GEOTHERMAL SYSTEM DESIGNS FOR LUNAR SURFACE ENVIRONMENT SCIENCE ACTIVITIES.

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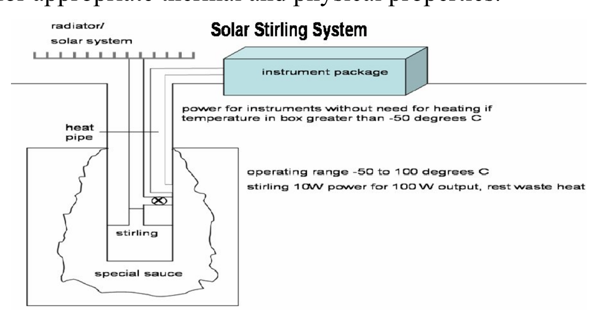
Introduction: We have been analyzing and modeling two promising innovative geothermally-based designs for science package power and/or thermal support systems which meet the operational challenges and harness the extreme thermal conditions on the lunar surface, the most typical surface environment in the solar system. Both 1) the combined solar thermal/stirling geothermal power system and 2) the heat-pipe based thermal protection system, involve preliminary deployment using innovative drilling and fluid injection technology with newly available designer fluids to transform the regolith into a viable heat reservoir. The goal is, in the face of great uncertainty in the availability of radioisotope-based power systems, to radically minimize the mass required for science payloads to meet small deliverable mass constraints, while maximizing performance under conditions even more demanding than those routinely experienced by spacecraft in deep space.

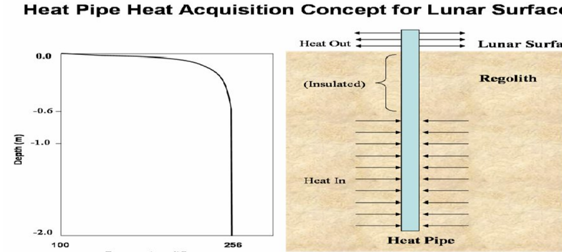
Thermal System: We investigated the feasibility of using heat pipes to bring heat from the constant (latitude-dependent) temperature regolith that exists 0.5 meters below the lunar surface. Heat pipes could be imbedded in the instrument mounting plate to maintain instruments temperature levels. For unmodified regolith, the volume required to provide a constant power of 10W for the entire night time is about 0.62 m^3. The heat transport requirement (10W) is well within the current heat pipe capability, but the extremely low thermal conductivity and heat capacity of the regolith severely limits the rate at which heat can be removed. More than 10 heat pipes with diameters of 0.625″ and flanges of 1″ width deployed to 2 meters depth would be required to increase the rate of heat transfer with major implications for mass and EVA time. Thus, at least one order of magnitude increase in thermal conductivity is required to make this concept feasible.

Power System: We developed a preliminary concept for a solar thermal/geothermal power system for instrument packages. A solar thermal system provides power while trapping excess heat in the 'heat sink' regolith during the day, and then harnesses that 'heat reservoir' to drive a sterling engine mechanism at night. Currently the free piston Stirling engine has been used for cryocoolers and as part of the ASRG to generate power reliably over long periods. We utilize this heat engine to generate electrical power from the temperature differential between the relatively warm regolith acting as a thermal storage reservoir during lunar night. Again, 1 to 2 orders of magnitude increase in thermal conductivity is required to make this concept feasible.

Geothermalizing the Regolith: We investigated approaches to 'geothermalizing' the regolith (increasing the low thermal conductivity and heat capacity normally resulting from limited heat transfer between grains in a vacuum) via subsurface deployment of 'geothermalizing' fluids to maintain contact between grains, facilitating heat transfer, without evaporating significantly over time. Such materials are in fact available within a suitable range of thermal (2 orders of magnitude or more greater thermal conductivity than lunar regolith) and physical (low volatility and melting point) properties These liquids would be injected with a Qortek-designed innovative low power, readily portable and deployable, muti-functional, high torque drill assembly enabling multiple drilling in a trilaterally stable configuration. This assembly would emplace the heat pipe or stirling into the regolith and transform the subsurface into a serviceable heat reservoir for geothermal use. Two fluid candidates are 1) AOS thermal grease 52030, a perfluorinated non-silicone zinc oxide compound with a very low melting point (-100^{o}C) combined with high thermal conductivity and heat capacity, extremely low vapor pressure and high viscosity; 2) Ionic liquids (organic salts) with low melting point (down to -80^{o}C) and negligible vapor pressure. We are in the process of screening liquid and regolith mixtures for appropriate thermal and physical properties.



Heat Pipe Heat Acquisition Concept for Lunar Surface



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