

MARTIAN ENVIRONMENT SIMULATOR/TEST SYSTEM (SimulTek-MESS)

Objectives

The design philosophy of SimulTek-MESS allows it to be extended to Mars surface conditions: pressure, gas composition, temperature, dust environment, UV radiation, as well as proton and electron radiation.

Introduction

SimulTek Research Company Ltd. has been developing the Planetary Environmental Simulator/Test System since 2011. The system has been used for testing and life time evaluation of planetary exploration spacecraft materials and systems, as well as for verification of the effectiveness of dust mitigation strategies and technologies to be developed for the planetary exploration surface systems.

Basic Configuration

The stainless steel high-vacuum chamber is cylindrical in shape with one of its ends designed to have a semi-spherical shape. The cylindrical part of the simulation chamber is 30" in diameter and ~51" long. The sample holder/sample transfer system allows a total displacement of ~12" inside the chamber and allows for heating, cooling, and thermal cycling of the samples (see Figure 1) .

The basic SimulTek-MESS includes the following components:

- thermal-vacuum chamber;
- dust particles source;
- wind tunnel;
- UV radiation sources;
- proton and electron source;
- gas mixture CO₂ and other variants; and
- support electronics and control software.

Technical Specifications

Wind tunnel

Testing of the samples would be conducted inside a dual wind tunnel (see Figure 2) designed to fit within the vacuum chamber which would be evacuated and backfilled with a CO₂, N₂, Ar, and O₂ gas mixture to pressures of 1-9 mbar to represent the Mars

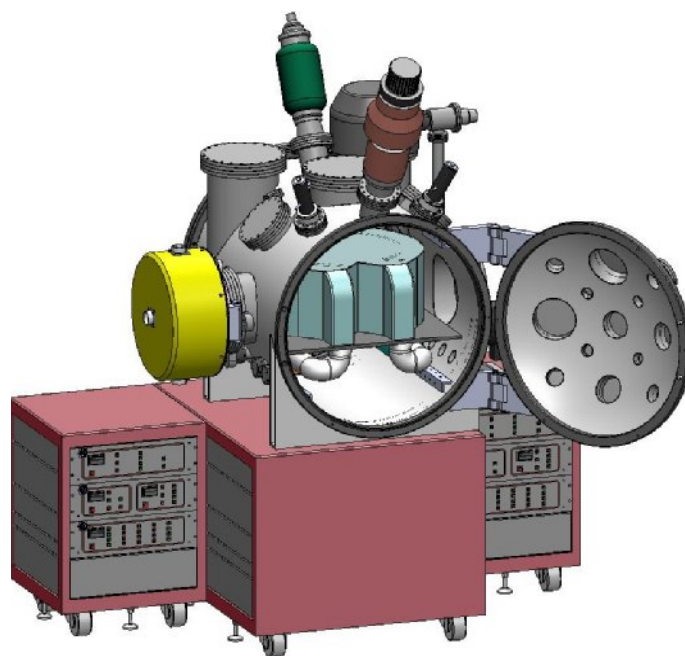


Figure 1. General view of SimulTek-MESS Concept

atmosphere. The wind tunnel is a dual tunnel arrangement with very rapid switching of airflow from one stream to another through the test section. One stream is heated warmer than the other and switching from one stream to the other would be used to provide the temperature and wind conditions in the Mars atmosphere.

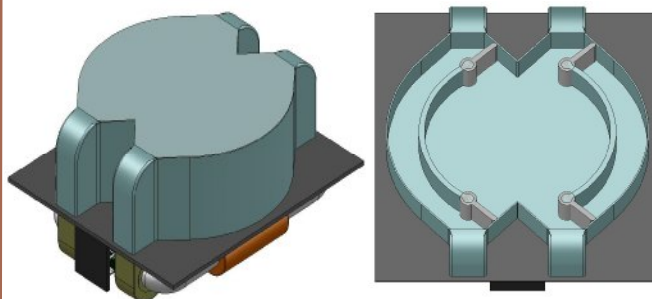


Figure 2. View of the dual wind tunnel and flow switching gears

Simulation Technologies

The tests would be conducted at a variety of wind speeds, typical Mars temperatures and pressures but the same system and procedures could be used for other conditions, for example, solar radiation, charged particles, and modeling of dust lifting mechanisms on Mars.

Proton Source

The protons observed below the induced magnetosphere boundary by the Analyzer of Space Plasma and Energetic Atoms (ASPERA-3) experiment on board Mars Express have energies of a few keV. The low-energy 1-50 keV electron and proton sources are intended to simulate the implanted solar wind on the upper Martian atmosphere. Such low electron and proton energies are sufficient for materials radiation resistance screening and pre-testing. Thus, it can apply to the external spacecraft materials and thermal control coatings and forecast their radiation stability in the near-Mars space environment.

Proton source (PS) is a standalone device, assembled from stainless steel and designed to produce a stream of protons according to the technical specifications (see Figure 3). PS is designed for installation on the vacuum chamber with critical vacuum better than 10^{-6} Torr and equipped with pumps for a total pumping speed of at least 2000 L/s. PS is attached to the vacuum chamber using a standard 8" CF flange.

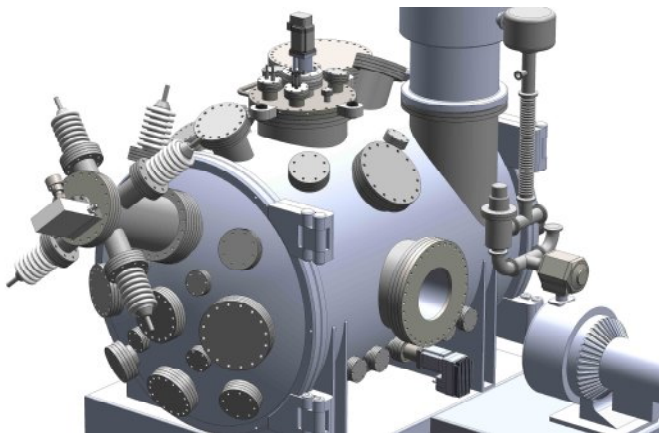


Figure 3. The simulator with the proton source mounted on the front door.

The PS concludes:

- a ionizer which is designed to convert the neutral hydrogen gas into protons and structurally consists of a mesh cell ionization chamber, cathode assembly, and extractor (see Figure 4).
- feedthroughs and isolated holders rated up to 50 kV are used to supply voltages to PS
- the hydrogen inlet system controls the flow of the working gas (hydrogen) into the ionizer (see Figure 5).

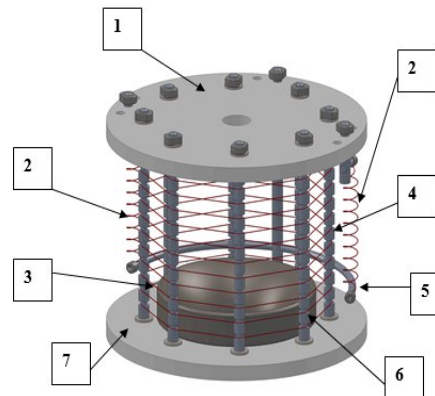


Figure 4. Ionizer assembly. 1-top insulated panel, 2-cathodes, 3-mesh cell ionization chamber, 4-mesh cell ionization chamber holders (8 in total), 5-cathode fastening system, 6-extractor, 7-bottom insulated panel.

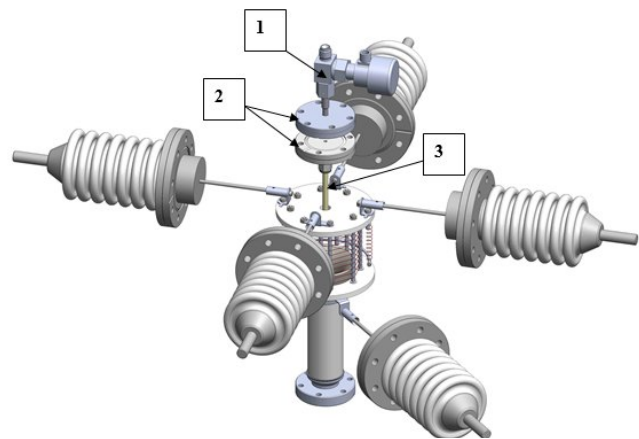


Figure 5. The hydrogen inlet system with the vacuum valve (1), vacuum connectors (2), and insulated gas inlet tube (3).

Conclusions

The potential uses of the SimulTek-MESS include:

- Evaluating adherence of the Martian dust stimulant to various power-system component surfaces and coatings while at operating temperatures;
- Evaluating the thermal performance of high-temperature radiators as a function of dust coverage;
- Adding solar simulator to conduct solar cell performance tests as function of dust coverage and temperature while in vacuum environment;
- Evaluating Martian dust mitigation techniques;
- Studying dust-particle behavior in electrostatic/magnetic fields.
- Evaluating of radiation effects taking place in the surface layer of space-bound polymer materials and coatings in the upper Martian atmosphere.

The proposed design will allow to upgrade SimulTek-MESS to include rocket's exhaust contaminations, a variety of fixtures and rigs for fretting and fretting fatigue mechanical testing of spacecraft materials, mechanical systems and mechanisms, tribological testers, etc.