Summary

The Mechanical Components Branch at NASA Glenn Research Center hosted a workshop on Tuesday, May 14, 2002 to discuss space mechanisms technology. The theme for this workshop was "Working in the Cold," a focus on space mechanisms that must operate at low temperatures. We define "cold" as below –60 °C (210K), such as would be found near the equator of Mars. However, we are also concerned with much colder temperatures such as in permanently dark craters of the Moon (about 40K).

Introduction

This was the second in a planned series of space mechanisms technology workshops sponsored by the Mechanical Components Branch at NASA Glenn Research Center. The previous workshop in November 2000 considered space drives, mechanical transmissions that perform as speed reducers to match the high speed, low torque output, typical of electric motors, to the low speed, high torque required to operate machinery. This workshop focused on space mechanisms that must operate at low temperatures. We define "cold" as below –60 °C (210K), such as would be found near the equator of Mars. However, we are also concerned with much colder temperatures such as in permanently dark craters of the Moon (about 40K).

These low temperatures present challenges for mechanisms design. At extreme temperatures, conventional liquid lubricants (including grease) may not be feasible, therefore either solid lubricants must be used, provision must be made to heat lubricants, or some unconventional lubricant may be considered. The goal is to identify the problems caused by these conditions and to project what resources will be needed to support future missions.

This report summarizes the nine presentations on space mechanisms technology given at the workshop.

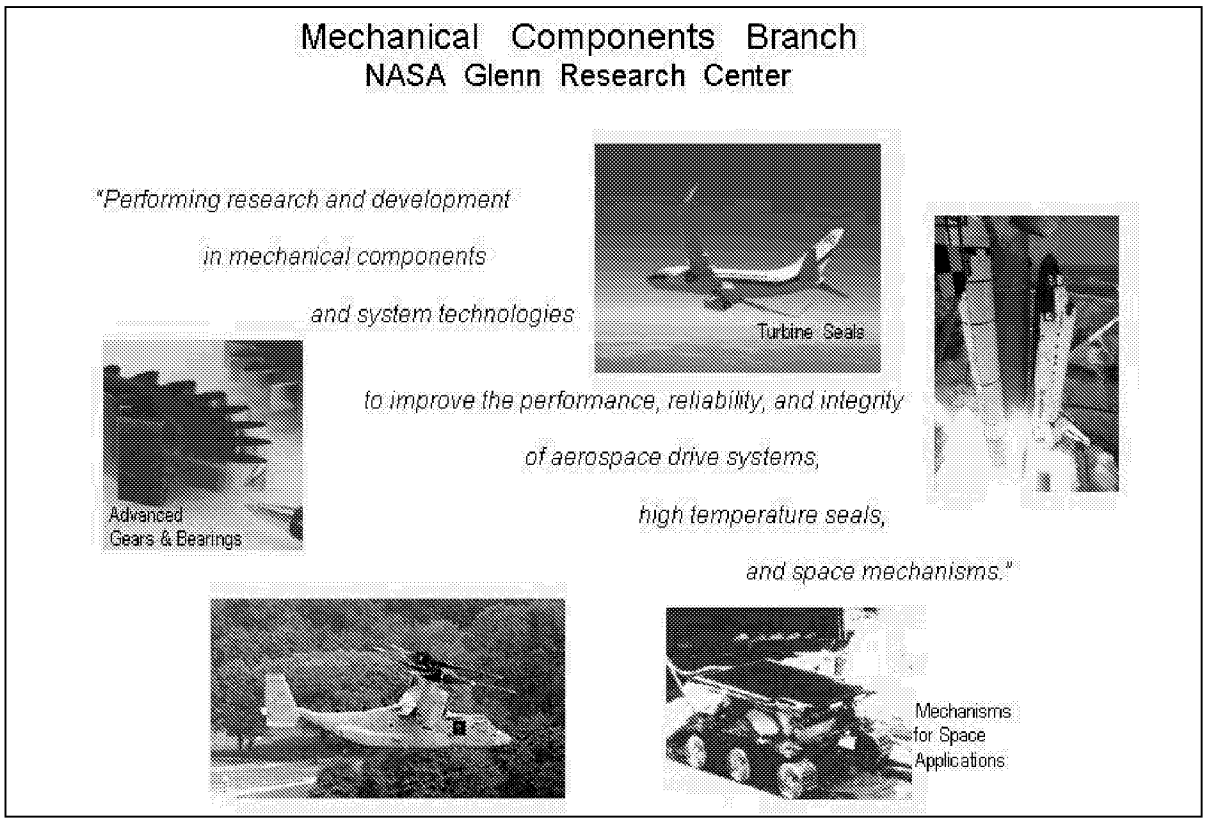
Overview of Glenn Mechanical Components Branch Research

Mr. James Zakrajsek, chief of the Mechanical Components Branch, gave an overview of research conducted by the branch. Branch members perform basic research on mechanical components and systems, including gears and bearings, turbine seals, structural and thermal barrier seals, and space mechanisms. The research is focused on propulsion systems for present and advanced aerospace vehicles.

For rotorcraft and conventional aircraft, we conduct research to develop technology needed to enable the design of low noise, ultra safe geared drive systems. We develop and validate analytical models for gear crack propagation, gear dynamics and noise, gear diagnostics, bearing dynamics, and thermal analyses of gear systems using experimental data from various component test rigs.

In seal research we develop and test advanced turbine seal concepts to increase efficiency and durability of turbine engines. We perform experimental and analytical research to develop advanced thermal barrier seals and structural seals for current and next generation space vehicles.

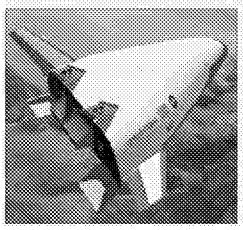
Our space mechanisms research involves fundamental investigation of lubricants, materials, components and mechanisms for deep space and planetary environments.



Mechanical Components Branch

Core Technologies

Seals



non-contacting turbine seals

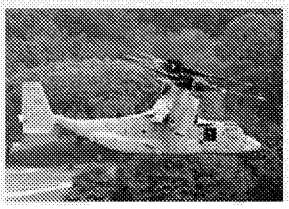
self adapting seals

thermal barrier seals development

acoustic seals development

structural seals development

Drive Systems



drive systems lubrication and thermodynamics

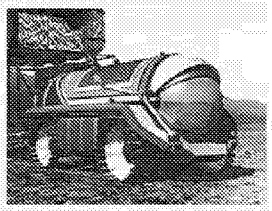
drive system health management

fracture mechanics

drive systems dynamics and noise

gear fatigue

Space Mechanisms



lubrication in space environment

space mechanisms design guidelines

coatings research

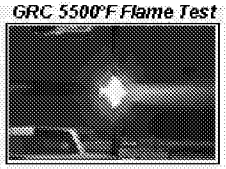
mechanical drives for planetary rovers

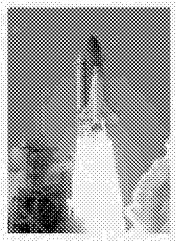
Mechanical Components Branch

Seal / Thermal Barrier Development for Space Transportation Programs

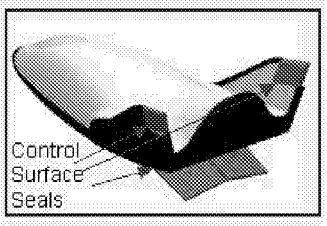
Developed thermal barrier to block hot gases from damaging Viton O-rings in Space Shuttle Solid Rocket Motor

GRC 5500°F Flame Test





Assist JSC in developing control surface seals to prevent hot, re-entry gas ingestion/damage of control surface hardware

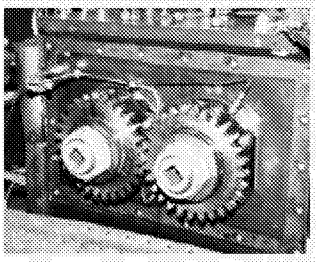
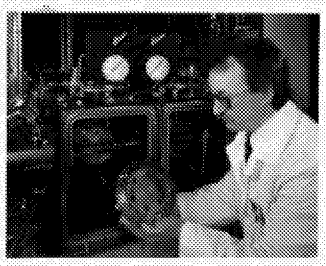
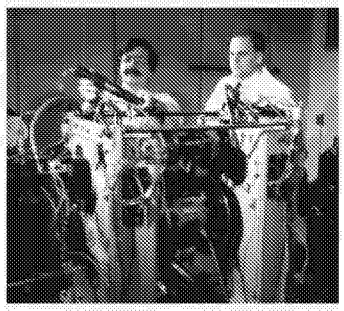
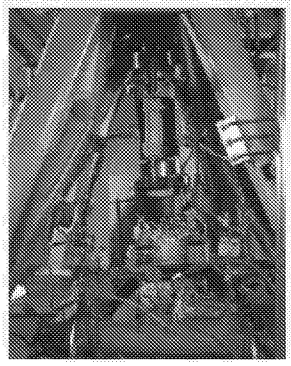
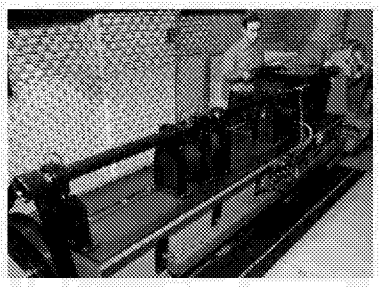


X-38 CRV

Developed conceptual design of inter-engine seal showing promise of accommodating large deflections in hot flow environment between aerospike engine modules

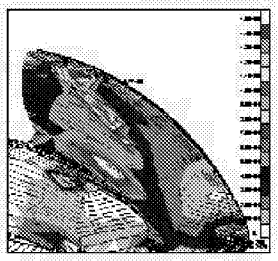
Mechanical Components Branch

Drive Systems Experimental Facilities - NASA Glenn Research Center

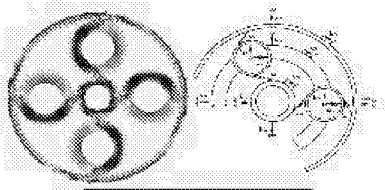






Mechanical Components Branch

Drive Systems Analytical Capabilities

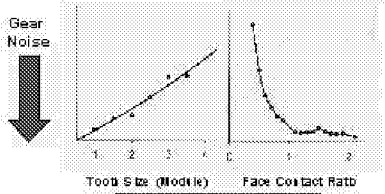


Finite Element Based Structural - Thermal

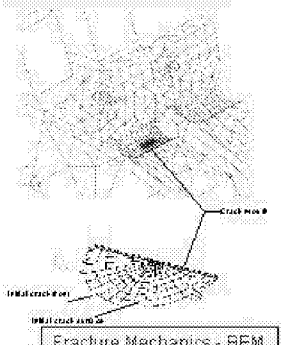


Planetary Gear Dynamics

Physics-Based Models



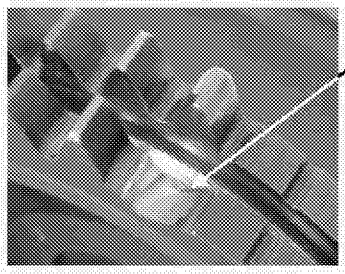
Helical Gear Dynamics



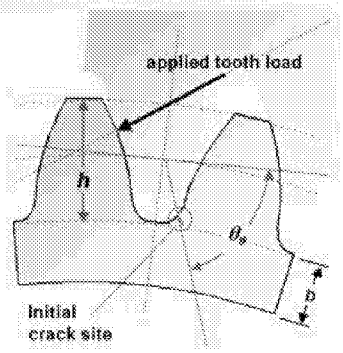
Fracture Mechanics - BEM

Mechanical Components Branch

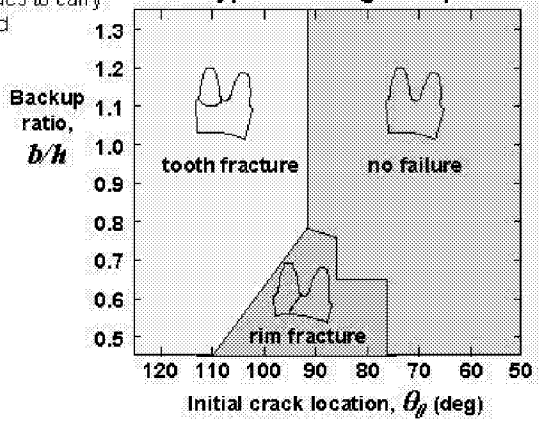
Gear Design Guide for Failsafe Operation



Tooth on one rim fractures but corresponding tooth on "second" rim continues to carry full load



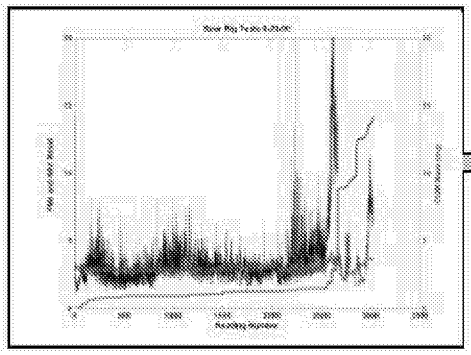
Typical Design Map



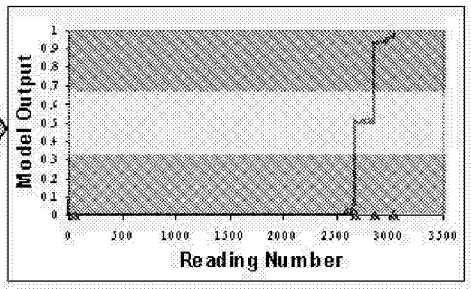
Mechanical Components Branch

Drive System Sensor Fusion for Increasing Reliability of Health Monitoring Systems

Vibration and Oil Debris Data



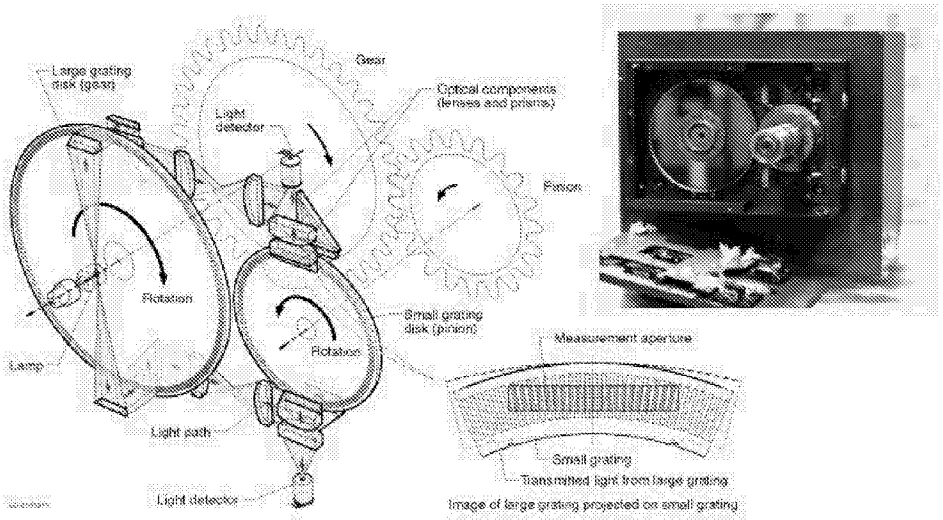
Output of Fuzzy Logic Model



Mechanical Components Branch

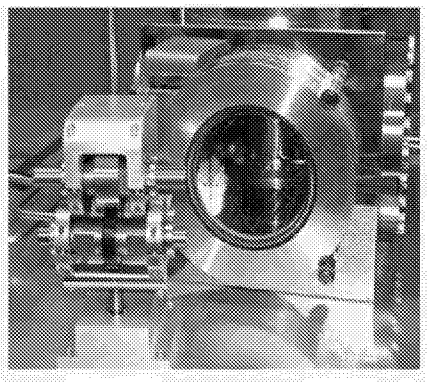
Technologies to Reduce Gear Noise at the Source

High Speed Gear Transmission Error Measurement System

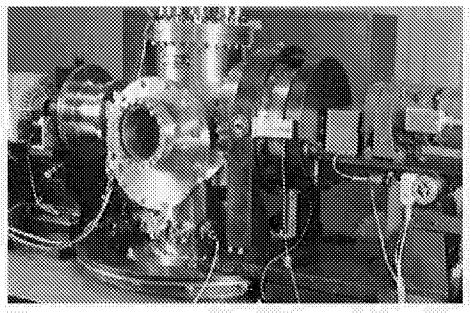


Mechanical Components Branch

Space Mechanisms Experimental Facilities - NASA Glenn Research Center



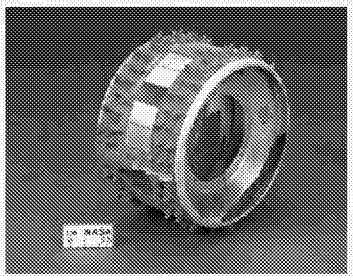
New proof-of-concept traction drive test unit with vacuum cube

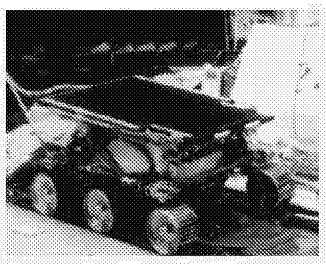


Vacuum roller test rig

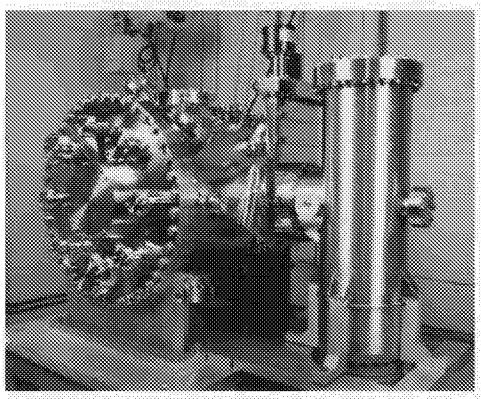
Mechanical Components Branch

Space Mechanisms Research
Mars Pathfinder Abrasive Wheel Experiment Test





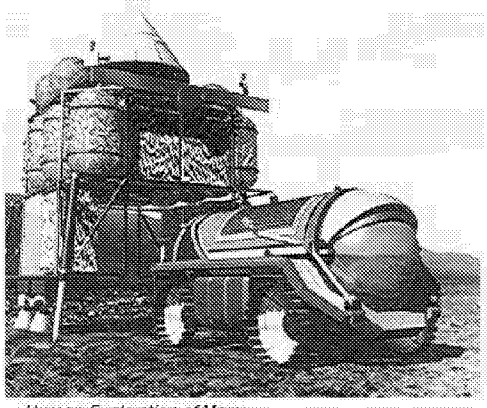
GRC test chamber with simulated Martian atmosphere and simulated Martian soil



Space Mechanisms Pathfinder

Mechanical Components Branch

Space Mechanisms Research - Initiative for Horizon
Advanced Space Drives Research



Human Exploration of Mars:
The Reference Mission of the NASA Mars Exploration Team
NASA SP 6107, July 1997

Investigating new concepts in solid lubricated traction drives for future planetary exploration vehicles

- 16.5 Metric ton rovers planned for future manned Mars missions
- Must be capable of reliable operations on 500Km, 10 day excursions
- Must be lightweight and power efficient
- Must be "oil-free", and capable of operating in extreme cold and dusty conditions