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A CONCEPT STUDY OF A MARTIAN ICE MINER FOR IN SITU RESOURCE UTILISATION IN SUPPORT OF A MARS COLONY

Abstract

Lately, Mars has gained substantial attention as a goal for human colonisation. The presence of water, earth-like surface temperatures as well as the second lowest transfer energy cost make it the most inviting destination in our solar system. In order to sustain human presence on our neighbour planet as well as optimising the launch mass, a colony will rely on the resources extracted from its vicinity. The most important feedstock is water, as other vital products like breathable oxygen can be synthesised from it. A colony of four members, growing crop for food is estimated to require 30 l of fresh water per day. This work focuses on identifying extractable sources of water and presents a way of retrieving them. A mining site in the mid-latitudes of Mars is proposed for its high groundwater ice content of 40 weight % buried under a relatively ice free layer of 15 cm depth. The Mars In Situ Water Extraction rover concept developed by Zacny is chosen as a baseline and its subsystems are proposed, outlined and sized. The miner uses an auger to drill trough the ice free layer and retains only the ice rich soil on its fins. The drill is retracted and sealed to heat up the mixture of soil and ice. The water ice is gasified and collected through a one-way valve condenser. A Radioisotope Thermoelectric Generator is chosen as power source and its excess heat is used to sublime the icy soil. This process requires an active thermal control system. Phase Change Materials, namely water, running in loop heat pipes are proposed to distribute and reject the RTGs heat. The rover's mass budget sums to around 250 kg and could produce 11 tonnes of water per earth year, thus meeting the requirement of 30 l per day. A potential colony will, for solar reasons, likely be located close to the equator. The mining needs therefore a transportation and storage system. It remains unclear, if the water content in the equatorial region consists of water ice or hydrated minerals. However, harvesting ice in this region would render a transportation system unnecessary. With two rovers the rate requirement can be met for a site with 15 wt %. The resulting Efficiency of Mining Mass per Year is in excess of 20 kg/year/kg. While the technology shows good potential, the water extraction process using RTG excess heat has a low TRL.