SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
Future Space Transportation Systems Verification and In-Flight Experimentation (6)

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MEASUREMENT OF PRESSURE IN THE IXV RE-ENTRY VEHICLE

Abstract

Computational predictions for atmospheric re-entry require flight validation. It is in this sense that the European Space Agency and national space agencies have developed re-entry test vehicles which are outfitted with sensors to determine their behaviour. The IXV, Intermediate eXperimental Vehicle scheduled for launch in 2014, is the latest European re-entry vehicle.

In addition to thermocouples and mechanical sensors the spacecraft is characterized by 39 pressure sensors with specially designed ceramic ports that allow measurement in the high enthalpy windward region as well as in the receding ablative thermal protection system. These ports are direct links between the hot plasma and the vehicle interior and are therefore subject to very large thermal gradients and thermomechanical loads.

Failure or leakage of the ports would be catastrophic so they have been designed to withstand re-entry heat loads without stressing the surrounding C-SiC ceramic. The design uses a stabilized zirconia cermaic bush as insulator to reduce heat transfer to the vehicle interior. This bush is decoupled from the port through used of compressed graphite washers which also dampen movement of the pipes and any transmission of vibroacoustic loads during launch.

A primary concern during design of the sensing system is the ability to capture slight pressure changes in real time. The hydraulic delay of the piping and the entry effects were minimized through a trade-off of geometries and extensive testing. Varying the inclination of the entry holes in adjacent ports allows measuring skin friction effects.

The sensitivity of the pressure system to input voltage variations and sensor temperature are a concern as the measurement occurs at very low pressures (below 10 hPa). These error sources were quantified and reduced through appropriate countermeasures and a dedicated calibration procedures.

The pressure port design and the end to end response of the system to thermal and mechanical loads have been validated in laboratory testing. A final test which will cover thermal shock is foreseen using the Scirocco plasma wind tunnel.

This paper describes:

- The placement of sensors in the IXV vehicle
- The selection process of pressure sensors and the overall design of the sensing system
- The design of ceramic ports for the nose and windward TPS
- The design of pressure ports for the ablative TPS including the vehicle base

- The qualification testing
- End to end performance testing of the sensing system