Oxygen-Methane Thruster

Marshall Space Flight Center, Alabama

An oxygen-methane thruster was conceived with integrated igniter/injector capable of nominal operation on either gaseous or liquid propellants. The thruster was designed to develop 100 lbf (≈445 N) thrust at vacuum conditions and use oxygen and methane as propellants. This continued development included refining the design of the thruster to minimize part count and manufacturing difficulties/cost, refining the modeling tools and capabilities that support system design and analysis, demonstrating the performance of the igniter and full thruster assembly with both gaseous and liquid propellants, and acquiring data from this testing in order to verify the design and operational parameters of the thruster.

Thruster testing was conducted with gaseous propellants used for the igniter and thruster. The thruster was demonstrated to work with all types of propellant conditions, and provided the desired performance. Both the thruster and igniter were tested, as well as gaseous propellants, and found to provide the desired performance using the various propellant conditions. The engine also served as an injector testbed for MSFC-designed refractory combustion chambers made of rhenium.

This work was done by Tim Pickens of Orion Propulsion, Inc. for Marshall Space Flight Center. For more information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-32776-1.

Lunar Navigation Determination System — LaNDS

Goddard Space Flight Center, Greenbelt, Maryland

A portable comprehensive navigational system has been developed that both robotic and human explorers can use to determine their location, attitude, and heading anywhere on the lunar surface independent of external infrastructure (needs no Lunar satellite network, line of sight to the Sun or Earth, etc.). The system combines robust processing power with an extensive topographical database to create a real-time atlas (GIS — Geospatial Information System) that is able to autonomously control and monitor both single unmanned rovers and fleets of rovers, as well as science payload stations. The system includes provisions for teleoperation and tele-presence. The system accepts (but does not require) inputs from a wide range of sensors.

A means was needed to establish a location when the search is taken deep in a crater (looking for water ice) and out of view of Earth or any other references. A star camera can be employed to determine the user's attitude in menial space and stellar map in body space. A local nadir reference (e.g., an accelerometer that orients the nadir vector in body space) can be used in conjunction with a digital ephemeris and gravity model of the Moon to isolate the latitude, longitude, and azimuth of the user on the surface. That information can be used in conjunction with a Lunar GIS and advanced navigation planning algorithms to aid astronauts (or other assets) to navigate on the Lunar surface.

This work was done by David Quinn and Stephen Talabac of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-15892-1

Launch Method for Kites in Low-Wind or No-Wind Conditions

Goddard Space Flight Center, Greenbelt, Maryland

Airborne observations using lightweight camera systems are desirable for a variety of applications. This system was contemplated as a method to provide a simple remote sensing aerial platform. Kites have been successfully employed for aerial observations, but have historically required natural wind or towing to become airborne. This new method negates this requirement, and widens the applicability of kites for carrying instrumentation. Applicability is primarily limited by the space available on the ground for launching.

The innovation is a method for launching kites in low-wind or no-wind conditions. This method will enable instrumentation to be carried aloft using simple (or complex) kite-based systems, to obtain observations from an aerial perspective. This technique will provide access to altitudes of 100 meters or more over any area normally suited for kite flying. The duration of any observation is dependent on wind strength; however, the initial altitude is relatively independent. The system does not require any electrical or combustion-based elements. This technology was developed to augment local-scale airborne measurement capabilities suitable for Earth science research, agricultural productivity, and environmental observations. The method represents an extension of techniques often used in aeronautical applications for launching fixed-wing aircraft, such as sailplanes, using mechanical means not incorporated in the aircraft itself.

The innovation consists of an elastic cord (for propulsive force), a tether extension (optional, for additional height), and the kite (instrumentation optional). Operation of the system is accomplished by fixing the elastic cord to ground (or equivalent), attaching the cord with/or without a tether extension to the kite, tensioning the system to store energy, and releasing the kite. The kite will climb until energy is dissipated.

This work was done by Geoffrey Bland and Ted Miles of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-16004-1

Supercritical CO_2 Cleaning System for Planetary Protection and Contamination Control Applications

This system can be used for precision cleaning in optical and semiconductor applications.

NASA's Jet Propulsion Laboratory, Pasadena, California

Current spacecraft-compatible cleaning protocols involve a vapor degreaser, liquid sonication, and alcohol wiping. These methods are not very effective in removing live and dead microbes from spacecraft piece parts of slightly complicated geometry, such as tubing and loosely fitted nuts and bolts. Contamination control practices are traditionally focused on cleaning and monitoring of particulate and oily residual. Vapor degreaser and outgassing bakeout have not been proven to be effective in removing some less volatile, hydrophilic biomolecules of significant relevance to life detection.

A precision cleaning technology was developed using supercritical CO_2 (SCC). SCC is used as both solvent and carrier for removing organic and particulate contaminants. Supercritical fluid, like SCC, is characterized by physical and thermal properties that are between those of the pure liquid and gas phases. The fluid density is a function of the temperature and pressure. Its solvating power can be adjusted by changing the pressure or temperature, or adding a secondary solvent such as alcohol or water.

Unlike a regular organic solvent, SCC has higher diffusivities, lower viscosity, and lower surface tension. It readily penetrates porous and fibrous solids and can reach hard-to-reach surfaces of the parts with complex geometry. Importantly, the CO_2 solvent does not leave any residue.

The results using this new cleaning device demonstrated that both supercritical CO_2 with 5% water as a co-solvent can achieve cleanliness levels of 0.01 mg/cm^2 or less for contaminants of a wide range of hydrophobicities. Experiments under the same conditions using compressed Martian air mix, which consists of 95% CO_2, produced similar cleaning effectiveness on the hydrophobic compounds.

The main components of the SCC cleaning system are a high-pressure cleaning vessel, a boil-off vessel located downstream from the cleaning vessel, a syringe-type high-pressure pump, a heat exchanger, and a back pressure regulator (BPR).

After soaking the parts to be cleaned in the clean vessel for a period, the CO_2 with contaminants is flushed out of the cleaning vessel using fresh CO_2 in a first-in-first-out (FIFO) method. The contaminants are either precipitating out in the boil-off container or being trapped in a filter subsystem. The parts to be cleaned are secured in a basket inside and can be rotated up to 1,400 rpm by a magnetic drive. The fluid flows within the vessel generate tangential forces on the parts' surfaces, enhancing the cleaning effectiveness and shortening the soaking time.

During the FIFO flushing, the pump subsystem pushes fresh CO_2 into the cleaning vessel at a constant flow rate between 0.01 and 200 mL/min, while the BPR regulates the pressure in the cleaning vessel to within 0.1 bar by controlling the needle position in an outlet valve.

The fresh CO_2 gas flows through the heat exchanger at a given temperature before entering the cleaning vessel. A platinum resistance thermometer (PRT) reads the cleaning vessel interior temperature that can be controlled to within 0.1 K. As a result, cleaning vessel temperature remains constant during the FIFO flushing. There is no change in solvent power during FIFO flushing since both temperature and pressure inside the cleaning vessel remain unchanged, thus minimizing contaminants left behind. During decompression, both temperature and pressure are strictly controlled to prevent bubbles from generating in the cleaning vessel that could stir up the contaminants that sank to the bottom by gravity.

This work was done by Ying Lin, Fang Zhong, David C. Aveline, and Mark S. Anderson of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-47414

Design and Performance of a Wideband Radio Telescope

NASA's Jet Propulsion Laboratory, Pasadena, California

The Goldstone Apple Valley Radio Telescope (GAVRT) is an outreach project, a partnership involving NASA's Jet Propulsion Laboratory (JPL), the Lewis Center for Educational Research (LCER), and the Apple Valley Unified School District near the NASA Goldstone deep space communication complex. This educational program currently uses a 34-meter antenna, DSS12, at Goldstone for classroom radio astronomy observations via the Internet. The current program utilizes DSS12 in two narrow frequency bands around S-band (2.3 GHz) and X-band (8.45 GHz), and