NASA SBIR 2008 Phase I Solicitation

X3.02 Oxygen Production from Lunar Regolith

Lead Center: JSC

Participating Center(s): GRC, KSC, MSFC

Oxygen (O_2) production from lunar regolith processing consists of receiving regolith from the excavation subsystem into a hopper, transferring that regolith into a chemical or an electrochemical reactor, intermediate reactions to produce O_2 and regenerate reactants if required, purification and transfer of the O_2 produced, and removal of processed regolith from the reactor to an outlet hopper. Three O_2 production from lunar regolith reaction concepts are currently under development: Hydrogen reduction, Carbothermal reduction, and Molten Oxide Electrolysis at initial lunar Outpost production scale of 1 to 2 MT per year. The production plant will utilize solar power, and two operation options are: 1) operate at polar location with solar energy available for processing to occur 70% of the year with highlands soil feedstock, and 2) operation at an equatorial location with solar energy available for processing to occur 45% of the year with mare soil feedstock. To maximize the benefits of ISRU for lunar missions, O_2 production systems must be able to produce many times their own mass in O_2 and other products, must be able to autonomously operate in a harsh environment that can have wide temperature swings, and must operate with little or no maintenance and little or no loss of reactants and O_2 while handling and processing highly abrasive lunar regolith. Systems must also be able to sustain numerous startup and shutdown sequences when solar power is not available. Shutdown periods can vary from twenty hours to 14 days.

This subtopic is seeking hardware, subsystem, and system components and technologies for insertion and integration into on-going oxygen extraction from regolith development and demonstration efforts. Component and technology areas of particular interest are:

- Move feedstock material from hopper on ground to 2 m height for reactor inlet hopper; 40 kg/hr; material size
- Inlet/outlet regolith hopper design and valve/seal concepts with no gas leakage, 1000's of operating cycles with abrasive lunar material, and minimum heat loss.
- Methods and hardware for recovering heat energy from spent regolith to pre-heat inlet regolith; 1050Â°C spent regolith temp, 750Â°C inlet regolith starting temp; 20 kg/batch.
- Molten material removal from molten electrolysis; 5 to 10 kg per batch size.
- Non-eroding cathode/anode concepts for molten oxide electrolysis; 5 to 10 kg batch size.

- Water condensers that use the space environment for water condensation/separation with minimal energy usage.

- Gas Separators that provide low pressure drop separation of the system and product gas streams from impurities (e.g. HCl, HF, H_2S, SO_2); impurities in ppm quantities.

- Microchannel methanation reactors that convert a mixture of carbon monoxide, carbon dioxide, and hydrogen to methane and water vapor with carbon monoxide and carbon dioxide consumed to the maximum extent possible.

- Advanced reactor concepts for carbothermal reduction or molten oxide electrolysis.

Phase 1 proposals should demonstrate technical feasibility of the technology or hardware concept through laboratory validation of critical aspects of the innovation proposed, as well as the design and path toward delivering hardware/subsystems in Phase 2 for incorporation into existing development activities. Interface requirements for on-going development efforts will be provided after selection. Proposers are encouraged to use the Lunar Sourcebook at a minimum for understanding lunar regolith material parameters in the design and testing of hardware proposed. It is also recommended that JSC-1a simulants be used during testing unless a more appropriate simulant can be obtained or manufactured.