Demonstration of Thermal Management System of Lunar Ice Miners System Components. S.K. Hota1, K.L. Lee2, Q. Truong3, and K. Zacny5, 1 R&D Engineer, Advanced Cooling Technologies, saikiran.hota@1-act.com, 2 Lead Engineer-R&D, Advanced Cooling Technologies, kuan-lin.lee@1-act.com, R&D Engineer- Advanced Cooling Technologies, quang.truong@1-act.com, Vice President- Exploration Technology Group, Honeybee Robotics, kazacny@honeybeerobotics.com

Introduction: The discovery of water-ice in the permanent shadow regions on the lunar south pole presented opportunities for in-situ resource utilization to sustain exploration activities and human presence on the moon. To extract water-ice from the lunar regolith, Advanced Cooling Technologies, Inc. (ACT) in collaboration with Honeybee Robotics (HBR) is developed an advanced thermal management system for lunar ice mining. The thermal management system consists of two principal components: 1. Thermal corer; and 2. Volatile cold trap tank. The thermal corer is essentially drill auger with integrated minichannels for heat transfer into the icy regolith for ice extraction. ACT fabricated and tested a prototype 17.3 cm long, 5 cm ID thermal corer for characterizing ice extraction. At 5% water-ice concentration, about 60-70% ice extraction efficiency was achieved by the thermal corer. ACT is currently characterizing the thermal performance of a scale-up 34.5 cm long, 5 cm ID thermal corer. On the ice collection side, a Variable Conductance Heat Pipe (VCHP) cold trap tank was designed, fabricated, and assembled. ACT is currently performing characterization tests on the VCHP cold trap tank to qualify ice collection & ice removal mechanism by modulating the heat transfer modes of the VCHPs from fully active condenser to diode mode.

Details of Prototype Thermal Corer:

Figure 1.: Prototype thermal corer

ACT fabricated a prototype minichannel based thermal corer with stainless steel by additive manufacturing. The thermal corer was 17.3 cm long and the ID was 5 cm. The size of the minichannel was 1.5 mm. The prototype thermal corer is shown in Figure 1 [1].

Ice-extraction experiments: To characterize ice extraction performance with the thermal corer, tests were performed with the thermal corer by fabricating and assembling a mockup environmental regolith chamber and a proxy cold trap tank. In the proxy cold trap tank, liquid nitrogen (LN) coils were used as ice deposition surfaces by circulating LN through them. Figure 2. shows the schematic of the experimental system.

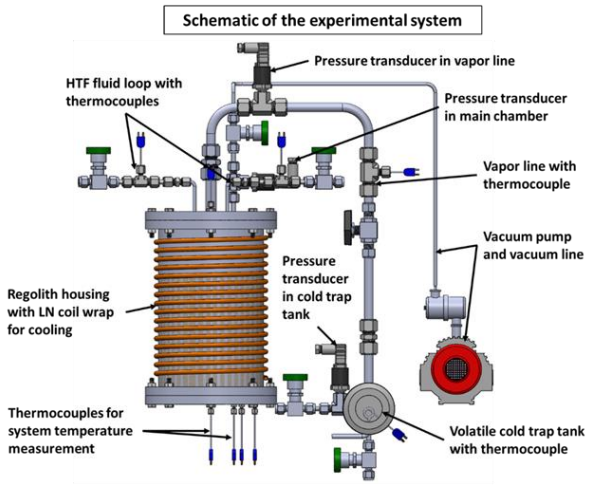

Figure 2.: Schematic of ice-extraction test setup

Experiments were performed with above setup by maintaining the regolith chamber at -30 °C and vacuum level ~ 1 Torr. Ethylene glycol (50% concentration) was used as the heat transfer fluid through the thermal corer. From test results, about 60-70% of ice extraction efficiency was achieved.

References: [1] K.L.Lee et al., Waste Heat-based Thermal Corer for Lunar Ice Extraction, *51st Int. Conf. Env. Systems*, 2022