

elasticity, so that between steps, the gripper returns to a default position that is roughly parallel to the wall.

In order to give the ankle freedom to rotate about all three degrees of freedom, the gripper is mounted on a series of gimbals similar to those found on a gyroscope. The rotation of the gimbals about radial directions is limited by springs, which bring the gripper back to a default position in between steps of the robot. These springs have a relatively low spring-constant so as not to induce large torques that may upset the gripper's hold on the rock. Additionally, microspine engagement is achieved

through a motor that turns a spool and pulls on cables connected to the spine arrays. A linear actuator that pulls the microspines up and away from the rock face provides disengagement. Previous microspine robots have been limited by their feet, which only sustain forces in one direction and only work on globally smooth surfaces like brick walls and concrete. The omnidirectional anchors extend the potential of legged robots using microspines to natural rock, and would allow gripping at any orientation including inverted or in zero gravity.

This work was done by Aaron Parness, Matthew A. Frost, and Nitish Thatte of Cal-

tech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

*Innovative Technology Assets Management
JPL*

Mail Stop 321-123

4800 Oak Grove Drive

Pasadena, CA 91109-8099

E-mail: iaoffice@jpl.nasa.gov

Refer to NPO-48315 volume and number of this NASA Tech Briefs issue, and the page number.

⚙️ Wind, Wave, and Tidal Energy Without Power Conditioning

NASA's Jet Propulsion Laboratory, Pasadena, California

Most present wind, wave, and tidal energy systems require expensive power conditioning systems that reduce overall efficiency. This new design eliminates power conditioning all, or nearly all, of the time.

Wind, wave, and tidal energy systems can transmit their energy to pumps that send high-pressure fluid to a central power production area. The central power production area can consist of a series of hydraulic generators. The hy-

draulic generators can be variable displacement generators such that the RPM, and thus the voltage, remains constant, eliminating the need for further power conditioning.

A series of wind blades is attached to a series of radial piston pumps, which pump fluid to a series of axial piston motors attached to generators. As the wind is reduced, the amount of energy is reduced, and the number of active hydraulic generators can be reduced to

maintain a nearly constant RPM. If the axial piston motors have variable displacement, an exact RPM can be maintained for all, or nearly all, wind speeds. Analyses have been performed that show over 20% performance improvements with this technique over conventional wind turbines.

This work was done by Jack A. Jones of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-48620

⚙️ An Active Heater Control Concept to Meet IXO Type Mirror Module Thermal-Structural Distortion Requirement

This innovation offers a number of advantages in terms of reduced mass, problem of routing, and the risk of x-ray attenuation.

Goddard Space Flight Center, Greenbelt, Maryland

Flight mirror assemblies (FMAs) of large telescopes, such as the International X-ray Observatory (IXO), have very stringent thermal-structural distortion requirements. The spatial temperature gradient requirement within a FMA could be as small as 0.05 °C. Conventionally, heaters and thermistors are attached to the stray light baffle (SLB), and centralized heater controllers (i.e., heater controller boards located in a large electronics box) are used. Due to the large number of heater harnesses, accommodating and routing them is extremely difficult. The total harness length/mass is

very large. This innovation uses a thermally conductive pre-collimator to accommodate heaters and a distributed heater controller approach. It minimizes the harness length and mass, and reduces the problem of routing and accommodating them.

Heaters and thermistors are attached to a short (4.67 cm) aluminum portion of the pre-collimator, which is thermally coupled to the SLB. Heaters, which have a very small heater power density, and thermistors are attached to the exterior of all the mirror module walls. The major portion (23.4 cm) of the pre-collimator for the middle and outer modules

is made of thin, non-conductive material. It minimizes the view factors from the FMA and heated portion of the pre-collimator to space. It also minimizes heat conduction from one end of the FMA to the other. Small and multi-channel heater controllers, which have adjustable set points and internal redundancy, are used. They are mounted to the mechanical support structure members adjacent to each module.

The IXO FMA, which is 3.3 m in diameter, is an example of a large telescope. If the heater controller boards are centralized, routing and accommodating heater harnesses is extremely dif-

ficult. This innovation has the following advantages. It minimizes the length/mass of the heater harness between the heater controllers and heater circuits. It reduces the problem of routing and accommodating the harness on the FMA.

It reduces the risk of X-ray attenuation caused by the heater harness. Its adjustable set point capability eliminates the need for survival heater circuits. The operating mode heater circuits can also be used as survival heater circuits.

In the non-operating mode, a lower set point is used.

This work was done by Michael Choi of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-16380-1

Waterless Clothes-Cleaning Machine

This machine can be used wherever water is at a premium, or to minimize washing with water.

Lyndon B. Johnson Space Center, Houston, Texas

A waterless clothes-cleaning machine has been developed that removes loose particulates and deodorizes dirty laundry with regenerative chemical processes to make the clothes more comfortable to wear and have a fresher smell. This system was initially developed for use in zero-g, but could be altered for 1-g environments where water or other resources are scarce. Some of these processes include, but are not limited to, airflow, filtration, ozone generation, heat, ultraviolet light, and photocatalytic titanium oxide.

The machine has a chamber large enough to contain and agitate several articles of clothing, as well as a self-sealing door for insertion and removal of the clothing. The agitation and removal of particulate and volatiles in the clothes is done by airflow and some kind of agitation mechanism, possibly by rotating the chamber and/or alter-

nating airflow and/or heater panels for the zero-g environment. Agitation in 1-g could be done with tumbling. One of the main purposes of the airflow is to remove particulate from the clothing and to deposit it into a filter where the particulate can be removed from the filter at the end of the cycle. This airflow can also carry ozone into the chamber to penetrate into the clothing to kill off bacteria and break down odorizing proteins or other organics. The chamber can also contain an ultraviolet light source to expose the agitating clothes to bacteria-killing wavelengths of light. This light source could also expose a photocatalytic material such as titanium oxide, embedded coated on the interior of the chamber walls or on agitation mechanisms, to energies that would produce hydroxyl ions from the chamber humidity to aid in the removal of organic compounds from the cloth.

Heat could be introduced into the clothing chamber either by heating the airflow or by heating the clothing chamber directly using electrical heater strips on the chamber walls. The heat would aid in the killing of bacteria, breaking down proteins, and evaporating volatiles from the clothes. The airflow for this system could either be completely recycled back through the system or vented out, depending on the needs of the clothes cleaner's surrounding environment. Airflow, ozone, UV light, and the heat can be controlled independently so each can be turned on or off without affecting the others to allow for the needs of the specific type of clothing or different types of soiling on the clothes.

This work was done by Glenn Johnson and Shane Ganske of United Space Alliance for Johnson Space Center. Further information is contained in a TSP (see page 1). MSC-25280-1

Integrated Electrical Wire Insulation Repair System

John F. Kennedy Space Center, Florida

An integrated system tool will allow a technician to easily and quickly repair damaged high-performance electrical wire insulation in the field. Low-melt polyimides have been developed that can be processed into thin films that work well in the repair of damaged polyimide or fluoropolymer insulated electrical wiring. Such thin films can be used in wire insulation repairs by affixing a film of this low-melt polyimide to the damaged wire, and heating the film to

effect melting, flow, and cure of the film. The resulting repair is robust, lightweight, and small in volume. The heating of this repair film is accomplished with the use of a common electrical soldering tool that has been modified with a special head or tip that can accommodate the size of wire being repaired.

This repair method can furthermore be simplified for the repair technician by providing replaceable or disposable soldering tool heads that have repair

film already "loaded" and ready for use. The soldering tool heating device can also be equipped with a battery power supply that will allow its use in areas where plug-in current is not available.

This work was done by Martha Williams of Kennedy Space Center and Scott Jolley, Tracy Gibson, and Steven Parks of ASRC Aerospace Corporation. For more information, contact the Kennedy Space Center Innovative Partnerships Office at 321-867-5033. KSC-13193