Temperatures
Elbuluk, Malik E.; Gerber, Scott; Hammoud, Ahmad; Patterson, Richard; Overton, Eric; September 2001; In English, 30 Sep. - 5 Oct. 2001, Chicago, IL, USA
Contract(s)/Grant(s): NAS3-98008; RTOP 755-A4-12
Report No.(s): NASA/TM-2001-211123; NAS 1.15:211123; E-12972; No Copyright; Avail: CASI; A03, Hardcopy

The operation of power electronic systems at cryogenic temperatures is anticipated in many NASA space missions such as planetary exploration and deep space probes. In addition to surviving the space hostile environment, electronics capable of low temperature operation would contribute to improving circuit performance, increasing system efficiency, and reducing development and launch costs. As part of the NASA Glenn Low Temperature Electronics Program, several commercial high-speed Pulse Width Modulation (PWM) chips have been characterized in terms of their performance as a function of temperature in the range of 25 to -196 C (liquid nitrogen). These chips ranged in their electrical characteristics, modes of control, packaging options, and applications. The experimental procedures along with the experimental data obtained on the investigated chips are presented and discussed.
Author
Chips (Electronics); Cryogenic Temperature; Spacecraft Electronic Equipment; Integrated Circuits; Electronic Equipment Tests

20020011681 NASA Glenn Research Center, Cleveland, OH USA
Performance of Power Converters at Cryogenic Temperatures
Elbuluk, Malik E.; Gerber, Scott; Hammoud, Ahmad; Patterson, Richard L.; September 2001; In English, 2-5 Sep. 2001, Malta
Contract(s)/Grant(s): NAS3-00145; RTOP 755-A4-12
Report No.(s): NASA/TM-2001-211130; E-12979; NAS 1.15:211130; No Copyright; Avail: CASI; A02, Hardcopy

Power converters capable of operation at cryogenic temperatures are anticipated to play an important role in the power system architecture of future NASA deep space missions. Design of such converters to survive cryogenic temperatures will improve the power system performance and reduce development and launch costs. Aerospace power systems are mainly a DC distribution network. Therefore, DC/DC and DC/AC converters provide the outputs needed to different loads at various power levels. Recently, research efforts have been performed at the NASA Glenn Research Center (GRC) to design and evaluate DC/DC converters that are capable of operating at cryogenic temperatures. This paper presents a summary of the research performed to evaluate the low temperature performance of five DC/DC converters. Various parameters were investigated as a function of temperature in the range of 20 to -196 C. Data pertaining to the output voltage regulation and efficiency of the converters is presented and discussed.
Author
Cryogenic Temperature; Inverted Converters (DC to AC); Power Converters; Voltage Converters (DC to DC); Spacecraft Electronic Equipment

20020003351 NASA Kennedy Space Center, Cocoa Beach, FL USA
A Quadrupole Ion Trap Mass Spectrometer for Quantitative Analysis of Nitrogen-Purged Compartments within the Space Shuttle
Ottens, Andrew K.; Griffin, Timothy P.; Helms, William R.; Yost, Richard A.; Steinrock, T., Technical Monitor; [2001]; In English; ASMS Conference, 28-31 May 2001, Chicago, IL, USA
Contract(s)/Grant(s): NAS10-98001; No Copyright; Avail: CASI; A01, Hardcopy

To enter orbit the Space Shuttle burns 1.8 million liters of liquid hydrogen combined with 0.8 million liters of liquid oxygen through three rocket engines mounted in the aft. NASA monitors the nitrogen-purged aft compartment for increased levels of hydrogen or oxygen in order to detect and determine the severity of a cryogenic fuel leak. Current monitoring is

accomplished with a group of mass spectrometer systems located as much as 400 feet away from the shuttle. It can take up to 45 seconds for gas to reach the mass spectrometer, which precludes monitoring for leaks in the final moments before liftoff (the orbiter engines are started at T-00:06 seconds). To remedy the situation, NASA is developing a small rugged mass spectrometer to be used as point-sources around the Space Shuttle.
Author
Mass Spectrometers; Monitors; Quadrupoles; Quantitative Analysis; Space Shuttles

20020002753 NASA Kennedy Space Center, Cocoa Beach, FL USA
The Advanced Technology Development Center (ATDC)
Clements, G. R.; Willcoxon, R., Technical Monitor; [2001]; In English; STAIF-2002, 3-7 Feb. 2002, Albuquerque, NM, USA; No Copyright; Avail: CASI; A02, Hardcopy

NASA is building the Advanced Technology Development Center (ATDC) to provide a 'national resource' for the research, development, demonstration, testing, and qualification of Spaceport and Range Technologies. The ATDC will be located at Space Launch Complex 20 (SLC-20) at Cape Canaveral Air Force Station (CCAFS) in Florida. SLC-20 currently provides a processing and launch capability for small-scale rockets; this capability will be augmented with additional ATDC facilities to provide a comprehensive and integrated in situ environment. Examples of Spaceport Technologies that will be supported by ATDC infrastructure include densified cryogenic systems, intelligent automated umbilicals, integrated vehicle health management systems, next-generation safety systems, and advanced range systems. The ATDC can be thought of as a prototype spaceport where industry, government, and academia, in partnership, can work together to improve safety of future space initiatives. The ATDC is being deployed in five separate phases. Major ATDC facilities will include a Liquid Oxygen Area; a Liquid Hydrogen Area, a Liquid Nitrogen Area, and a multipurpose Launch Mount; 'Iron Rocket' Test Demonstrator; a Processing Facility with a Checkout and Control System; and Future Infrastructure Developments. Initial ATDC development will be completed in 2006.
Author
Launching Bases; Management Systems

20020002697 NASA Kennedy Space Center, Cocoa Beach, FL USA
Quick Cooling and Filling Through a Single Port for Cryogenic Transfer Operations
Jones, J. R.; Fesmire, James E.; MacDowell, L. G., Technical Monitor; [2001]; In English; Joint CEC and ICMC, 16-20 Jul. 2001, Madison, WI, USA
Contract(s)/Grant(s): NAS10-98001; No Copyright; Avail: CASI; A02, Hardcopy

Improved technology for the efficient transfer of cryogens is needed for future on-orbit fueling and remote Lunar/Mars operations. The cooling and filling of a liquid nitrogen (LN2) test vessel through a single port were investigated in a series of experiments. A new 'in-space' transfer tube design concept was used to demonstrate the ability to quickly cool and load cryogens through a single feed-through connection. Three different fill tube configurations with three different diameters were tested. The tubes providing the quickest cooldown time and the quickest fill time for the test article tank were determined. The results demonstrated a clear trade-off between cooling time and filling time for the optimum tube design. This experimental study is intended to improve technology for future flight tank designs by reducing fill system size, complexity, heat leak rate, and operations time. These results may be applied to Space Shuttle Power Reactant Storage and Distribution (PRSD) System upgrades and other future applications. Further study and experimental analysis for optimization of the fill tube design are in progress.
Author
Liquid Cooling; Pipes (Tubes); Liquid Nitrogen

20020001030 DYNACS Engineering Co., Inc., Cocoa Beach, FL USA
Chemical Engineering in Space
Lobmeyer, Dennis A.; Meneghelli, Barry J.; [2001]; In English, 11-13 Jul. 2001, Milwaukee, WI, USA
Contract(s)/Grant(s): NAS10-98001; No Copyright; Avail: CASI; A02, Hardcopy

The state of the art in launch systems uses chemical propulsion systems, primarily liquid hydrogen and liquid oxygen, to provide the energy necessary to achieve orbit and escape the bonds of Earth's gravity. In the future there may be other means available; however, currently few of these alternatives can compare to the speed or the ease of use provided by cryogenic chemical propulsion agents. Cryogenics, the science and art of producing cold operating conditions, has become increasingly important to our ability to travel within our solar system. The production and transport of cryogenic fuels as well as the

long-term storage of these fluids are necessary for mankind to travel within our solar system. It is with great care and at a significant cost that gaseous compounds such as hydrogen and oxygen are liquified and become dense enough to use for rocket fuel. As our explorations move farther away from Earth, we need to address how to produce the necessary fuels to make a complete round-trip. The cost and the size of any expedition to another celestial body are extreme. If we are constrained by the need to take everything necessary (fuel, life support, etc.) for our survival and return, we greatly increase the risk of being able to go. As with the early explorers on Earth, we will need to harvest much of our energy and our life support from the celestial bodies. The in situ production of these energy sources is paramount to success. Due to the current propulsion system designs, the in-situ processes will require liquefaction and the application of cryogenics. The challenge we face for the near future is to increase our understanding of cryogenic long-term storage and off-world production of cryogenic fluids. We must do this all within the boundaries of very restricted size, weight, and robustness parameters so that we may launch these apparatus from Earth and utilize them elsewhere. Miniaturization, efficiency, and physically robust systems will all play a part in making space exploration possible; however, it is cryogenics that will enable all of this to occur.
Author
Chemical Engineering; Cryogenics; Space Exploration; Cryogenic Fluids

20010120058 NASA Ames Research Center, Moffett Field, CA USA
Helium Dilution Cryocooler for Space Applications
Roach, Pat; Hogan, Robert, Technical Monitor; Feb. 26, 2001; In English; Original contains color illustrations
Contract(s)/Grant(s): RTOP 629-60-01; No Copyright; Avail: Other Sources; Abstract Only

NASA's New Millenium Program Space Technology presents the Helium Dilution Cryocooler for Space Applications. The topics include: 1) Capability; 2) Applications; and 3) Advantages. This paper is in viewgraph form.
CASI
Aerospace Engineering; Cryogenic Cooling; Helium; Technology Utilization

20010105243 BAE Systems, Lexington, MA USA
AIRS-Light Instrument Concept and Critical Technology Development
Maschhoff, Kevin; [2001]; In English, 28-30 Aug. 2001, Greenbelt, MD, USA
Contract(s)/Grant(s): NAS5-99140; No Copyright; Avail: CASI; A02, Hardcopy

Understanding Earth's climate, atmospheric transport mechanisms, and the hydrologic cycle requires a precise knowledge of global atmospheric circulation, temperature profiles, and water vapor distribution. The accuracy of advanced sounders such as AIRS/AMSU/HSB on NASA's Aqua spacecraft can match radiosonde accuracy. It is essential to fold those capabilities fully into the NPOESS, enabling soundings of radiosonde accuracy, every 6 hours around the globe on an operational basis. However, the size, mass, power demands, and thermal characteristics of the Aqua sounding instrument suite cannot be accommodated on the NPOESS spacecraft. AIRS-Light is an instrument concept, developed under the Instrument Incubator Program, which provides IR sounding performance identical to the AIRS instrument, but uses advances in HgCdTe FPA technology and pulse tube cooler technology, as well as design changes to dramatically reduce the size, mass, and power demand, allowing AIRS-Light to meet all NPOESS spacecraft interface requirements. The instrument concept includes substantial re-use of AIRS component designs, including the complex AIRS FPA, to reduce development risk and cost. The AIRS-Light Instrument Incubator program fostered the development of photovoltaic-mode HgCdTe detector array technology for the 13.5-15.4 micron band covered by photoconductive-mode HgCdTe arrays in AIRS, achieved state of the art results in this band, and substantially reduced the development risk for this last new technology needed for AIRS-Light implementation, A demonstration of a prototype 14.5-15.4 micron band IRFPA in a reduced heat-load dewar together with the IMAS pulse tube cryocooler is in progress.
Author
Atmospheric Circulation; Hydrological Cycle; Atmospheric Temperature; Water Vapor; Temperature Profiles; Radiosondes

20010097614 Los Alamos National Lab., NM USA
Low Luminosity Compact Stellar Objects and the Size of the Universe
Epstein, R. I.; Bailey, V.; Sep. 01, 2000; In English
Report No.(s): DE2001-764697; LA-UR-00-4674; No Copyright; Avail: Department of Energy Information Bridge

We have carried out an experimental and theoretical program in high-energy astrophysics. We participated in the creation of the Milagro Gamma Ray Observatory. This facility is a revolutionary advance in high-energy astrophysics that will be capable of observing TeV radiation from sources over much of the sky. We built a new class of compact, vibration-free solid

state cryocoolers that will enable space-based infrared imaging and gammaray spectroscopy missions. We developed theoretical models that describe the dynamical processes in neutron stars and explain how variations in pulsar periods indicate the occurrence of starquakes. We computed the encounters between red-giant stars and other stars to determine whether these events could explain the observed depletion of red-giants towards the center of the galaxy. We studied chaotic stellar orbits in galactic potentials with the aim of understanding the equilibrium structures of galaxies and interpreting recent data from the Hubble Space Telescope.
NTIS
Luminosity; Mathematical Models; Stellar Orbits; Universe; Asteroseismology

20010097151 Micro Craft, Inc., Huntsville, AL USA
The Nitrous Oxide - Propane Rocket Engine
Tyll, Jason S.; Herdy, Roger; Aug. 16, 2001; In English
Contract(s)/Grant(s): DABT63-00-C-1026
Report No.(s): AD-A393448; GSL-TR-387; No Copyright; Avail: CASI; A08, Hardcopy

This work, in response to DARPA BAA 99-22, topic title ‘ Small Scale Propulsion Systems,’ focused on the development of a nitrous oxide (N2o) / propane (C3H8) rocket engine (NOP), that utilizes catalytic decomposition of N20 as an ignition system for propane. This propellant combination is proposed as an alternative to the present space propulsion systems that use hypergolic or cryogenic liquids, or solid propellants. Phase I work has resulted in a successful demonstration of the key technologies associated with the development of such a propulsion system. In particular, rocket performance for the NOP propellants and catalytic decomposition of nitrous oxide were demonstrated. The work began with two parallel efforts: the experimental evaluation of rocket performance using nitrous oxide and propane as propellants, and an experimental evaluation of various catalysts for the decomposition of nitrous oxide. The development of a catalytic reactor to efficiently decompose N20 for propane autoignition was central to this research effort.
DTIC
Rocket Engines; Propane; Nitrous Oxides; Spontaneous Combustion

20010091010 NASA Glenn Research Center, Cleveland, OH USA
Electronic Components and Systems for Cryogenic Space Applications
Patterson, R. L.; Hammoud, A.; Dickman, J. E.; Gerber, S.; Elbuluk, M. E.; Overton, E.; August 2001; In English, 16-20 Jul. 2001, Madison, WI, USA
Contract(s)/Grant(s): NAS3-00145; RTOP 755-A4-12
Report No.(s): NASA/TM-2001-211129; NAS 1.15:211129; E-12978; No Copyright; Avail: CASI; A03, Hardcopy

Electronic components and systems capable of operation at cryogenic temperatures are anticipated in many future NASA space missions such as deep space probes and planetary surface exploration. For example, an unheated interplanetary probe launched to explore the rings of Saturn would reach an average temperature near Saturn of about - 183 C. In addition to surviving the deep space harsh environment, electronics capable of low temperature operation would contribute to improving circuit performance, increasing system efficiency, and reducing payload development and launch costs. Terrestrial applications where components and systems must operate in low temperature environments include cryogenic instrumentation, superconducting magnetic energy storage, magnetic levitation transportation system, and arctic exploration. An on-going research and development program at the NASA Glenn Research Center focuses on the development of reliable electronic devices and efficient power systems capable of surviving in low temperature environments. An overview of the program will be presented in this paper. A description of the low temperature test facilities along with selected data obtained from in-house component testing will also be discussed. Ongoing research activities that are being performed in collaboration with various organizations will also be presented.
Author
Research and Development; Space Probes; Spacecraft Electronic Equipment; Cryogenic Temperature

20010091008 NASA Glenn Research Center, Cleveland, OH USA
Low Temperature Testing of a Radiation Hardened CMOS 8-Bit Flash Analog-to-Digital (A/D) Converter
Gerber, Scott S.; Hammond, Ahmad; Elbuluk, Malik E.; Patterson, Richard L.; Overton, Eric; Ghaffarian, Reza; Ramesham, Rajeshuni; Agarwal, Shri G.; July 2001; In English, 29 Jul. - 2 Aug. 2001, Savannah, GA, USA
Contract(s)/Grant(s): NAS3-145; RTOP 755-A4-12
Report No.(s): NASA/TM-2001-211074; E-12913; NAS 1.15:211074; IECEC2001-AT-31; No Copyright; Avail: CASI; A03, Hardcopy

Power processing electronic systems, data acquiring probes, and signal conditioning circuits are required to operate reliably under harsh environments in many of NASA:s missions. The environment of the space mission as well as the operational requirements of some of the electronic systems, such as infrared-based satellite or telescopic observation stations where cryogenics are involved, dictate the utilization of electronics that can operate efficiently and reliably at low temperatures. In this work, radiation-hard CMOS 8-bit flash A/D converters were characterized in terms of voltage conversion and offset in the temperature range of +25 to -190 C. Static and dynamic supply currents, ladder resistance, and gain and offset errors were also obtained in the temperature range of +125 to -190 C. The effect of thermal cycling on these properties for a total of ten cycles between +80 and - 150 C was also determined. The experimental procedure along with the data obtained are reported and discussed in this paper.
Author
Cryogenics; CMOS; Analog to Digital Converters; Thermal Cycling Tests; Low Temperature Tests; Temperature Dependence; Digital Electronics

20010086595 NASA Marshall Space Flight Center, Huntsville, AL USA
COI Structural Analysis Presentation
Cline, Todd; Stahl, H. Philip, Technical Monitor; [2001]; In English; MSFC Technology Days, 9-10 May 2001, Huntsville, AL, USA
Contract(s)/Grant(s): NAS8-00187; No Copyright; Avail: Other Sources; Abstract Only

This report discusses the structural analysis of the Next Generation Space Telescope Mirror System Demonstrator (NMSD) developed by Composite Optics Incorporated (COI) in support of the Next Generation Space Telescope (NGST) project. The mirror was submitted to Marshall Space Flight Center (MSFC) for cryogenic testing and evaluation. Once at MSFC, the mirror was lowered to approximately 40 K and the optical surface distortions were measured. Alongside this experiment, an analytical model was developed and used to compare to the test results. A NASTRAN finite element model was provided by COI and a thermal model was developed from it. Using the thermal model, steady state nodal temperatures were calculated based on the predicted environment of the large cryogenic test chamber at MSFC. This temperature distribution was applied in the structural analysis to solve for the deflections of the optical surface. Finally, these deflections were submitted for optical analysis and comparison to the interferometer test data.
Author
Next Generation Space Telescope Project; Cryogenics; Structural Analysis; Mirrors; Deflection

20010086475 Sandia National Labs., Albuquerque, NM USA
Optical Interconnections to Focal Plane Arrays
Rienstra, J. L.; Hincklely, M. K.; Dec. 10, 2000; In English
Report No.(s): DE2001-769029; SAND2000-2882; No Copyright; Avail: Department of Energy Information Bridge

The objective of this project was to identify and refine candidate optical interconnection concepts and to demonstrate the selected concept. Several approaches for an optical data link are possible. An optical source can be located on the cold focal plane and directly modulated with the output signal voltage. Another choice involves the use of optical fibers or free space transmission across the warm-cold interface. The approach selected for this effort uses an optical source and receiver on the warm side of the interface, where power dissipation is not as critical as on the cryogenic side. A very low power optical modulation device on the cold side of the interface impresses the focal plane output signal on a free space optical beam.
NTIS
Optical Fibers; Optical Communication; Focal Plane Devices

20010081064 NASA Ames Research Center, Moffett Field, CA USA
An Explorer-Class Astrobiology Mission
Sandford, Scott; Greene, Thomas; Allamandola, Louis; Arno, Roger; Bregman, Jesse; Cox, Sylvia; Davis, Paul K.; Gonzales, Andrew; Haas, Michael; Hanel, Robert; DeVincenzi, Donald L., Technical Monitor, et al.; [2000]; In English; UV, Optical and IR Space Telescopes and Instruments, 26-31 Mar. 2000, Munich, Germany
Contract(s)/Grant(s): RTOP 632-70-04-03; No Copyright; Avail: CASI; A03, Hardcopy

In this paper we describe a potential new Explorer-class space mission, the AstroBiology Explorer (ABE), consisting of a relatively modest dedicated space observatory having a 50 cm aperture primary mirror which is passively cooled to T less than 65 K, resides in a low-background orbit (heliocentric orbit at 1 AU, Earth drift-away), and is equipped with a suite of three moderate order (m approx. 10) dispersive spectrographs equipped with first-order cross-dispersers in an ‘echellette’

configuration and large format (1024xl024 pixel) near- and mid-IR detector arrays cooled by a modest amount of cryogen. Such a system would be capable of addressing outstanding problems in Astrochemistry and Astrophysics that are particularly relevant to Astrobiology and addressable via astronomical observation. The observational program of this mission would make fundamental scientific progress in each of the key areas of the cosmic history of molecular carbon, the distribution and chemistry of organic compounds in the diffuse and dense interstellar media, and the evolution of ices and organic matter in young planetary systems. ABE could make fundamental progress in all of these areas by conducting an approximately one year mission to obtain a coordinated set of infrared spectroscopic observations over the 2.5-20 micrometers spectral range at spectral resolutions of R greater than or equal to 1000 of approximately 1000 galaxies, stars, planetary nebulae, and young star planetary systems.
Author
Astrophysics; Exobiology; Space Missions; Astronomical Models; Organic Compounds

20010080458 NASA Marshall Space Flight Center, Huntsville, AL USA
Evaluation of Microcracking in Two Carbon-Fiber/Epoxy-Matrix Composite Cryogenic Tanks
Hodge, A. J.; August 2001; In English; Original contains color illustrations
Report No.(s): NASA/TM-2001-211194; M-1024; NAS 1.15:211194; No Copyright; Avail: CASI; A03, Hardcopy

Two graphite/epoxy cryogenic pressure vessels were evaluated for microcracking. The X-33 LH2 tank lobe skins were extensively examined for microcracks. Specimens were removed from the inner skin of the X-33 tank for tensile testing. The data obtained from these tests were used to model expected microcrack density as a function of stress. Additionally, the laminate used in the Marshall Space Flight Center (MSFC) Composite Conformal, Cryogenic, Common Bulkhead, Aerogel-Insulated Tank (CBAT) was evaluated. Testing was performed in an attempt to predict potential microcracking during testing of the CBAT.
Author
Graphite-Epoxy Composites; Pressure Vessels; X-33 Reusable Launch Vehicle; Storage Tanks; Cryogenic Fluid Storage; Microcracks; Liquid Hydrogen

20010078971 NASA Marshall Space Flight Center, Huntsville, AL USA
XRCF Testing Capabilities
Reily, Cary; Kegely, Jeff; Burdine, Robert, Technical Monitor; [2001]; In English; MSFC Technology Days, 9-10 May 2001, Huntsville, AL, USA; No Copyright; Avail: Other Sources; Abstract Only

The Space Optics Manufacturing Technology Center's X-ray Calibration Facility has been recently modified to test Next Generation Space Telescope (NGST) developmental mirrors at cryogenic temperatures (35 degrees Kelvin) while maintaining capability for performance testing of x-ray optics and detectors. The facility's current cryo-optical testing capability and potential modifications for future support of NGST will be presented.
Author
X Ray Optics; Calibrating; Cryogenics; Performance Tests; Space Manufacturing; Mirrors

20010078914 NASA Marshall Space Flight Center, Huntsville, AL USA
Structural Analysis of a 50 cm Diameter Open-Back Triangular Cell Beryllium Mirror in a Cryogenic Environment
Craig, Larry; Stahl, H. Philip, Technical Monitor; [2001]; In English; MSFC Technology Days, 9-10 May 2001, Huntsville, AL, USA; No Copyright; Avail: Other Sources; Abstract Only

This paper discusses NASTRAN structural analysis of the Sub-Scale Beryllium Mirror Demonstrator (SBMD), which has been developed by Ball Aerospace as an experimental design concept for the Next Generation Space Telescope (NGST). The mirror was repeatedly subjected to 35K environment in the large cryogenic test chamber at Marshall Space Flight Center (MSFC). Deformations on the mirror surface were measured optically. The surface distortions predicted by NASTRAN are analyzed optically for comparison with the measured values. Model results compare favorably with measured results for an ambient temperature validation case. For the cryogenic environment case the influence of geometry and material property variations is being investigated to obtain closer correlation.
Author
Mirrors; Beryllium; Cryogenics; Structural Analysis; Surface Distortion; Deformation

20010076853 National Space Development Agency, Tsukuba, Japan
Study on the cryogenic tanks for Fully Reusable Space Transportation Vehicles
Morino, Yoshiko; Proceedings of Advanced Space Technology Workshop; September 2000; In English; Also available within the Conference Proceedings with 4 other reports on CD-ROM. See 20010068892.; Copyright; Avail: CASI; A02, Hardcopy; US Distribution and Sales Only

I would first like to speak about the objective and background of this study. To dramatically lower the cost of transportation to low Earth orbits in space, the idea of a single-stage fully reusable transportation vehicle with a rocket propulsion system is receiving much attention recently, and studies for realizing this type of a transportation system have begun in countries around the world. In Japan also, two years ago, a meeting was held to discuss the matter at the Science and Technology Agency, and it was decided then that studies should begin on these types of rocket planes. To construct this type of vehicle, the vehicle's weight must be reduced as far as possible. As you can see here, most of the weight of a vehicle comes from the propellant. Therefore, it is important to make the propellant tank lightweight. The transportation vehicle uses a cryogenic propellant. The main candidate among lightweight materials is a carbon-fiber reinforced composite material. However, it has never been used under such low-temperature conditions. Basic research must be carried out to confirm whether the material can withstand such an environment, and the Office of Research and Development is beginning to carry out studies on this theme as advanced research. The main technical issue right now is to determine potential problems, and at this point, I think we must evaluate whether the newly developed high-performance materials have sufficient strength and toughness. The size of a tank for a practical vehicle would have a large diameter that is approx. 8 m long. Is it possible to construct such a large structure out of CFRP? Furthermore, because the tank will contain fuel, no leaks are allowed. These issues are critical.
Derived from text
Carbon Fiber Reinforced Plastics; Cryogenic Fluid Storage; Propellant Tanks; Reusable Spacecraft

20010073391 NASA Goddard Space Flight Center, Greenbelt, MD USA
Far-Infrared Extragalactic Surveys: Past, Present, and Future
Moseley, Samuel H., Jr.; Fisher, Richard R., Technical Monitor; [2001]; In English; AAS Conference, June 2001; No Copyright; Avail: Other Sources; Abstract Only

As much as one third of the luminosity of the local universe is emitted in the far infrared. In order to understand the history of energy release in the universe, it is crucial to characterize this rest-frame far-infrared contribution from the present back to the era of initial galaxy formation. Over the redshift range from 0 to 10, this energy is received in the 80 micrometers to 1 mm spectral region. In the 1980's the Infrared Astronomy Satellite (IRAS) all-sky survey provided the first comprehensive view of the far infrared emission from the local universe. The diffuse background measurements by Cosmic Background Explorer Satellite (COBE) have provided constraints on the integral contributions from the high redshift universe. In the past five years, submillimeter measurements made using the SCUBA instrument have revealed powerful high redshift sources. To develop a clear history of energy release in the universe, we need numbers and redshifts of representative populations of energetically important objects. The near future will bring the Space Infrared Telescope Facility Multiband Imaging Photometer (SIRTF)(MIPS) survey, which will cover about 100 square degrees at wavelengths out to 160 micrometers, providing a large sample of energetically important galaxies out to z of approx.3. In 2005, the Japanese IRIS survey will provide a 160 micrometers full sky survey, which will provide larger samples of the high z galaxy populations and will find intrinsically rare high luminosity objects. The SPIRE instrument on the FIRST facility will extend these surveys to longer wavelengths, providing a view of the universe at higher redshifts in three spectral bands. A concept for an all-sky submillimeter survey is under development, called the Survey of Infrared Cosmic Evolution (SIRCE). With a 2 m cryogenic telescope, it can map the entire sky to the confusion limit in the 100 to 500 micrometers range in six months. This survey will provide photometric redshifts, number counts, and will find the most luminous objects in the universe. In the next decade, the opening of the submillimeter, combined with the near infrared capability of NGST will provide us with a clear picture of energy release in the early universe.
Author
Far Infrared Radiation; Sky Surveys (Astronomy); Galaxies; Telescopes; Infrared Astronomy Satellite

20010071142 NASA Kennedy Space Center, Cocoa Beach, FL USA
Cryogenics Testbed Technology Focus Areas
Fesmire, James E.; Space Transportation Technology Workshop: Propulsion Research and Technology; [2000]; In English; No Copyright; Avail: CASI; A03, Hardcopy

Our mission is to bring together the mutual elements of research, industry, and training in the field of cryogenics to

advance technology development for the spaceports of the future. Successful technology and productive collaboration comes from these three ingredients working together in a triangle of interaction.
Derived from text
Cryogenics; Technology Utilization; Aerospace Engineering; Test Stands

20010069622 Alabama Univ., Huntsville, AL USA
MSFC COI NMSD Cryogenic Test Data Review
Hadaway, James B.; Stahl, H. Philip, Technical Monitor; [2001]; In English; MFSC Technology Days, 9-10 May 2001, Huntsville, AL, USA
Contract(s)/Grant(s): NASA Order H-33242-D; No Copyright; Avail: Other Sources; Abstract Only

The NGST Mirror System Demonstrator (NMSD) from Composite Optics Incorporated (COI) was developed in support of the Next Generation Space Telescope (NGST) program. The goal was to produce a 1.6 m class, ultra light-weight (\h15 kg/sq m), glass-on-composite mirror that could be operated at 35 K. The mirror has been cryogenically tested at the Marshall Space Flight Center (MSFC) a total of two times. This paper will describe the test goals, the test instrumentation, and the test results (low & high order figure and radius of curvature) for both cryogenic tests.
Author
Cryogenics; Glass; Mirrors

20010069512 Composite Optics, Inc., San Diego, CA USA
NMSD Mirror Status Review
Mehle, Greg; Stahl, H. Philip, Technical Monitor; [2001]; In English; MSFC Technology Days, 9-10 May 2001, Huntsville, AL, USA; No Copyright; Avail: Other Sources; Abstract Only

This presentation provides an overview of the 1.6meter hybrid mirror demonstrator for the Next Generation Space Telescope (NGST) Program. The COI design approach for the NGST program combines the optical performance of glass, with the high specific stiffness capabilities of composite materials. The foundation technologies being exploited in the development of the hybrid mirror focus upon precision composite materials for cryogenic operation, and non-contact optical processing (ion figuring) of the lightweight mirror surface. The NGST Mirror System Demonstrator (NMSD) has been designed and built by Composite Optics, Inc. (COI) and is being optically processed by REOSC The mirror has recently completed the second of three cryogenic optical tests for demonstration of the hybrid technology. The test results will be used for the detailed cryo-figuring of the substrate.
Author
Cryogenics; Optical Materials; Hubble Space Telescope; Mirrors

20010069508 NASA Marshall Space Flight Center, Huntsville, AL USA
Modeling and Test Data Analysis of a Tank Rapid Chill and Fill System for the Advanced Shuttle Upper Stage (ASUS) Concept
Flachbart, Robin; Hedayat, Ali; Holt, Kimberly A.; Cruit, Wendy, Technical Monitor; [2001]; In English; Cryogenic Engineering Conference, 16-20 Jul. 2001, Madison, WI, USA; No Copyright; Avail: CASI; A02, Hardcopy

The Advanced Shuttle Upper Stage (ASUS) concept addresses safety concerns associated .with cryogenic stages by launching empty, and filling on ascent. The ASUS employs a rapid chill and fill concept. A spray bar is used to completely chill the tank before fill, allowing the vent valve to be closed during the fill process. The first tests of this concept, using a flight size (not flight weight) tank. were conducted at Marshall Space Flight Center (MSFC) during the summer of 2000. The objectives of the testing were to: 1) demonstrate that a flight size tank could be filled in roughly 5 minutes to accommodate the shuttle ascent window, and 2) demonstrate a no-vent fill of the tank. A total of 12 tests were conducted. Models of the test facility fill and vent systems, as well as the tank, were constructed. The objective of achieving tank fill in 5 minutes was met during the test series. However, liquid began to accumulate in the tank before it was chilled. Since the tank was not chilled until the end of each test, vent valve closure during fill was not possible. Even though the chill and fill process did not occur as expected, reasonable model correlation with the test data was achieved.
Author
Fuel Tanks; Cryogenics; Cooling; Space Shuttles

20010069319 Alabama Univ., Huntsville, AL USA

MSFC SBMD Cryogenic Test Data Review

Hadaway, James B.; Stahl, H. Philip, Technical Monitor; [2001]; In English; MSFC Technology Days, 9-10 May 2001, Huntsville, AL, USA

Contract(s)/Grant(s): NASA Order H-33241-D; No Copyright; Avail: Other Sources; Abstract Only

The Subscale Beryllium Mirror Demonstrator (SBMD) was developed in support of the Next Generation Space Telescope program. The goal was to produce a 0.5 m class, ultra lightweight (\h12 kg/sq m), beryllium mirror that could be operated at 35 K. The mirror, developed by Ball Aerospace, has been cryogenically tested at the Marshall Space Flight Center (MSFC) a total of three times. The first two tests established the cryogenic performance and repeatability of the SBMD. Between the second and third tests, the mirror was cryo-figured. Thus, the third test measured the performance of the mirror with cryo-figuring applied. This paper will describe the test goals, the test instrumentation, and the test results (low & high order figure and radius of curvature) for all three cryogenic tests.

Author

Cryogenics; Mirrors; Beryllium

20010069318 Alabama Univ., Huntsville, AL USA

MSFC Optical Test Pallet

Hadaway, James B.; Stahl, H. Philip, Technical Monitor; [2001]; In English; MSFC Technology Days, 9-10 May 2001, Huntsville, AL, USA

Contract(s)/Grant(s): NASA Order H-33241-D; No Copyright; Avail: Other Sources; Abstract Only

Several mirror technology development programs have been initiated by Marshall Space Flight Center (MSFC) in support of the Next Generation Space Telescope (NGST) program. The goal is to advance the technology for producing 0.5-2.0 m class, ultra light-weight (\h15 kg/sq m) mirrors that can be operated at or near 35 K. The NGST Mirror System Demonstrators (NMSDs) consist of a 1.6 m glass-on-composite mirror from Composite Optics Incorporated (COI) and a 2.0 m glass-on-actuators-on-composite mirror from the University of Arizona. The Subscale Beryllium Mirror Demonstrator (SBMD) is a 0.5 m beryllium mirror from Ball Aerospace. These mirrors require cryogenic surface figure and radius of curvature testing in order to verify their performance in the operational environment predicted for the NGST. An optical testing capability has been developed at the X-Ray Calibration Facility (XRCF) at MSFC. This paper will describe the optical test goals, the optical testing system design, the test instrumentation, and the test system performance as used for SBMD & NMSD cryogenic testing.

Author

Optical Equipment; Design Analysis; Mirrors; Actuators; Beryllium; Calibrating

20010067323 Technology Partnership, Gross Ile, MI USA

Polymer Matrix Composites (PMCs) Cryopipe for Rocket Engine Lines and Ducts

Bettinger, D.; Proceedings of The 4th Conference on Aerospace Materials, Processes, and Environmental Technology; February 2001; In English; No Copyright; Abstract Only; Available from CASI only as part of the entire parent document

Alloy rocket engine ducts and lines have been targeted for conversion to lighter, polymer composites. The concern with polymer composites is assured performance for multiple reuse. The need is for stress control and polymer protection from LOX and LH2. A suite of seven polymer composite technologies is presented that make the component fabrication, assembly, and performance of polymer cryopipe practical and economical. Flanges are eliminated and expensive expansion alloy bellows are replaced by more efficient and lightweight components. These technologies use stress design to configure superior performance composites with existing space-qualified materials.

Author

Polymer Matrix Composites; Ducts; Rocket Engines

20010067299 NASA Marshall Space Flight Center, Huntsville, AL USA

Effects of Cryogenic Treatment on the Residual Stress and Mechanical Properties of an Aerospace Aluminum Alloy

Chen, P.; Malone, T.; Bond, R.; Torres, P.; Proceedings of The 4th Conference on Aerospace Materials, Processes, and Environmental Technology; February 2001; In English; No Copyright; Avail: CASI; A01, Hardcopy

Investigators at Marshall Space Flight Center (MSFC) are studying the potential benefits of cryogenic treatment for

aerospace Aluminum (Al) alloys. This paper reports the effects of cryogenic treatment on residual stress, tensile strength, hardness, fatigue life, and stress corrosion cracking (SCC) resistance.
Author
Aluminum Alloys; Cryogenics; Mechanical Properties

20010067262 NASA Marshall Space Flight Center, Huntsville, AL USA
Composite,Cryogenic, Conformal, Common Bulkhead, Aerogel-Insulated Tank (CBAT)
Roberts, J. K.; Kovach, M. P.; McMahon, W. M.; Finckenor, J. L.; Proceedings of The 4th Conference on Aerospace Materials, Processes, and Environmental Technology; February 2001; In English; Copyright; Avail: Other Sources

The objective of the Composite, Cryogenic, Conformal, Common Bulkhead, Aerogel-insulated Tank (CBAT) Program is to evaluate the potential for using various new technologies in next generation Reusable Launch Vehicles (RLVs) through design, fabrication, and testing of a subscale system. The new technologies include polymer matrix composites (PMCs), conformal propellant storage, common bulkhead packaging, and aerogel insulation. The National Aeronautics and Space Administration (NASA) and Thiokol Propulsion from Cordant Technologies are working together to develop a design and the processing methodologies which will allow integration of these technologies into a single structural component assembly. Such integration will significantly decrease subsystem weight and reduce shape, volume, and placement restrictions, thereby enhancing overall launch system performance. This paper/presentation focuses on the challenges related to materials and processes that were encountered and overcome during this program to date.
Author
Technology Assessment; Reusable Launch Vehicles; Technology Utilization; Fabrication; Propellant Tanks

20010067228 Lockheed Martin Manned Space Systems, New Orleans, LA USA
Composite Manufacturing for Space Launch Vehicles
Knezevich, D. Y.; Proceedings of The 4th Conference on Aerospace Materials, Processes, and Environmental Technology; February 2001; In English; No Copyright; Abstract Only; Available from CASI only as part of the entire parent document

Composite materials offer a large potential for performance increase and weight reduction over metallic components for advanced launch vehicles. Building composite hardware for large high-efficiency launch vehicles is one of the most demanding engineering challenges from the aspects of materials science, structure, and manufacturing. Modern launch vehicles require robust, durable, and reliable components capable of operating in cryogenic, high-pressure, and high-temperature environments, while in contact with highly volatile oxidizers and fuels. Lockheed Martin Space Systems Company, Michoud Operations, has developed critical technologies for this effort by building, testing, and flight qualifying composite hardware for launch vehicle applications for numerous projects, such as the Space Shuttle, X-33, X-34, and the A2100 Satellite. Composite hardware built and tested by Lockheed Martin Space Systems Company includes high-temperature vehicle fairings and nose cones, launch vehicle intertank skirts, high-pressure cryogenic helium tanks, cryogenic liquid hydrogen and liquid oxygen tanks, feedlines, and tank coverplates. Composite manufacturing for space launch vehicles will soon be enhanced by activation of the National Center for Advanced Manufacturing (NCAM). Located at Michoud, NCAM will partner government, industry, and academia and bring on line fiber placement and autoclave capabilities that are required for production of large composite structures.
Author
Reusable Launch Vehicles; Manufacturing; Composite Structures; Composite Materials; Spacecraft Construction Materials

20010056316 NASA Kennedy Space Center, Cocoa Beach, FL USA
A Quadrupole Ion Trap Mass Spectrometer for Quantitative Analysis of Nitrogen-Purged Compartments within the Space Shuttle
Ottens, Andrew K.; Griffin, Timothy P.; Helms, William R.; Yost, Richard A.; Steinrock, T., Technical Monitor; [2001]; In English; ASMS Conference, 28-31 May 2001, Chicago, IL, USA
Contract(s)/Grant(s): NAS10-98001; No Copyright; Avail: CASI; A01, Hardcopy

To enter orbit, the Space Shuttle burns 1.8 million liters of liquid hydrogen combined with 0.8 million liters of liquid oxygen through three rocket engines mounted in the aft. NASA monitors the nitrogen-purged aft compartment for increased levels of hydrogen or oxygen in order to detect and determine the severity of a cryogenic fuel leak. Current monitoring is accomplished with a group of mass spectrometer systems located as much as 400 feet away from the Shuttle. It can take up to 45 seconds for gas to reach the mass spectrometer, which precludes monitoring for leaks in the final moments before liftoff (the orbiter engines are started at T-00:06 seconds). To remedy the situation, NASA is developing a small rugged mass

spectrometer to be used as point-sensors around the Space Shuttle. As part of this project, numerous mass analyzer technologies are being investigated. Presented here are the preliminary results for one such technology, quadrupole ion trap mass spectrometry (QITMS). A compact QITMS system has been developed in-house at the University of Florida for monitoring trace levels of four primary gases, hydrogen, helium, oxygen, and argon, all in a nitrogen background. Since commercially available QITMS systems are incapable of mass analysis at m/z(exp 2), the home-built system is preferred for the evaluation of QITMS technology.
Derived from text
Mass Spectrometers; Monitors; Leakage

20010048664 NASA Ames Research Center, Moffett Field, CA USA
Zero Boil Off Cryogen Storage for Future Launchers
Valentian, D.; Plachta, D.; Kittel, P.; Hastings, L. J.; Salerno, Louis J.; Arnold, James O., Technical Monitor; [2001]; In English; Third European Conference on Launcher Technology, Strasbourg, France; No Copyright; Avail: Other Sources; Abstract Only

Zero boil off (ZBO) cryogen storage using both cryocoolers and passive insulation technologies will enable long-term exploration missions by allowing designers to optimize tankage without the need for excess cryogen storage to account for boil off. Studies of ZBO (zero boil off) have been on-going in the USA for several years. More recently, a review of the needs of advanced space propulsion took place in Europe. This showed the interest of the European community in cryogenic propulsion for planetary missions as well as the use of liquid hydrogen for large power electric propulsion (manned Mars missions). Although natural boiling could be acceptable for single leg missions, passive insulation techniques yield roughly a I% per month cryogen loss and this would not be cost effective for robotic planetary missions involving storage times greater than one year. To make economic sense, long-term exploration missions require lower tank capacity and longer storage times. Recent advances in cryocooler technology, resulting in vast improvements in both cooler efficiency and reliability, make ZBO is a clear choice for planetary exploration missions. Other, more near term applications of ZBO include boil-off reduction or elimination applied to first and upper stages of future earth-to-orbit (ETO) launchers. This would extend launch windows and reduce infrastructure costs. Successors to vehicles like Ariane 5 could greatly benefit by implementing ZBO. Zero Boil Off will only be successful in ETO launcher applications if it makes economic sense to implement. The energy cost is only a fraction of the total cost of buying liquid cryogen, the rest being transportation and other overhead. Because of this, higher boiling point cryogens will benefit more from on-board liquefaction, thus reducing the infrastructure costs. Since hydrogen requires a liquefier with at least a 17% efficiency just to break even from a cost standpoint, one approach for implementing ZBO in upper stages would be to actively cool the shield in the hydrogen tank to reduce the parasitic losses. This would allow the use of less expensive, presently available coolers (80 K vs. 20 K) and potentially simplify the system by requiring only a single compressor on the pad amd a single disconnect line. The compressor could be a hefty commercial unit, with only the cold head requiring expensive flight development and qualification. While this is actually a reduced boil off configuration rather than a zero-boil off case, if the cryogen loss could be cut significantly, the increase in hold time and reduced need for draining and refilling the propellant tanks could meet the vehicle operations needs in the majority of instances.Bearing in mind the potential benefits of ZBO, NASA AMES and SNECMA Moteurs decided to exchange their technical views on the subject. This paper will present a preliminary analysis for a multi-mission module using a fairly low thrust cryogenic engine and ZBO during cruise. Initial mass is 5.5. tons (in ETO). The cryogenic engine will be used near each periapsis in order to minimize the AV requirement. The payload obtained by this propulsion system is compared to a classical storable bipropellant propulsion system for several cases (e. g. Mars lander, Jupiter orbiter, Saturn orbiter). For the Jupiter and Saturn cases, the power source could be an RTG or a large parabolic mirror illuminating a solar panel. It is shown -that - due to its much larger specific impulse - the cryogenic ZBO solution provides much higher payloads, especially for exploration missions involving landing on planets, asteroids, comets, or other celestial bodies.
Author
Boiling; Celestial Bodies; Coolers; Cryogenic Cooling; Cryogenic Equipment; Cryogenic Fluids; Thermoelectric Generators; Tanks (Containers)

20010043662 NASA Langley Research Center, Hampton, VA USA
Cryogenic Tank Structure Sizing With Structural Optimization Method
Wang, J. T.; Johnson, T. F.; Sleight, D. W.; Saether, E.; [2001]; In English, 16-19 Apr. 2001, Seattle, WA, USA
Report No.(s): AIAA Paper 2001-1599; Copyright; Avail: CASI; A03, Hardcopy

Structural optimization methods in MSC/NASTRAN are used to size substructures and to reduce the weight of a composite sandwich cryogenic tank for future launch vehicles. Because the feasible design space of this problem is

non-convex, many local minima are found. This non-convex problem is investigated in detail by conducting a series of' analyses along a design line connecting two feasible designs. Strain constraint violations occur for some design points along the design line. Since MSC/NASTRAN uses gradient based optimization procedures, it does not guarantee that the lowest weight design can be found. In this study, a simple procedure is introduced to create a new starting point based on design variable values from previous optimization analyses. Optimization analysis using this new starting point can produce a lower weight design. Detailed inputs for setting up the MSC/NASTRAN optimization analysis and final tank design results are presented in this paper. Approaches for obtaining further weight reductions are also discussed.
Author
Composite Structures; Cryogenic Fluid Storage; Sandwich Structures; Storage Tanks; Structural Analysis; Applications Programs (Computers); Design Analysis; Design Optimization

20010041227 NASA Glenn Research Center, Cleveland, OH USA
Low-Temperature Spacecraft: Challenges/Opportunities
Dickman, J. E.; Patterson, R. L.; Overton, E.; Hammoud, A. N.; Gerber, S. S.; Forum on Innovative Approaches to Outer Planetary Exploration 2001-2020; 2001; In English; No Copyright; Abstract Only; Available from CASI only as part of the entire parent document

Imagine sending a spacecraft into deep space that operates at the ambient temperature of its environment rather than hundreds of degrees Kelvin warmer. The average temperature of a spacecraft warmed only by the sun drops from 279 K near the Earth's orbit to 90 K near the orbit of Saturn, and to 44 K near Pluto's orbit. At present, deep space probes struggle to maintain an operating temperature near 300 K for the onboard electronics. To warm the electronics without consuming vast amounts of electrical energy, radioisotope heater units (RHUs) are used in vast numbers. Unfortunately, since RHU are always 'on', an active thermal management system is required to reject the excess heat. A spacecraft designed to operate at cryogenic temperatures and shielded from the sun by a large communication dish or solar cell array could be less complex, lighter, and cheaper than current deep space probes. Before a complete low-temperature spacecraft becomes a reality, there are several challenges to be met. Reliable cryogenic power electronics is one of the major challenges. The Low-Temperature Power Electronics Research Group at NASA Glenn Research Center (GRC) has demonstrated the ability of some commercial off the shelf power electronic components to operate at temperatures approaching that of liquid nitrogen (77 K). Below 77 K, there exists an opportunity for the development of reliable semiconductor power switching technologies other than bulk silicon CMOS. This paper will report on the results of NASA GRC's Low-Temperature Power Electronics Program and discuss the challenges to (opportunities for) the creation of a low-temperature spacecraft.
Derived from text
Low Temperature Environments; Spacecraft Electronic Equipment; Temperature Control; Switching

20010039031 Boeing Co., Huntington Beach, CA USA, NASA Marshall Space Flight Center, Huntsville, AL USA
A Cryogenic Propellant Production Depot for Low Earth Orbit
Potter, Seth D.; Henley, Mark; Guitierrez, Sonia; Fikes, John; Carrington, Connie; Smitherman, David; Gerry, Mark; Sutherlin, Steve; Beason, Phil; Howell, Joe, Technical Monitor; [2001]; In English; International Space Development Conference, 24-28 May 2001, Albuquerque, NM, USA; No Copyright; Avail: CASI; A03, Hardcopy

The cost of access to space beyond low Earth orbit can be lowered if vehicles can refuel in orbit. The power requirements for a propellant depot that electrolyzes water and stores cryogenic oxygen and hydrogen can be met using technology developed for space solar power. A propellant depot is described that will be deployed in a 400 km circular equatorial orbit, receive tanks of water launched into a lower orbit from Earth by gun launch or reusable launch vehicle, convert the water to liquid hydrogen and oxygen, and store Lip to 500 metric tonnes of cryogenic propellants. The propellant stored in the depot can support transportation from low Earth orbit to geostationary Earth orbit, the Moon, LaGrange points, Mars, etc. The tanks are configured in an inline gravity-gradient configuration to minimize drag and settle the propellant. Temperatures can be maintained by body-mounted radiators; these will also provide some shielding against orbital debris. Power is supplied by a pair of solar arrays mounted perpendicular to the orbital plane, which rotate once per orbit to track the Sun. In the longer term, cryogenic propellant production technology can be applied to a larger LEO depot, as well as to the use of lunar water resources at a similar depot elsewhere.
Author
Cryogenic Rocket Propellants; Low Earth Orbits; Refueling

20010037606 NASA Langley Research Center, Hampton, VA USA

Cryogenic Tank Structure Sizing With Structural Optimization Method

Wang, J. T.; Johnson, T. F.; Sleight, D. W.; Saether, E.; [2001]; In English; 42nd, 16-19 Apr. 2001, Seattle, WA, USA

Report No.(s): AIAA Paper 2001-1599; Copyright; Avail: CASI; A03, Hardcopy

Structural optimization methods in MSC /NASTRAN are used to size substructures and to reduce the weight of a composite sandwich cryogenic tank for future launch vehicles. Because the feasible design space of this problem is non-convex, many local minima are found. This non-convex problem is investigated in detail by conducting a series of analyses along a design line connecting two feasible designs. Strain constraint violations occur for some design points along the design line. Since MSC/NASTRAN uses gradient-based optimization procedures. it does not guarantee that the lowest weight design can be found. In this study, a simple procedure is introduced to create a new starting point based on design variable values from previous optimization analyses. Optimization analysis using this new starting point can produce a lower weight design. Detailed inputs for setting up the MSC/NASTRAN optimization analysis and final tank design results are presented in this paper. Approaches for obtaining further weight reductions are also discussed.

Author

Composite Structures; Cryogenic Fluid Storage; Nastran; Storage Tanks

20010021550 NASA Marshall Space Flight Center, Huntsville, AL USA

Cryogenic Propellant Long-term Storage With Zero Boil-off

Hedayat, A.; Hastings, L. J.; Sims, J.; Plachta, D. W.; [2001]; In English, 16-20 Jul. 2001, Madison, WI, USA

Contract(s)/Grant(s): NAS8-40836; No Copyright; Avail: Other Sources; Abstract Only

Significant boil-off losses of cryogenic propellant storage systems in long-duration space mission applications result in additional propellant and large tanks. The zero boil-off (ZBO) concept consists of an active cryo-cooling system integrated with traditional passive thermal insulation. The potential mass reductions with the ZBO concept are Substantial; therefore, further exploration through technology programs has been initiated within NASA. A large-scale demonstration of the ZBO concept has been devised utilizing the Marshall Space Flight Center (MSFC) Multipurpose Hydrogen Test Bed (MHTB) along with a cryo-cooler unit. The cryo-cooler with the MHTB and spraybar recirculation/mixer system in a manner that enables thermal energy removal at a rate that equals the total tank heat leak. The liquid hydrogen is withdrawn from the tank, passed through a heat exchanger, and then the chilled liquid is sprayed back into the tank through a spraybar. The test series will be performed over a 30-40 day period. Tests will be conducted at multiple fill levels and various mixer operational cycles to demonstrate concept viability and to provide benchmark data to be used in analytical model development. In this paper. analytical models for heat flows through the MHTB tank, cryo-cooler performance. and spraybar performance will be presented.

Author

Cryogenics; Propellant Storage; Cooling Systems; Mathematical Models; Propellant Tanks; Evaporation

20010021346 NASA Marshall Space Flight Center, Huntsville, AL USA

Analytical Models for Variable Density Multilayer Insulation Used in Cryogenic Storage

Hedayat, A.; Hastings, L. J.; Brown, T.; [2001]; In English, 16-20 Jul. 2001, Madison, WI, USA

Contract(s)/Grant(s): NAS8-40836; No Copyright; Avail: Other Sources; Abstract Only

A unique multilayer insulation concept for orbital cryogenic storage was experimentally evaluated at NASA Marshall Space Flight Center (MSFC) using the Multipurpose Hydrogen Test Bed (MHTB). A combination of foam/Multi layer Insulation (MLI) was used. The MLI (45 layers of Double Aluminized Mylar (DAM) with Dacron net spacers) was designed for an on-orbit storage period of 45 days and included several unique features such as: a variable layer density and larger but fewer DAM perforations for venting during ascent to orbit. The focus of this paper is on analytical modeling of the variable density MLI performance during orbital coast periods. The foam/MLI combination model is considered to have five segments. The first segment represents the foam layer. The second, third, and fourth segments represent the three layers of MLI with different layer densities and number of shields. Finally, the last segment is considered to be a shroud that surrounds the last MLI layer. The hot boundary temperature is allowed to vary from 164 K to 305 K. To simulate MLI performance, two approaches are considered. In the first approach, the variable density MLI is modeled layer by layer while in the second approach, a semi-empirical model is applied. Both models account for thermal radiation between shields, gas conduction, and solid conduction through the separator materials. The heat flux values predicted by each approach are compared for different boundary temperatures and MLI systems with 30, 45, 60, and 75 layers.

Author

Mathematical Models; Multilayer Insulation; Density (Mass/Volume); Foams; Cryogenic Fluid Storage

20010021213 NASA Marshall Space Flight Center, Huntsville, AL USA

Cryogenic Treatment of Al-Li Alloys for Improved Weldability, Repairability, and Reduction of Residual Stresses

Malone, Tina W.; Graham, Benny F.; Gentz, Steven J., Technical Monitor; [2001]; In English, 26-30 Mar. 2001, Cocoa Beach, FL, USA; No Copyright; Avail: Other Sources; Abstract Only

Service performance has shown that cryogenic treatment of some metals provides improved strength, fatigue life, and wear resistance to the processed material. Effects such as these were initially discovered by NASA engineers while evaluating spacecraft that had returned from the cold vacuum of space. Factors such as high cost, poor repairability, and poor machinability are currently prohibitive for wide range use of some aerospace aluminum alloys. Application of a cryogenic treatment process to these alloys is expected provide improvements in weldability and weld properties coupled with a reduction in repairs resulting in a significant reduction in the cost to manufacture and life cycle cost of aerospace hardware. The primary purpose of this effort was to evaluate the effects of deep cryogenic treatment of some aluminum alloy plate products, welds, and weld repairs, and optimize a process for the treatment of these materials. The optimized process is being evaluated for improvements in properties of plate and welds, improvements in weldability and repairability of treated materials, and as an alternative technique for the reduction of residual stresses in repaired welds. This paper will present the results of testing and evaluation conducted in this effort. These results will include assessments of changes in strength, toughness, stress corrosion susceptability, weldability, repairability, and reduction in residual stresses of repaired welds.
Author

Cryogenics; Maintainability; Weldability; Aluminum-Lithium Alloys; Optimization; Residual Stress

20010020439 Defence Research Establishment Ottawa, Ottawa, Ontario Canada

QWIP-LED/CCD Coupling Study

Chiu, Shan; Scott, Al; Nov. 2000; In English

Report No.(s): AD-A385572; DREO-TR-2000-101; No Copyright; Avail: CASI; A04, Hardcopy

Many space-based imaging applications demand a sensitive, low noise long wavelength IR detector which is able to image a wide field of view in a short time. Quantum Well Infrared Photodetector (QWIP)-LED detectors offer the potential for large imaging area, and ultra-low noise operation when cooled to cryogenic temperatures (approx. 30K). Due to these factors the QWIP-LED holds a significant advantage over conventional detectors. It is in the area of system efficiency, however, that current QWIP-LEDs are less competitive for low signal space applications. This study was a collaborative effort between EMS technologies, DND, CRESTech and NRC with a goal to design and implement a method to increase the efficiency of QWIP-LED systems. As a result of this study, it has become apparent that early projections about the cost, quality, and efficiency of pixel-less QWIP-LED technology were highly optimistic regarding critical implementation details. Unforeseen difficulties with the application of
DTIC

Infrared Detectors; Light Emitting Diodes; Quantum Wells; Charge Coupled Devices; Photometers; Technology Utilization

20010020380 Lockheed Martin Michoud Space Systems, New Orleans, LA USA

Adhesive Bonding Characterization of Composite Joints for Cryogenic Usage

Graf, Neil A.; Schieleit, Gregory F.; Biggs, Robert; [2000]; In English, 5-9 Nov. 2000, Boston, MA, USA

Contract(s)/Grant(s): NCC8-115; No Copyright; Avail: CASI; A02, Hardcopy

The development of polymer composite cryogenic tanks is a critical step in creating the next generation of launch vehicles. Future reusable launch vehicles need to minimize the gross liftoff weight (GLOW). This weight reduction is possible due to the large reduction in weight that composite materials can provide over current aluminum technology. In addition to composite technology, adhesively bonded joints potentially have several benefits over mechanically fastened joints, such as weight savings and cryogenic fluid containment. Adhesively bonded joints may be used in several areas of these cryogenic tanks, such as in lobe-to-lobe joints (in a multi-lobe concept), skirt-to-tank joint, strut-to-tank joint, and for attaching stringers and ring frames. The bonds, and the tanks themselves, must be able to withstand liquid cryogenic fuel temperatures that they contain. However, the use of adhesively bonded composite joints at liquid oxygen and hydrogen temperatures is largely unknown and must be characterized. Lockheed Martin Space Systems Company, Michoud Operations performed coupon-level tests to determine effects of material selection, cure process parameters, substrate surface preparation, and other factors on the strength of these composite joints at cryogenic temperatures. This led to the selection of a material and process that would be suitable for a cryogenic tank. KEY WORDS: Composites, Adhesive Bonding, Cryogenics
Author

Fabrication; Bonded Joints; Cryogenic Fluid Storage; Storage Tanks; Weight Reduction; Adhesive Bonding; Composite Materials

20010020285 NASA Marshall Space Flight Center, Huntsville, AL USA

Effects of Cryogenic Treatment on the Residual Stress and Mechanical Properties of an Aerospace Aluminum Alloy

Chen, Po; Malone, Tina; Bod, Robert; Torres, Pablo; [2000]; In English, 18-20 Sep. 2000, Huntsville, AL, USA; No Copyright; Avail: CASI; A01, Hardcopy

Investigators at Marshall Space Flight Center (MSFC) are studying the potential benefits of cryogenic treatment for aerospace Aluminum (Al) alloys. This paper reports the effects of cryogenic treatment on residual stress, tensile strength, hardness, fatigue life, and stress corrosion cracking (SCC) resistance.

Author

Aluminum Alloys; Cryogenics; Mechanical Properties; Residual Stress; Aerospace Environments

20010020154 Lockheed Martin Michoud Space Systems, New Orleans, LA USA

Subscale Composite Liquid Oxygen Tank Testing

Graf, Neil A.; Davis, Kevin; McBain, Michael; Austin, Robert E., Technical Monitor; [2000]; 32nd SAMPE International Technical Conference, 5-9 Nov. 2000, Boston, MA, USA

Contract(s)/Grant(s): NCC8-115; No Copyright; Avail: CASI; A03, Hardcopy

Lockheed Martin Space Systems Company recently completed a two-year fabrication and test program on subscale composite liquid oxygen (LO2) tanks. The goals of this program included the development of fabrication and inspection techniques, cryogenic acceptance testing of composite articles, and demonstrating oxygen compatibility under launch vibration loads. Two subscale diameter test bottles were fabricated using a proprietary Lockheed Martin material, known as LM21C03. The bottles were then inspected using an array of NDE techniques and then put through a cryogenic acceptance test program at Lockheed Martin. A NASA/Lockheed Martin test team then subjected a composite bottle to testing at an X-33 vibration profile for 15 minutes at use pressure. The tests were run at various LO2 fill levels, with and without intentionally added debris. All tests were successful in that the composite bottle showed no signs of ignition or combustion as a result of the vibration testing. This test program is an important bridge between coupon-level and subcomponent LO2 compatibility tests and full-scale composite LO2 tank use.

Author

Aerospace Systems; Product Development; Composite Propellants; Liquid Oxygen; Propellant Tanks

20010019001 NASA Glenn Research Center, Cleveland, OH USA

Development of Electronics for Low-Temperature Space Missions

Patterson, Richard L.; Hammoud, Ahmad; Dickman, John E.; Gerber, Scott S.; Overton, Eric; January 2001; In English; 4th, 21-23 Jun. 2000, Noordwijk, Netherlands

Contract(s)/Grant(s): RTOP 755-A4-12

Report No.(s): NASA/TM-2001-210235; NAS 1.15:210235; E-12354; No Copyright; Avail: CASI; A03, Hardcopy

Electronic systems that are capable of operating at cryogenic temperatures will be needed for many future NASA space missions, including deep space probes and spacecraft for planetary surface exploration. In addition to being able to survive the harsh deep space environment, low-temperature electronics would help improve circuit performance, increase system efficiency, and reduce payload development and launch costs. Terrestrial applications where components and systems must operate in low-temperature environments include cryogenic instrumentation, superconducting magnetic energy storage, magnetic levitation transportation systems, and arctic exploration. An ongoing research and development project for the design, fabrication, and characterization of low-temperature electronics and supporting technologies at NASA Glenn Research Center focuses on efficient power systems capable of surviving in and exploiting the advantages of low-temperature environments. Supporting technologies include dielectric and insulating materials, semiconductor devices, passive power components, optoelectronic devices, and packaging and integration of the developed components into prototype flight hardware. An overview of the project is presented, including a description of the test facilities, a discussion of selected data from component testing, and a presentation of ongoing research activities being performed in collaboration with various organizations.

Author

Space Missions; Low Temperature; Electronic Equipment; NASA Space Programs; Aerospace Environments; Semiconductor Devices; Fabrication

20000121130 NASA Ames Research Center, Moffett Field, CA USA

Terrestrial Applications of Zero Boil-Off Cryogen Storage

Salerno, L. J.; Gaby, J.; Hastings, L.; Johnson, R.; Kittel, P.; Marquardt, E.; Plachta, D.; Arnold, James O., Technical Monitor; [2000]; In English; 11th Cryocooler Conference, 20-22 Jun. 2000, Keystone, CO, USA

Contract(s)/Grant(s): RTOP 242-81-01; No Copyright; Avail: Other Sources; Abstract Only

Storing cryogenic propellants with zero boil off (ZBO) using a combination of active (cryocoolers) and passive technologies has recently received a great deal of attention for applications such as future long-term space missions. This paper will examine a variety of potential near-term terrestrial applications for ZBO and, where appropriate, provide a rough order of magnitude cost benefit of implementing ZBO technology. NASA's Space Shuttle power system uses supercritical propellant tanks, which are filled several days before launch. If the launch does not occur within 48-96 hours, the tanks must be drained and refilled, further delaying the launch. By implementing ZBO, boil off could be eliminated and pad hold time extended. At the launch site, vented liquid hydrogen (LH2) storage dewars lose 1200-1600 gal/day through boiloff. Implementing ZBO would eliminate this, saving $300,000-$400,000 per year. Similarly, overland trucking of LH2 from the supplier to the launch site via roadable dewars results in a cryogen loss of ten percent per tanker (1500 gal/tanker). Providing a cryocooler on board the rig would prevent this loss. Previous work investigating variable density insulation found that a 50% reduction in evaporation from a 6000 gallon dewar would save $5000 per year. For a 20 year dewar lifetime, the payback period would be less than two years. Similar benefits could be realized at other storage facilities across the nation. Within the superconductivity community, there is skepticism about using coolers, based upon reliability concerns. By providing a cooler on the dewar, lifetime could be extended while retaining fail-safe capability. If the cooler failed, it would merely lower the storage life of the dewar.

Author

Cryogenic Equipment; Evaporation; Storage Stability; Service Life

20000120758 Lee and Associates, LLC, USA

Support to X-33/Reusable Launch Vehicle Technology Program

Nov. 29, 2000; In English

Contract(s)/Grant(s): NASA Order H-31417-D; No Copyright; Avail: CASI; A03, Hardcopy

The Primary activities of Lee & Associates for the referenced Purchase Order has been in direct support of the X-33/Reusable Launch Vehicle Technology Program. An independent review to evaluate the X-33 liquid hydrogen fuel tank failure, which recently occurred after-test of the starboard tank has been provided. The purpose of the Investigation team was to assess the tank design modifications, provide an assessment of the testing approach used by MSFC (Marshall Space Flight Center) in determining the flight worthiness of the tank, assessing the structural integrity, and determining the cause of the failure of the tank. The approach taken to satisfy the objectives has been for Lee & Associates to provide the expertise of Mr. Frank Key and Mr. Wayne Burton who have relevant experience from past programs and a strong background of experience in the fields critical to the success of the program. Mr. Key and Mr. Burton participated in the NASA established Failure Investigation Review Team to review the development and process data and to identify any design, testing or manufacturing weaknesses and potential problem areas. This approach worked well in satisfying the objectives and providing the Review Team with valuable information including the development of a Fault Tree. The detailed inputs were made orally in real time in the Review Team daily meetings. The results of the investigation were presented to the MSFC Center Director by the team on February 15, 2000. Attached are four charts taken from that presentation which includes 1) An executive summary, 2) The most probable cause, 3) Technology assessment, and 4) Technology Recommendations for Cryogenic tanks.

Author

X-33 Reusable Launch Vehicle; Fuel Tanks; Technology Assessment; Cryogenic Fluid Storage

20000120471 ISRO Satellite Centre, Peenya, Bangalore, India

Preparations and Performance of Large Space Simulation Chamber (LSSC) During INSAT-2E Solar Simulation Thermal Balance and Thermal Vacuum Performance Tests

Satish, R.; Govindan, P.; Kulkarni, C.; Adhikary, Arvind; Gopinath, R.; Raj, D. K. Sagaraya; Aravindakshan, P.; Prakash, S. N.; Misra, N. K.; Baliga, B. N.; Twenty-first Space Simulation Conference: The Future of Space Simulation Testing in the 21st Century; October 2000; In English; No Copyright; Avail: CASI; A03, Hardcopy

Solar simulation Thermal Balance and Thermal Vacuum performance tests on INSAT-2E (Indian National Satellite) were conducted in the Large Space Simulation Chamber (LSSC) available at ISRO Satellite Centre, Bangalore, India during OctoberNovember1998. The performance of the chamber system was excellent. Both tests were conducted in stabilized environments of vacuum, temperature, solar beam and motion simulator operations as required. The good performance of the

chamber can be attributed to a number of modifications, trial runs and performance reviews conducted prior to the above tests. Primarily, certain deterioration in the achievable chamber vacuum was noticed over a period of time since commissioning of the chamber in 1991. A study revealed that a major reason for these degradations are development of leaks at the inter panel connections of shrouds. The panel interconnection arrangements originally provided were reviewed and modifications to the panel interconnection and shroud anchoring incorporated. Subsequently an elaborate leak rate verification of each shroud panel was conducted keeping a bench mark for the acceptable leak level as less than 1 x 10(exp -8) std cc/sec. Panels with higher leak levels were rectified identifying the degraded welds at the tubes inter connecting the panels. After rectification of leaks by re welding and qualification of each panel, vacuum trial runs were conducted to ensure that the overall vacuum performance of the chamber met specifications. During the analysis of some earlier tests conducted in the chamber it was noticed that there had been some vacuum fluctuation due to sudden release of gases by the cryo pumps. A study revealed the possibility of cryo pumps taking excessive gas load. To avoid this excessive loading and subsequent saturation of cryo pumps during extended chamber evacuation, an additional turbo molecular pump was incorporated to the pumping system of the chamber. This additional turbo molecular pump ensured a stable state lower order vacuum and an overlapped pumping regime with the cryo pumps thus relieving the cryo pumps from being loaded excessively due to outgassing from the shrouds or the test object during the pump down. Further during the INSAT-2E thermal balance test shrouds were cooled to the required temperature of less than 100 deg K in a gaseous Nitrogen mode. The temperature uniformity achieved was comparable with that achieved in LN2 mode using sub coolers during the earlier tests. The GN2 mode of operation was adapted on a trial basis as a safeguard against the power failure kind of test interruptions. The operation of the chamber shrouds in GN2 mode to achieve a temperature less than 100 K for conducting a thermal balance test has been found acceptable after a review of temperature distribution on shrouds and the resulted stable spacecraft temperature data. Also given in this paper are a gist of major problems encountered since commissioning of the facility and solutions provided, for the benefit of personnel who are engaged in maintenance and operation of facilities of similar capabilities elsewhere.
Author
Indian Spacecraft; Spacecraft Environments; Thermal Vacuum Tests; Vacuum Chambers; Thermal Simulation; Space Simulators; Solar Simulation; Performance Tests

20000120465 Johns Hopkins Univ., Laurel, MD USA
Thermal Vacuum Testing of the Timed Spacecraft Inside an Enclosure in a Warm Chamber
Williams, Bruce D.; Twenty-first Space Simulation Conference: The Future of Space Simulation Testing in the 21st Century; October 2000; In English; No Copyright; Avail: CASI; A03, Hardcopy

The Thermosphere-Ionosphere-Mesosphere-Energetics and Dynamics (TIMED) spacecraft will be placed in a 625 km, 74.1 degree inclination low earth orbit, with four scientific instruments on board. The TIMED spacecraft will be launched from Vandenberg Air Force Base on a Delta II rocket. The TIMED spacecraft is a comanifested launch with the JASON spacecraft (TOPEX follow-on). The TIMED spacecraft will be encapsulated in a Dual Payload Attach Fitting (DPAF), with the JASON spacecraft mounting to the top of the DPAF. The TIMED instruments are designed to characterize the Earth's upper atmosphere using visible, UV and IR sensors. Due to the stringent thermal requirements for the instruments, the spacecraft must maintain an anti-sun side, as well as a Nadir pointing side. These basic requirements, along with instrument field of view requirements have resulted in a very interesting spacecraft design and thermal vacuum testing. The TIMED spacecraft was scheduled to be thermal vacuum tested in the large Space Environment Simulation Chamber (SES 290) at the Goddard Space Flight Center starting on Dec. 10, 1999. However, six weeks prior, during a verification of the newly upgraded thermal system in the SES chamber, a part within a steam heat exchange failed. The steam heat exchanger is used to flush the liquid nitrogen from the chamber cold walls and warm the walls back up to ambient temperature. Without the steam heat exchange, the cold wall could not be flooded for the next test, which was the TIMED spacecraft test. Within 6 weeks, the thermal shroud used for MSX spacecraft was fitted with cryo panels. The thermal shroud enclosure was used to surround the TIMED spacecraft providing the necessary environment for both thermal balance and thermal cycle testing. This paper will discuss this interesting test configuration, successful test results and correlation between model predictions and test data.
Author
Thermal Vacuum Tests; Vacuum Chambers; Spacecraft Environments; Environmental Tests; Thermal Cycling Tests; Shrouds

20000120461 Chart Industries, Inc., Unknown, USA
Thermal Vacuum Test Facility Design Options for the Next Generation Space Telescope
Than, Y. R.; McWilliams, D. A.; Twenty-first Space Simulation Conference: The Future of Space Simulation Testing in the 21st Century; October 2000; In English; No Copyright; Abstract Only; Available from CASI only as part of the entire parent document

The study presents several design options for a thermal system that can produce the required space environment for testing of the NGST. Because of the large size of the thermal vacuum environment and the 20K background temperature, a large cryogenic refrigeration system is required, resulting in system that is costly, with high power and LN2 use. The goal is to minimize parasitic heat loads thus keeping the cryogenic system small. The challenge is to achieve a design that is economical in terms of both initial capital investment and utility consumption. In addition, the thermal shroud system should be able to be used for other space vehicle tests with minimal, or no, rework. Thermal system design issues studied and the implications on the vacuum performance include: 1) active shielding utilizing liquid nitrogen, 2) passive shielding using MLI, 3) thermal zone configurations, 4) refrigeration system tradeoffs. Relative values for initial capital and operating costs are also presented.
Author
Thermal Vacuum Tests; Test Facilities; Research Facilities; High Temperature Tests

20000120459 NASA Glenn Research Center, Cleveland, OH USA
Thermal Vacuum Testing of the Heat Rejection System Radiator for the International Space Station
Beach, Duane; Carek, Jerry; Ziemke,Robert; Twenty-first Space Simulation Conference: The Future of Space Simulation Testing in the 21st Century; October 2000; In English; No Copyright; Avail: CASI; A02, Hardcopy

The International Space Station (ISS) is designed with large deployable radiator panels that are used to reject waste heat from the habitation modules. A system level test was performed in a thermal vacuum environment to demonstrate the ability to deploy these radiators once on-orbit. A Heat Rejection System (HRS) radiator successfully passed deployment tests at the extreme thermal conditions expected during the assembly of the ISS. Testing was conducted in the Space Power Facility (SPF) located at the NASA Glenn Research Center (GRC) Plum Brook Station in Sandusky, Ohio. The radiator system was installed in the 30.5m (100ft) diameter by 37.2m (122ft) tall vacuum chamber on a special deployment track that simulated weightless conditions. A large cryoshroud was used to simulate the cold space environment conditions, while a quartz lamp heater array was used to simulate the hot space environment conditions. Radiator deployments were performed at several thermal conditions using both the primary deployment mechanism and the back-up deployment mechanism. Special thermal vacuum compatible test hardware was developed to simulate the astronauts EVA drive tool for the back-up deployment mechanism. This paper discusses the test set-up, the test conditions, and the test results. The test results yield a high level of confidence for successful deployment and retraction of the ISS radiators at all expected on-orbit conditions.
Author
Thermal Vacuum Tests; Vacuum Chambers; High Altitude Environments

20000120456 Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick, Germany
Reduction of Cooler Induced Vibrations by Means of an Adaptive Add-On System
Melz, Tobias; Melcher, Joerg; Sachau, Delf; Twenty-first Space Simulation Conference: The Future of Space Simulation Testing in the 21st Century; October 2000; In English; No Copyright; Avail: CASI; A03, Hardcopy

Future space missions' requirements on high precision structures get continuously more challenging with respect to structural accuracy. With classical structural technology coming to its limits, adaptive structure technology offers the potential to solve a variety of quasistatic and dynamic problems. With respect to the dynamic excitation of sensitive equipment, mechanical cryocooler systems, which are often used in aerospace applications to cool specific equipment to their cryogenic working temperatures, represent a typical dynamic disturbance source within a satellite. They either directly excite vibrations at the attached, cryogenic equipment or indirectly by exciting elastic interface structures leading to vibrations of one or multiple remote systems. One approach to compensate for cryocooler vibrations utilizing adaptive structure technologies is presented in the paper. Within a typical small satellite project, two infrared detectors have to be mechanically cooled by two independent miniature Stirling cryocoolers. The induced cooler vibrations critically excite the detectors, leading to a severe reduction of the quality of the scientific results. Opposite alignment of the coolers was impractical due to mission constraints. Within an ESA project, DLR developed an add-on, long life adaptive vibration compensation system that removes critical vibratory energy and works without launch locking devices. The system has been designed and qualified for general space applications on material and system level. Functional demonstration proved a vibration reduction by 53 dB, representing a significant improvement on the general acceptance specifications for residual cryocooler vibration force levels for future missions. Long life testing showed no performance degradation after more than 10(exp 8) cycles. The system was designed to be easily transferred to other applications.
Author
Coolers; Air Conditioning Equipment; Cryogenic Cooling; Cryogenic Equipment; Cryogenic Temperature

20000118211 NASA Ames Research Center, Moffett Field, CA USA

The AstroBiology Explorer (ABE) MIDEX Mission

Greene, Thomas; Sandford, Scott; Allamandola, Louis; Arno, Roger; Bregman, Jesse; Cox, Sylvia; Davis, Paul; Gonzales, Andrew; Hanel, Robert; Hines, Michael; Hudgins, Douglas; DeVincenzi, Donald L., Technical Monitor, et al.; [2000]; In English; UV, Optical and IR Space Telescopes and Instruments, 26-31 Mar. 2000, Munich, Germany

Contract(s)/Grant(s): RTOP 632-70-04-03; No Copyright; Avail: Other Sources; Abstract Only

The Astrobiology Explorer (ABE) is a Medium-Class Explorer (MIDEX) mission concept currently under study at NASA's Ames Research Center. ABE will conduct infrared (IR) spectroscopic observations with much better sensitivity than Infrared Space Observatory (ISO) or the Stratospheric Observatory for Infrared Astronomy program (SOFIA) in order to address outstanding astrobiologically important problems in astrochemistry as well as important astrophysical investigations. The core observational astrobiology program would make fundamental scientific progress in understanding the cosmic history of molecular carbon, the distribution of organic matter in the diffuse interstellar medium, tracing the chemical history of complex organic molecules in the interstellar medium, and the evolution of organic ices in young planetary systems. The ABE instrument concept includes a 0.5 m aperture Cassegrain telescope and a suite of three moderate resolution (R = 1000 - 4000) spectrographs which cover the entire lambda = 2.5-20 micron spectral region. Use of large format (1024 x 1024 pixel or larger) IR detector arrays will allow each spectrograph to cover an entire octave of spectral range per exposure without any moving parts. The telescope is passively cooled by a sun shade to below 65 K, and the detectors are cooled with solid H2 cryogen to approximately 8 K. ABE will be placed in an Earth-trailing one AU solar orbit by a Delta II launch vehicle. This energetically favorable orbit provides a low thermal background, affords good access to the entire sky over the one year mission lifetime, and allows adequate communications bandwidth. The spacecraft will be stabilized in three axes and will be pointed to an accuracy of approximately one arcsecond at ABE's several thousand individual scientific targets.

Author

Bioastronautics; Exobiology; Infrared Detectors; Infrared Spectroscopy; Telescopes; Mission Planning

20000112954 NASA Marshall Space Flight Center, Huntsville, AL USA

Aluminum Lithium Alloy 2195 Fusion Welding Improvements with New Filler Wire

Russell, Carolyn; Bjorkman, Gerry; McCool, Carolyn, Technical Monitor; [2000]; In English; Aerospace Materials, Processes and Environmental Technology, 18-20 Sep. 2000, Huntsville, AL, USA; No Copyright; Avail: CASI; A03, Hardcopy

A viewgraph presentation outlines NASA Marshall Space Flight Center, Lockheed Martin Michoud Space Systems, and McCook Metals' development an aluminum-copper weld filler wire for fusion welding 2195 aluminum lithium. The aluminum-copper based weld filler wire has been identified as B218, which is the result of six years of weld filler wire development funded by NASA, Lockheed Martin, and McCook Metals. The Super Lightweight External Tank for the NASA Space Shuttle Program consists of 2195 welded with 4043 aluminum-silicon weld filler wire. The B218 filler wire chemistry was developed to produce enhanced 2195 weld and repair weld mechanical properties. An initial characterization of the B218 weld filler wire was performed consisting of initial weld and repair weld evaluation comparing B218 and 4043. The testing involved room temperature and cryogenic tensile testing along with fracture toughness testing. B218 weld filler wire proved to produce enhanced initial and repair weld tensile and fracture properties over 4043. B218 weld filler wire has proved to be a superior weld filler wire for welding 2195 and other aluminum lithium alloys over 4043.

Author

Aluminum Alloys; Fillers; Copper; Fusion Welding; Tensile Properties; Welding; Wire

20000109714 Creare, Inc., Hanover, NH USA

Advanced Developments for Low Temperature Turbo-Brayton Cryocoolers

Nellis, G. F.; McCormick, J. A.; Sixsmith, H.; Zagarola, M. V.; Swift, W. L.; Gibbon, J. A.; Reilly, J. P.; Obenschain, Arthur F., Technical Monitor; [2000]; In English; 11th 11th International Cryocooler Conference, Jun. 2000, CO, USA

Contract(s)/Grant(s): NAS5-97027; No Copyright; Avail: Other Sources; Abstract Only

Turbo-Brayton cryocooler technology that has been space qualified and demonstrated on the NICMOS cryocooler is being adapted for applications with lower cooling loads at lower telqoeratures. The applications include sensor cooling for space platforms and telescopes at temperatures between 4 K and 35 K, where long life and reliable, vibration-free operation are important. This paper presents recent advances in the miniaturization of components that are critical to these systems. Key issues addressed in adapting the NICMOS cryocooler technology to lower temperatures involve reducing parasitic losses when scaling to smaller size machines. Recent advances include the successful design and testing of a small, permanent magnet driven compressor that operates at up to 10,000 rev/sec and the successful demonstration of self acting gas bearings supporting a I mm. diameter shaft. The compressor is important for cryocoolers with input powers between 50 W and 100 W. The

miniature shaft and bearing system has applications in compressors and turbines at temperatures from 300 K to 6 K. These two technology milestones are fundamental to achieving exceptional thermodynamic performance from the turboBrayton system in low temperature systems. The paper discusses the development of these components and test results, and presents the implications of their performance on cryocooler systems.
Author
Low Temperature; Cryogenics; Cryogenic Cooling; Cryogenic Equipment; Refrigerating Machinery; Coolers

20000106073 Houston Univ., TX USA
Basic Research Impacting Advanced Energy Generation and Storage in Space
Chu, Wei-Kan; Ma, Ki; Aug. 08, 2000; In English
Contract(s)/Grant(s): F49620-97-1-0101
Report No.(s): AD-A381573; Rept-37-307-307-30-8000; Rept-1-5-51080; AFRL-SR-BL-TR-00-0432; No Copyright; Avail: CASI; A02, Hardcopy

We have studied the feasibility of using High Temperature Superconducting levitation bearings for Flywheels and momentum wheels in energy and momentum storage for space applications. We have constructed a small flywheel prototype to demonstrate the principle. Measurement of small residual losses in HTS levitation bearings so as to be able to optimize design parameters to keep the losses to the lowest possible. There are two distinct loss mechanisms: magnetic hysteresis in HTS, or eddy currents in the rotating magnet. There are three parts to our study efforts: measurement of torque in a simple HTS levitation bearing with a non-axisymmetric magnet to study hysteresis loss in HTS; development of instrumentation capable of detecting varying magnetic field in reference frame co-rotating with magnet to study eddy current loss in magnet; and modeling and computation to provide understanding and direction to the experimental efforts. Impact on cryocoolers to the overall power consumption are estimated. All studies are summarized in a set of preprints to be published.
DTIC
High Temperature Superconductors; Flywheels; Levitation; Superconductivity; Design Analysis; Aerospace Systems; Energy Storage; Energy Consumption

20000097959 Creare, Inc., Hanover, NH USA
Life and Reliability Characteristics of TurboBrayton Coolers
Breedlove, Jeff J.; Zagarola, Mark; Nellis, Greg; Dolan, Frank; Swift, Walt; Gibbon, Judith; Obenschain, Arthur F., Technical Monitor; [2000]; In English; 11th 11th International Cryocooler Conference, Jun. 2000, CO, USA
Contract(s)/Grant(s): NAS5-31281; No Copyright; Avail: Other Sources; Abstract Only

Wear and internal contaminants are two of the primary factors that influence reliable, long-life operation of turbo-Brayton cryocoolers. This paper describes tests that have been conducted and methods that have been developed for turbo-Brayton components and systems to assure reliable operation. The turbomachines used in these coolers employ self-acting gas bearings to support the miniature high-speed shafts, thus providing vibration-free operation. Because the bearings are self-acting, rubbing contact occurs during initial start-up and shutdown of the machines. Bearings and shafts are designed to endure multiple stop/start cycles without producing particles or surface features that would impair the proper operation of the machines. Test results are presented for a variety of turbomachines used in these systems. The tests document extended operating life and start/stop cycling behavior for machines over a range of time and temperature scales. Contaminants such as moisture and other residual gas impurities can be a source of degraded operation if they freeze out in sufficient quantities to block flow passages or if they mechanically affect the operation of the machines. A post-fabrication bakeout procedure has been successfully used to reduce residual internal contamination to acceptable levels in a closed cycle system. The process was developed during space qualification tests on the NICMOS cryocooler. Moisture levels were sampled over a six-month time interval confirming the effectiveness of the technique. A description of the bakeout procedure is presented.
Author
Brayton Cycle; Service Life; Coolers; Turbomachinery; Component Reliability; Reliability Analysis; Turbine Engines; Fabrication; Miniaturization

20000096219 Aerospace Corp., El Segundo, CA USA
Characterization of Cryogenic Mechanical Properties of Aluminum-Lithium Alloy C-458
Kooi, D. C.; Park, W.; Hilton, M. R.; May 30, 2000; In English
Contract(s)/Grant(s): F04701-93-C-0094
Report No.(s): AD-A380362; TR-99(8565)-4; SMC-TR-00-16; No Copyright; Avail: CASI; A02, Hardcopy

Mechanical properties of aluminum-lithium alloy C-458, which is one of the new generation alloys being developed for aerospace structural applications, were characterized. In light of potential applications of this alloy in future space launch vehicles, the effect of decreasing temperature down to 4K on the tensile and fracture properties were investigated. The tensile strength and the ductility increased at cryogenic temperatures, while the fracture toughness reduced slightly at 4K. This alloy was not sensitive to long-term low-temperature aging unlike some previous aluminum-lithium alloys. This may be attributed to the fact that the level of alkaline metal impurities in 0-458 is substantially lower than those of other aluminum-lithium alloys.
DTIC
Cryogenics; Aluminum-Lithium Alloys; Tensile Strength; Fracture Strength; Ductility

20000091534 NASA Goddard Space Flight Center, Greenbelt, MD USA
Cryo-Transmittance and -Reflectance of Filters and Beamsplitters for the SIRTF Infrared Array Camera
Stewart, Kenneth P.; Quijada, Manuel A.a; [2000]; In English, Aug. 2000; No Copyright; Avail: CASI; A02, Hardcopy

The Space Infrared Telescope Facility (SIRTF) Infrared Array Camera (IRAC) uses two dichroic beamsplitters, four bandpass filters, and four detector arrays to acquire images in four channels at wavelengths between 3 and 10 micron. Accurate knowledge of the pass bands is necessary because, in order to meet the science objectives, IRAC is required to do 2% relative photometry in each band relative to the other bands. We report the in-band and out-of-band polarized transmittance and reflectance of these optical elements measured near the instrument operating temperature of 1.4 K. Details of the experimental apparatus, which include a continuous flow liquid helium optical cryostat and a Fourier transform infrared (FTIR) spectrometer are discussed.
Author
Cameras; Infrared Spectrometers; Reflectance; Transmittance

20000084158 NASA Goddard Space Flight Center, Greenbelt, MD USA
A Near IR Fabry-Perot Interferometer for Wide Field, Low Resolution Hyperspectral Imaging on the Next Generation Space Telescope
Barry, R. K.; Satyapal, S.; Greenhouse, M. A.; Barclay, R.; Amato, D.; Arritt, B.; Brown, G.; Harvey, V.; Holt, C.; Kuhn, J., et al.; [2000]; In English; No Copyright; Avail: CASI; A03, Hardcopy

We discuss work in progress on a near-infrared tunable bandpass filter for the Goddard baseline wide field camera concept of the Next Generation Space Telescope (NGST) Integrated Science Instrument Module (ISIM). This filter, the Demonstration Unit for Low Order Cryogenic Etalon (DULCE), is designed to demonstrate a high efficiency scanning Fabry-Perot etalon operating in interference orders 1 - 4 at 30K with a high stability DSP based servo control system. DULCE is currently the only available tunable filter for lower order cryogenic operation in the near infrared. In this application, scanning etalons will illuminate the focal plane arrays with a single order of interference to enable wide field lower resolution hyperspectral imaging over a wide range of redshifts. We discuss why tunable filters are an important instrument component in future space-based observatories.
Author
Near Infrared Radiation; Infrared Interferometers; Fabry-Perot Interferometers; Etalons

20000074079 Jet Propulsion Lab., California Inst. of Tech., Pasadena, CA USA
The Fast Alternative Cryogenic Experiment Testbed
Nash, Alfred; Holmes, Warren; [2000]; In English; No Copyright; Avail: Other Sources; Abstract Only

One of the challenges in the area of cryogenics for space exploration in the next millennium is providing the capability for inexpensive, frequent, access to space. Faced with this challenge during the International Space Station (ISS) build era, when other Space Shuttle manifesting opportunities are unavailable, a ‘proof of concept’ cryostat has been developed to demonstrate the ability to accommodate low temperature science investigations within the constraints of the Hitchhiker siderail carrier. The Hitchhiker siderail carrier is available on a ‘mass available’ basis during the ISS build era. In fact, several hitchhiker payloads flew with the deployment of the Unity module. Hitchhiker siderail carrier payloads have historically flown an average of about four times a year. A hybrid Solid Neon - Superfluid Helium cryostat has been developed with Janis Research Company to accommodate instruments of 16.5 cm diameter and 30 cm. length. This hybrid approach was taken in part to provide adequate on-orbit lifetime for instruments with high (conducted) heat loads from the instrumentation wiring. Mass, volume, lifetime and the launch hold scenario were all design drivers. In addition, with Ball Aerospace and Technologies Corporation, a multichannel VME architecture Germanium Resistance Thermometer (GRT) readout and heater

control servo system has been developed. In a flight system, the cryostat and electronics payloads would be umbilically attached in a paired Hitchhiker siderail mount, and permit on-orbit command and telemetry capability. The results of performance tests of both the cryostat, and a helium sample instrument will be presented. The instrument features a self contained, miniaturized, nano-Kelvin resolution High Resolution Thermometer (HRT). This high level of thermal resolution is achieved through the utilization of a dc Superconducting Quantum Interference Device (SQUID). Although developed for the Low Temperature Microgravity Fundamental Physics investigator community, many design features are applicable in fields such as infrared and x-ray astronomy.
Author
Cryostats; Germanium; Heaters; Helium; Liquid Helium 2; Low Temperature; Microgravity; Performance Tests; Resistance Thermometers; Solid Cryogens; Squid (Detectors); Fabrication

20000070417 Dean Applied Technology Co., Huntsville, AL USA
Design and Testing of Demonstration Unit for Maintaining Zero Cryogenic Propellant Boiloff
Dean, W. G.; [2000]; In English; 36th, 17-19 Jul. 2000, Huntsville, AL, USA
Contract(s)/Grant(s): NAS8-98026; Copyright; Avail: CASI; A03, Hardcopy

Launching of cryogenic propellants into earth orbit and beyond is very expensive. Each additional pound of payload delivered to low earth orbit requires approximately 35 pounds of additional weight at liftoff. There is therefore a critical need to minimize boiloff in spacecraft long term missions/systems. Various methods have been used to date, including superinsulation and thermodynamic vents to reduce boiloff. A system was designed and tested as described herein that will totally eliminate boiloff. This system is based on a closed-loop, two-stage pulse tube refrigerator with a net refrigeration of four watts at 15k for the recovery of hydrogen propellant. It is designed to operate at 30 Hz which is an order of magnitude higher than other typical pulse tube refrigerators. This high frequency allows the use of a much smaller, lighter weight compressor, This paper describes the system design, fabrication and test results.
Author
Cryogenic Rocket Propellants; Fabrication; Spacecraft Launching; Systems Engineering; Evaporation

20000068441 Lockheed Martin Michoud Space Systems, Huntsville, AL USA
B218 Weld Filler Wire Characterization for Al-Li Alloy 2195
Bjorkman, Gerry; Russell, Carolyn; [2000]; In English, 26-29 Jun. 2000, Seattle, WA, USA
Contract(s)/Grant(s): NAS8-36200; No Copyright; Avail: CASI; A03, Hardcopy

NASA Marshall Space Flight Center, Lockheed Martin Space Systems- Michoud Operations, and McCook Metals have developed an aluminum-copper weld filler wire for fusion welding aluminum lithium alloy 2195. The aluminum-copper based weld filler wire has been identified as B218, a McCook Metals designation. B218 is the result of six years of weld filler wire development funded by NASA, Lockheed Martin, and McCook Metals. The filler wire chemistry was developed to produce enhanced 2195 weld and repair weld mechanical properties over the 4043 aluminum-silicon weld filler wire, which is currently used to weld 2195 on the Super Lightweight External Tank for the NASA Space Shuttle Program. An initial characterization was performed consisting of a repair weld evaluation using B218 and 4043 weld filler wires. The testing involved room temperature and cryogenic repair weld tensile testing along with fracture toughness testing. From the testing, B218 weld filler wire produce enhanced repair weld tensile strength, ductility, and fracture properties over 4043. B218 weld filler wire has proved to be a superior weld filler wire for welding aluminum lithium alloy 2195 over 4043.
Author
Aluminum Alloys; Fusion Welding; Welded Joints; Aluminum-Lithium Alloys; Copper; Weld Strength; Welding

20000056865 NASA Glenn Research Center, Cleveland, OH USA
Development of Electronics for Low Temperature Space Missions
Patterson, Richard L.; Hammoud, Ahmad; Dickman, John E.; Gerber, Scott; Overton, Eric; [2000]; In English; 4th, 21-13 Jun. 2000, Noordwijk, Netherlands
Contract(s)/Grant(s): NAS3-98008; RTOP 632-6A-1H; No Copyright; Avail: CASI; A01, Hardcopy

The operation of electronic systems at cryogenic temperatures is anticipated for many future NASA space missions such as deep space probes and planetary surface exploration. For example, an unheated interplanetary probe launched to explore the rings of Saturn would reach an average temperature near Saturn of about -183 C. In addition to surviving the deep space harsh environment, electronics capable of low temperature operation would contribute to improving circuit performance, increasing system efficiency, and reducing payload development and launch costs. Terrestrial applications where components

and systems must operate in low temperature environments include cryogenic instrumentation, superconducting magnetic energy storage, magnetic levitation transportation system, and arctic exploration. An on-going research and development program on low temperature electronics at the NASA Glenn Research Center focuses on the development of efficient power systems capable of surviving and exploiting the advantages of low temperature environments. Inhouse efforts include the design, fabrication, and characterization of low temperature power systems and the development of supporting technologies for low temperature operations, such as dielectric and insulating materials, semiconductor devices, passive power components, opto-electronic devices, as well as packaging and integration of the developed components into prototype flight hardware.
Author
Research and Development; Electronic Equipment; Operating Temperature; Cryogenic Temperature; Space Temperature; Deep Space; Space Missions

20000048411 NASA Marshall Space Flight Center, Huntsville, AL USA
Marshall Space Flight Center High Speed Turbopump Bearing Test Rig
Gibson, Howard; Moore, Chip; Thom, Robert; 34th Aerospace Mechanisms Symposium; May 2000; In English; No Copyright; Avail: CASI; A03, Hardcopy

The Marshall Space Flight Center has a unique test rig that is used to test and develop rolling element bearings used in high-speed cryogenic turbopumps. The tester is unique in that it uses liquid hydrogen as the coolant for the bearings. This test rig can simulate speeds and loads experienced in the Space Shuttle Main Engine turbopumps. With internal modifications, the tester can be used for evaluating fluid film, hydrostatic, and foil bearing designs. At the present time, the test rig is configured to run two ball bearings or a ball and roller bearing, both with a hydrostatic bearing. The rig is being used to evaluate the lifetimes of hybrid bearings with silicon nitride rolling elements and steel races.
Author
High Speed; Turbine Pumps; Ball Bearings; Roller Bearings; Inspection

20000039218 NASA Marshall Space Flight Center, Huntsville, AL USA
Manufacturing and NDE of Large Composite Aerospace Structures at MSFC
Whitaker, Ann; [2000]; In English, 27-31 Mar. 2000, Birmingham, AL, USA; No Copyright; Avail: Other Sources; Abstract Only

NASA's vision for transportation to orbit calls for new vehicles built with new materials technology. The goals of this new launch system development are to improve safety, dramatically reduce cost to orbit, and improve vehicle turn around time. Planned Space Shuttle upgrades include new reusable liquid propellant boosters to replace the solid propellant boosters. These boosters are to have wings and return to the launch site for a horizontal landing on an airport runway. New single and two stages to orbit concepts are being investigated. To reduce weight and improve performance composite materials are proposed for fuel and oxidizer tanks, fuel feedlines, valve bodies, aerostructures, turbomachinery components. For large composite structures new methods of fabrication are being proposed and developed. Containment of cryogenic fuel or oxidizer requires emphases on composite material densification and chemical compatibility. Ceramic matrix and fiber composites for hot rotating turbomachinery have been developed with new fabrication processes. The new requirements on the materials for launcher components are requiring development of new manufacturing and inspection methods. This talk will examine new and proposed manufacturing methods to fabricate the revolutionary components. New NDE methods under consideration include alternative X-ray methods, X-ray laminagraphy, advanced CT, Thermography, new ultrasonic methods, and imbedded sensors. The sizes, complexity, use environment, and contamination restrictions will challenge the inspection process. In flight self-diagnosis and rapid depot inspection are also goals of the NDE development.
Author
Composite Structures; Manufacturing; Nondestructive Tests; Aeronautical Engineering; Spacecraft Launching

20000038347 NASA Marshall Space Flight Center, Huntsville, AL USA
Poster Presentation: Optical Test of NGST Developmental Mirrors
Hadaway, James B.; Geary, Joseph; Reardon, Patrick; Peters, Bruce; Keidel, John; Chavers, Greg; [2000]; In English, 27-31 Mar. 2000, Munich, Germany; No Copyright; Avail: Other Sources; Abstract Only

An Optical Testing System (OTS) has been developed to measure the figure and radius of curvature of NGST developmental mirrors in the vacuum, cryogenic environment of the X-Ray Calibration Facility (XRCF) at Marshall Space Flight Center (MSFC). The OTS consists of a WaveScope Shack-Hartmann sensor from Adaptive Optics Associates as the main instrument, a Point Diffraction Interferometer (PDI), a Point Spread Function (PSF) imager, an alignment system, a Leica

Disto Pro distance measurement instrument, and a laser source palette (632.8 nm wavelength) that is fiber-coupled to the sensor instruments. All of the instruments except the laser source palette are located on a single breadboard known as the Wavefront Sensor Pallet (WSP). The WSP is located on top of a 5-DOF motion system located at the center of curvature of the test mirror. Two PC's are used to control the OTS. The error in the figure measurement is dominated by the WaveScope's measurement error. An analysis using the absolute wavefront gradient error of 1/50 wave P-V (at 0.6328 microns) provided by the manufacturer leads to a total surface figure measurement error of approximately 1/100 wave rms. This easily meets the requirement of 1/10 wave P-V. The error in radius of curvature is dominated by the Leica's absolute measurement error of VI.5 mm and the focus setting error of Vi.4 mm, giving an overall error of V2 mm. The OTS is currently being used to test the NGST Mirror System Demonstrators (NMSD's) and the Subscale Beryllium Mirror Demonstrator (SBNM).
Author
Errors; Mirrors; Next Generation Space Telescope Project; Optical Equipment; Test Equipment

20000037724 Tokyo Univ., Japan
Cryocoolers for Space
Castles, Stephen; [2000]; In English, 17-18 Apr. 2000, Japan; No Copyright; Avail: CASI; A03, Hardcopy

This paper presents Cryocoolers for Space in viewgraph form. The topics include: 1) U.S. Cryocoolers for 4 to 6 Kelvin; 2) Turbo Brayton Cryocooler-Features; 3) HST/NICMOS (Hubble Space Telescope/Near Infrared Camera and Multiobject Spectrometer) 75 Kelvin Cryocooler; 4) Turbo-Brayton Cryocooler-NGST Design; and 5) Two-stage Sorption J-T Cryocooler.
CASI
Space Missions; Design Analysis; Cryogenic Cooling; Cryogenics

20000033992 NASA Marshall Space Flight Center, Huntsville, AL USA
X-33 Leading the Way to VentureStar(Trademark) in this Decade
Austin, Robert E.; Rising, Jerry J.; [2000]; In English; 51st, 2-6 Oct. 2000, Rio de Janeiro, Brazil; No Copyright; Avail: Other Sources; Abstract Only

The X-33, reusable space plane technology demonstrator is on course to begin the flights of the X-33 by the end of 2002 that will serve as a basis for industry and government decisions that could lead to VentureStar(Trademark). Lockheed Martin has placed the VentureStar(Trademark) LLC in it's Space Company and is now competing in an industry wide effort that will permit NASA to select a Second Generation RLV source by 2005. This move provides the focus for firm business planning needed to enable the decision by the time X-33 flies in mid 2002 and possibly with upgraded technologies a year or so later. Since the IAF 50th Congress in Amsterdam, most of the major hardware elements of X-33 have been through their assembly and test. The flight liquid oxygen tank was the first major element to complete final assembly. Aerospike Engine qualification testing has progressed successfully through its test objectives and the two flight engines are in preparation to be delivered to the Assembly Facility in Palmdale. All Thermal Protection System (TPS) metallic panels have completed qualification testing and have been delivered to Palmdale and all remaining TPS elements have been assembled and are ready for delivery. Flight Software and Avionics have been delivered and are in integration testing. In November 1999, the first graphite composite liquid hydrogen tank experienced a debond between the tank inner skin and the honeycomb core in testing. This tank had completed its third successful cryogenic and loads testing at MSFC. Replacement liquid hydrogen tanks have completed design and are in fabrication. The resulting delay from this change of design for the liquid hydrogen tank will be approximately two years.
Author
X-33 Reusable Launch Vehicle; Venturestar Launch Vehicle; Aerospace Planes; Aerospike Engines; Engine Tests

20000032752 NASA Goddard Space Flight Center, Greenbelt, MD USA
A Tethered Formation Flying Concept for the SPECS Mission
Quinn, David A.; Folta, David C.; [2000]; In English; 23rd, 2-6 Feb. 2000, Breckenridge, CO, USA
Report No.(s): AAS-00-015; No Copyright; Avail: CASI; A03, Hardcopy

The Sub-millimeter Probe of the Evolution of Cosmic Structure (SPECS) is a bold new mission concept designed to address fundamental questions about the Universe, including how the first stars formed from primordial material, and the first galaxies from pre-galactic structures, how the galaxies evolve over time, and what the cosmic history of energy release, heavy element synthesis, and dust formation is. Half of the luminosity and 98% of the post Big-Bang photons exit in the sub-millimeter range. The spectrum of our own Milky Way Galaxy shows this, and many galaxies have even more pronounced long-wavelength emissions. There can be no doubt that revolutionary science will be enabled when we have tools to study the

sub-millimeter sky with Hubble- Space-Telescope-class resolution and sensitivity. Ideally, a very large telescope with an effective aperture approaching one kilometer in diameter would be needed to obtain such high quality angular resolution at these long wavelengths. However, a single aperture one kilometer in diameter would not only be very difficult to build and maintain at the cryogenic temperatures required for good seeing, but could actually turn out to be serious overkill. Because cosmic sub-millimeter photons are plentiful and the new detectors will be sensitive, the observations needed to address the questions posed above can be made with an interferometer using well established aperture synthesis techniques. Possibly as few as three 3-4 meter diameter mirrors flying in precision formation could be used to collect the light. To mitigate the need for a great deal of propellant, tethers may be needed as well. A spin-stabilized, tethered formation is a possible configuration requiring a more advanced form of formation flying controller, where dynamics are coupled due to the existence of the tethers between nodes in the formation network. The paper presents one such concept, a proposed configuration for a mission concept which combines the best features of structure, tethers and formation flying to meet the ambitious requirements necessary to make a future SPECS mission a success.
Author
Tethering; Mathematical Models; Cosmic Rays; Submillimeter Waves; Spacecraft Configurations; Galactic Structure

20000025497 NASA Marshall Space Flight Center, Huntsville, AL USA
Magnetically Actuated Propellant Orientation, Controlling Fluids in a Low-Gravity Environment
Martin, James J.; Holt, James B.; Jan. 01, 2000; In English; 36th, 16-19 Jul. 2000, Huntsville, AL, USA; No Copyright; Avail: CASI; A02, Hardcopy

Cryogenic fluid management (CFM) is a technology area common to virtually every space transportation propulsion concept envisioned. Storage, supply, transfer and handling of sub-critical cryogenic fluids are basic capabilities that have long been needed by multiple programs and the need is expected to continue in the future. The use of magnetic fields provides another method, which could replace or augment current/traditional approaches, potentially simplifying vehicle operational constraints. The magnetically actuated propellant orientation (MAPO) program effort focused on the use of magnetic fields to control fluid motion as it relates to positioning (i.e. orientation and acquisition) of a paramagnetic substance such as LO2. Current CFM state- of-the-art systems used to control and acquire propellant in low gravity environments rely on liquid surface tension devices which employ vanes, fine screen mesh channels and baskets. These devices trap and direct propellant to areas where it's needed and have been used routinely with storable (non-cryogenic) propellants. However, almost no data exists r,egarding their operation in cryogenics and the use of such devices confronts designers with a multitude of significant technology issues. Typical problems include a sensitivity to screen dry out (due to thermal loads and pressurant gas) and momentary adverse accelerations (generated from either internal or external sources). Any of these problems can potentially cause the acquisition systems to ingest or develop vapor and fail. The use of lightweight high field strength magnets may offer a valuable means of augmenting traditional systems potentially mitigating or at least easing operational requirements. Two potential uses of magnetic fields include: 1) strategically positioning magnets to keep vent ports clear of liquid (enabling low G vented fill operations), and 2) placing magnets in the center or around the walls of the tank to create an insulating vapor pocket (between the liquid and the tank wall) which could effectively lower heat transfer to the liquid (enabling increased storage time).
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Subject Terms

CRYOGENIC EQUIPMENT

CRYOGENIC FLUID STORAGE

CRYOGENIC FLUIDS

CRYOGENIC ROCKET PROPELLANTS

CRYOGENIC STORAGE

CRYOGENIC TANKS

CRYOGENIC TEMPERATURE

CRYOGENICS

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