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Design of a small Martian chamber for simulating the RLS-ExoMars operation mode

Catalá, A.(1); López, G.(1); Rull, F.(1); Vegas, A. (2)
(1) Unidad Asociada UVA-CSIC al Centro de Astrobiología (CAB-INTA), (2) TCP Sistemas e Ingeniería
(alejandro.catala.espi@cab.inta-csic.es / Fax: +34-983-140514)

Abstract

Here the design of a small chamber in which Martian atmospheric conditions will be recreated is presented. This chamber contains a sample holder where powdered samples will be placed for Raman analysis. Temperature and atmospheric pressure will be fine-tuned to have an accurate control over the experimental conditions. The objective of this instrumental system is to simulate the operation mode of the Raman Laser Spectrometer (RLS) on board ExoMars mission.

1. Introduction

The RLS is part of the scientific payload of the ExoMars mission[1]. It performs the Raman analysis of the powdered samples provided to the analytical laboratory by the Sample Preparation and Distribution System (SPDS). This powder is deposited on a sample holder which is moved under a blade in order to get a flat surface with which to operate. After that sample preparation, the sample holder is moved under the Internal Optical Head (iOH) and is analyzed.
Up to now, this operation mode is being performed under "terrestrial" conditions[2]. Despite some chambers have been developed for Martian ambient simulation[3], this one fulfills the specific requirements related with the Exomars operation mode.
The idea with the design of this small chamber is to perform the flattening and analysis operations under the environmental conditions expected inside the analytical laboratory (ALD) of the ExoMars rover.

2. Chamber overview

The chamber assembly can be subdivided in several subsystems:

- The chamber body
- The motorized linear motion manipulator
- The pressure and gas flow control subsystem
- The control and monitorization subsystem

2.1. Chamber body

The chamber body is a 80mm-diameter aluminium structure (Figure 1) with six DN16CF vacuum ports and a self-constructed viewport with a 1mm thickness fused silica window. These ports give input and output access to up-to-air/backfill valves with and without a gas flow control valve, a pressure gauge, a vacuum-enabled electric connector and a motorized linear motion manipulator.
This chamber contains an ExoMars-like sample holder mounted on a TEC system comprised of two Peltier cells. The whole chamber is thermically connected to a heat dissipator with a fan.

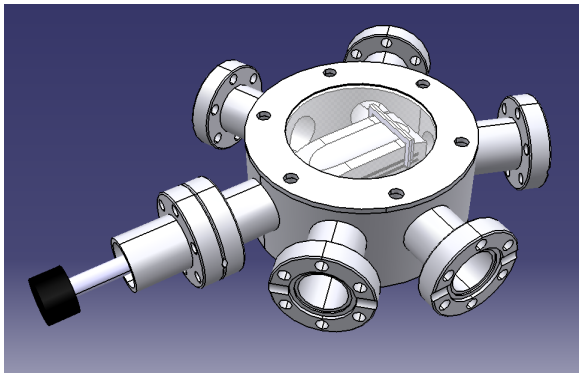

Figure 1: 3D view of the design

2.2. Linear motion manipulator

This vacuum-enabled motorized tool is connected to one of the vacuum ports of the chamber. Its function is the displacement of the flattening blade along the surface of the sample holder in order to flatten the powder

deposited prior to the closing of the chamber. This action will be taken once the chamber has reached the desired atmospheric conditions. The speed and direction of the movement is controlled externally by the control and monitorization subsystem.

2.3. Pressure and gas flow control

This subsystem is comprised of a Pirani gauge, a flow control valve and a control device for a fine adjustment and measurement of both the total pressure in the chamber and the input flow of gas (Martian atmosphere mixture).

2.4. Control and monitorization

The control and monitorization subsystem comprises:

1. A physical element, that is, a PCB with a microcontroller which ultimately sets the electronic signals to control the temperature and motion actuators, and monitors the temperature at the sample holder to give feedback to the user.

2. A PC software for enabling the user to interact with this PCB and also with the pressure and gas flow control device, both sending control commands and receiving and presenting visually the evolution of the variables inside the chamber: temperature, pressure and gas flow.

3. Summary and Conclusions

This is the next logical step in the scientific process for, not only evaluating the RLS operation modes and detecting irregularities, but also for building the scientific database of Raman spectra which will be used during the data exploitation phase of the mission, as a base for identification of compounds found on the Martian shallow subsurface.

References

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