Solar Energy System for In-Situ Resource Utilization

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AIAA-2004-6035

Space 2004 Conference and Exhibit
Session: 74-HUMAN-13 Surface Bases and Analogs
San Diego, CA

28-30 September 2004
Schematic Representation of the OW Solar Energy System for Lunar Materials Processing

- Steerable Secondary Concentrators
  - Tracking Concentration Array
  - Coupler
- Optical Fiber Bundle
  - Spectrum Analysis
  - Calorimeter
- To Thermal Reactor

C-4459b
The Ground Test Model of the OW Solar Thermal Power System
Thermal Reactor for Hydrogen Reduction of JSC-1
Thermal Reactor Temperature versus Solar Power

![Graph showing the relationship between temperature (°C) and power input (W).]

- Least square fit
- 3/23/96, moly rad shields added
- 4/13/96, moly sleeve insert added
- 4/27/96
- 4/29/96
- 5/9/96

Power Input (W) vs. Temperature (°C)
**Hydrogen Reduction of JSC-1**

- Reactor Temperature: 832°C
- Reactant: Ar+5%H₂
- Sample Weight: 20 gram
- Mass Flow Rate: 0.25 slpm at t=0
- Dotted Line: Least Squares Curve Fit
# System Efficiency of the Engineering Model and the Future Space Based System

<table>
<thead>
<tr>
<th></th>
<th>Engineering Model Results</th>
<th>Space-Based Operational System</th>
<th>Improvement Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary concentrator</td>
<td>0.722</td>
<td>0.864</td>
<td></td>
</tr>
<tr>
<td>Reflectivity Intercept factor</td>
<td>0.82 0.88</td>
<td>0.90 0.96</td>
<td>Reflectivity enhancing coating Intercept factor in space will be higher</td>
</tr>
<tr>
<td>Concentrator fiber coupling</td>
<td>0.708</td>
<td>0.965</td>
<td></td>
</tr>
<tr>
<td>Front-end Fresnel reflection Fiber fill factor</td>
<td>0.965 0.734</td>
<td>0.965 1.00</td>
<td>Improve fiber cable front termination design for higher fill factor</td>
</tr>
<tr>
<td>Optical fiber cable transmitter (10 meter)</td>
<td>0.743</td>
<td>0.868</td>
<td></td>
</tr>
<tr>
<td>Fiber transmission Back-end Fresnel reflection</td>
<td>0.77 0.965</td>
<td>0.90 0.965</td>
<td>Use low-OH fiber for higher transmission efficiency</td>
</tr>
<tr>
<td>System efficiency</td>
<td>~0.380</td>
<td>~0.724</td>
<td></td>
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</tbody>
</table>
# High Temperature Processes for Lunar ISRU

<table>
<thead>
<tr>
<th>Class</th>
<th>Description</th>
<th>Examples</th>
<th>Temperature [K]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chemical Process Recovery</strong></td>
<td>1  Pyrolysis</td>
<td>O₂ production at low to medium pressure</td>
<td>2000-2500</td>
</tr>
<tr>
<td></td>
<td>2  Gas-solid reactions</td>
<td>Reduction of regolith to produce O₂</td>
<td>1000-1200</td>
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<tr>
<td></td>
<td>3  Gas-liquid or three-phase reactions</td>
<td>Reduction of magma to produce O₂, silicates</td>
<td>1600-1800</td>
</tr>
<tr>
<td></td>
<td>4  Desorption of solids</td>
<td>Solar wind volatiles, drying</td>
<td>1000-1200</td>
</tr>
<tr>
<td><strong>Manufacturing</strong></td>
<td>5  Hot liquid processing</td>
<td>Metal/basalt casting, glass processing</td>
<td>1200-1800</td>
</tr>
<tr>
<td></td>
<td>6  Sinter forming</td>
<td>Powder metallurgy, refractory sintering</td>
<td>900-1800</td>
</tr>
<tr>
<td></td>
<td>7  Composite forming</td>
<td>Fibers, whiskers, flakes in matrix</td>
<td>900-1800</td>
</tr>
<tr>
<td></td>
<td>8  Welding/Glass blowing</td>
<td></td>
<td>1600-1800</td>
</tr>
<tr>
<td><strong>Power Operations</strong></td>
<td>9  Thermal energy storage</td>
<td>In fused basalt</td>
<td>&lt; 1400</td>
</tr>
</tbody>
</table>
Conclusions

- The optical waveguide (OW) solar thermal system is capable of collection, concentration and transmission of solar energy for ISRU

- Technology issues for future development
  - lightweight concentrator
  - space-qualified optical fiber
  - cable connector
  - furnace for material processing

- The OW solar thermal system can be implemented broad uses of solar energy
Acknowledgment

This work was supported by NASA/JSC through Contract NAS9-18865 (1992) and NAS9-19105 (1994)