THE KICT DIRTY THERMAL VACUUM CHAMBER (DTVC): LARGE-SCALE SPACE ENVIRONMENT SIMULATION OF THE MOON AND MARS. Y. Yoo[1], T. Chung[1], H. S. Shin[1], E. Patrick[2], R Graham[2], G. Fletcher[2], [1]Korea Institute of Civil Engineering and Building Technology, Goyang-Si, Geyonggi-Do, 10223, Korea, [2]Southwest Research Institute®, PO Drawer 28510, San Antonio, TX 78228

Introduction: Few laboratories place large quantities of soil inside a vacuum system, but such space environment conditions are precisely what await future probes and robotic rovers returning to the lunar surface. In anticipation of our national space program to explore the Moon and to contribute to the capabilities of the international lunar science community, the Korean Institute of Civil Engineering and Building Technology (KICT) has undertaken the construction of the Dirty Thermal Vacuum Chamber (DTVC).

Design and construction of the DTVC leverages our decades of experience in large-scale architecture and construction projects with our staff expertise in science and engineering. The completed DTVC will be capable of reproducing dusty surface conditions for the study of rover, equipment and sensor operations on the moon and Mars. Our broader intent is to provide a regolith environment simulation facility for conducting large-scale engineering and scientific investigations in collaboration with the international planetary science community.

To gain experience toward the operation of the DTVC, we have constructed a number of smaller chambers and systems to study gas-surface interactions and the behavior of lunar simulant under vacuum conditions. One of these systems is the Contaminant Control System (Fig. 1) used for studying the trapping and filtration of dust contamination.

Figure 1. Contaminant Control Chamber for testing contaminant trapping.

A facility was also constructed for characterizing the effects of dust on mechanical systems (Fig. 2). This facility permits the operation of rovers and robotic systems under the harsh environment typical of the regolith-laden surfaces of the Moon or Mars.

Figure 2. KICT has a number of facilities for testing robotic and mechanical systems under harsh environments.

The largest of our harsh environment vacuum systems serves as a protoype testbed for the DTVC. This system is shown in the 3D model of Figure 3 and is known as the Pilot DTVC. This system design features a cryopump, turbopump, and a large dry pump with an extensive dust filtration vessel on the pump inlet.

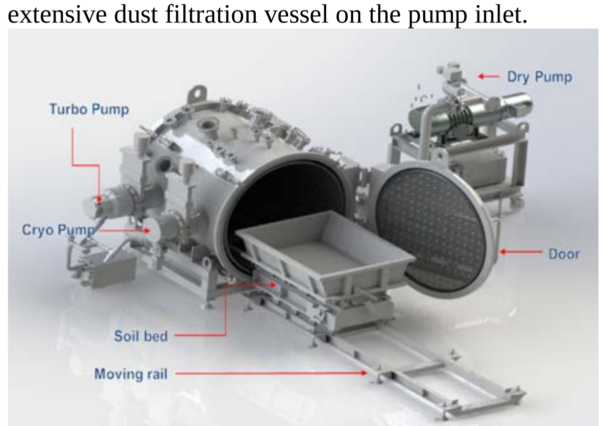

Figure 3. 3D model of Pilot DTVC, July 2017, showing dry pump manifold, cryopump, turbopump and soil bed with moving rail system.

To make this pilot system more analogous to the much larger DTVC, the design also included a large soil bed and moving rail system. The soil bed is filled with our KLS-1 lunar soil simulant manufactured from the volcanic ash of a native volcano in Korea.

In December 2017, our collaborating team of space systems experts from Southwest Research Institute (SwRI) visited KICT. Figure 4 is a photograph taken during SwRI's tour and inspection of the completed and operational Pilot DTVC system.

Figure 4. Pilot DTVC operational at KICT in December 2017 during inspection visit by SwRI space systems team.

The empty chamber is expected to achieve base pressures of $1x10^{-7}$ Torr. Under dust load, the expected chamber base pressure is $1x10^{-4}$ Torr. The temperature range is designed to be -190^{o} C to 150^{o} C.

The SwRI team also visited the DTVC fabrication facility (Vacsco) to observe the first evacuation and venting of the Main Chamber (Fig. 5).

Figure 5. The Main Chamber of the DTVC System is put under vacuum for the first time in December 2017.

The complete DTVC system (Fig. 6) incorporates this Main Chamber and a Load-Lock Chamber to be built next. A large gate door will isolate the two chambers, preserving the Main Chamber base pressure during loading of test articles.

The simulant bed will be loaded into the Main Chamber from the end opposite the Load-Lock Chamber. The Load-Lock Chamber includes an interior scaffold for introducing the rover at the same level as the simulant bed. A concept sketch appears in Figure 6. The top half of the figure shows the rail system, simulant bed, outer door, Main Chamber, gate door, and Load-Lock Chamber. The bottom half of the figure shows a detailed view of the gate door.

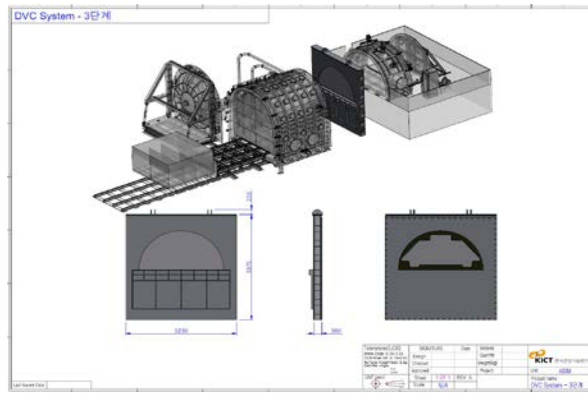

Figure 6. This mechanical drawing shows the details of the complete DTVC system design.

In the planned facility for housing the DTVC at KICT (Fig. 7), the system will occupy the center of the building with adjacent utility rooms and laboratories for science and engineering operations.

Figure 7. Concept architecture of future building to house the DTVC at KICT.

Figure 8. Korea Pathfinder Lunar Orbiter (KPLO)

DTVC represents KICT's vision for a unique facility for regolith environment simulation. In our presentation we will update the status of DTVC and its role in the future of Korea's space science and engineering research (Fig. 8).

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