MSFC-113

Ongoing Space Nuclear Activities

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Most ongoing US activities related to space nuclear power and propulsion are sponsored by NASA. NASA-sponsored space nuclear work is currently focused on evaluating potential fission surface power (FSP) systems and on radioisotope power systems (RPS). In addition, significant efforts related to nuclear thermal propulsion (NTP) systems have been completed and will provide a starting point for potential future NTP work.

Fission Surface Power

Fission surface power work includes studies and hardware work focused on technical and programmatic risk reduction. The primary ongoing study is the Affordable Fission Surface Power System (AFSPS) study, aimed at determining if affordable options exist for developing FSP systems. The study team includes representatives from NASA and DOE headquarters as well as three NASA centers and four DOE national laboratories. Numerous system design attributes have been identified for helping ensure affordability, including the following:

1. The FSP system can use a fuel pin design very similar to that used in FFTF or EBR-II.

2. The FSP system can use materials for which there is an extensive terrestrial nuclear database (e.g. 316 stainless steel).

3. The FSP system can use a primary coolant loop very similar to those flown in space by the US and Russia.

4. The FSP system can use components and technologies for which there is a large terrestrial database.

5. The FSP system can use a power conversion subsystem with heritage to power conversion subsystems being developed for use on earth and in space radioisotope power systems (e.g. Stirling).

6. The FSP system can use a waste heat rejection subsystem with heritage to the International Space Station radiator and radiators used by large commercial satellites.

7. The FSP system can be designed to facilitate flight qualification, launch, and operation.

Initial findings of the AFSPS study will be available in 2007.

Technical work in support of FSP system development

In addition to technical work being performed in support of the AFSPS study, significant technology development is being performed at Glenn Research Center (GRC), Marshall Space Flight Center (MSFC), and elsewhere. Ongoing research at GRC includes development of Stirling power conversion subsystems (Fig. 1), development of radiators and radiator heat pipes (Fig. 2), and development of power control and distribution components for FSP applications.

Figure 1. Stirling engine test at GRC.

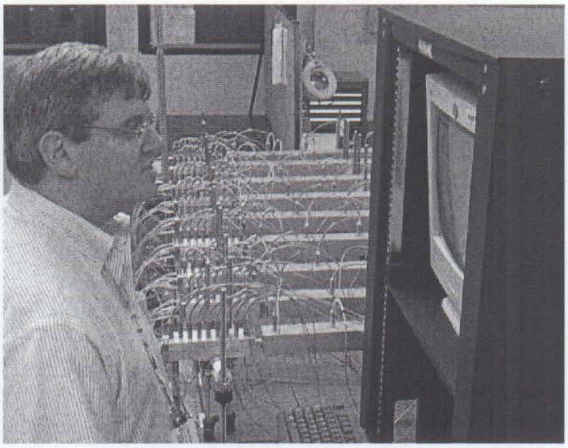

Figure 2. Titanium/water heat pipe test.

Work at MSFC (in close coordination with GRC and DOE) includes testing of primary loop components (e.g. pumps, heat exchangers), quantification of representative loop material transport, testing of loop purification systems, investigation of potential freeze/thaw issues, and investigation of other potential issues, technologies, and components associated with the FSP primary heat transport system. A picture of MSFC's fission surface power primary test circuit (FSP-PTC) is shown in Figure 3.

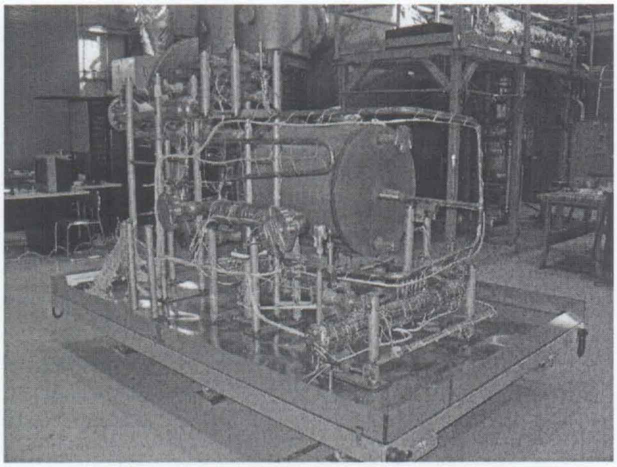

Figure 3. Fission Surface Power Primary Test Circuit (FSP-PTC).

Work at DOE national laboratories has included reactor component and system designs, development of testing strategies, development of fundamental approaches to safety and flight qualification, and other tasks associated with the FSP reactor module and shield.

Radioisotope Power Systems

Near term activities on RPS include readying the Multi-Mission Radioisotope Thermoelectric Generator (MMRTG) for use on the Mars Science Laboratory (MSL). MSL is a sophisticated Mars rover that will investigate conditions for life to exist, past and present, by performing various in-situ experiments, including rock and soil sample processing. The DOE is currently managing the effort to fabricate an MMRTG qualification unit, and plans to deliver one flight unit and a spare for the MSL mission in time for launch in September 2009. Other work is focused on the development of a high efficiency Advanced Stirling Radioisotope Generator (ASRG), which is being designed to operate in space vacuum as well as planetary atmospheres. Glenn Research Center is the lead for technology development of Stirling components. DOE is developing the ASRG system and moving toward fabrication of a test and evaluation engineering model next year. Work is also being done to improve the efficiency of thermoelectric couples for possible application to a next generation RTG. The Jet Propulsion Laboratory is leading this effort, with support from a variety of institutions, to capitalize on the ability of nanostructures to reduce thermal conductivity in semi-conductor materials. Conceptual designs for an advanced RTG based on these materials are being investigated at this time.

Nuclear Thermal Propulsion

NTP systems have the potential for enabling sustained, affordable exploration of the planet Mars and beyond. The primary attribute of NTP systems is their potential to achieve specific impulses in excess of 900 s, roughly twice that of the best chemical systems.

Significant capability has been developed over the past three years that could facilitate initial work on the development of NTP systems. System modeling tools have been developed with contributions from GRC, MSFC, Idaho National Laboratory (INL), Los Alamos National Laboratory (LANL), and Oak Ridge National Laboratory (ORNL). LANL has demonstrated present-day capability to fabricate Rover/NERVA fuel elements. MSFC has fabricated high quality cermets with a high volume fraction (60-80%) of fuel surrogate. MSFC has also completed the Nuclear Thermal Rocket Environmental Effects Simulator (NTREES), which is capable of testing potential NTP materials at prototypic hydrogen flow rates, high power density, and temperatures up to 3000 K. GRC is leading five tasks related to NTP systems that will be completed in mid-2007. The tasks include:

1. Mars Mission Analysis and Engine / Stage Characterization Supporting Requirements Definition;

2. NTP Fuels and Coatings Assessment and Initial Test Plan Formulation;

3. Engine Conceptual Design, Analysis, and Modeling Upgrades;

4. NTP Infrastructure and Ground Test Facility Assessment; and

5. NTP Program, Technology and Engine Acquisition Strategy.

In addition to the NASA-sponsored work described above, ongoing efforts related to the design, development, and utilization of space nuclear power and propulsion systems exist within various universities and organizations.