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Author: Mr. Thierry Pichon
Herakles, Safran group, France

Mr. Marc Lacoste
Herakles (Safran group), France
Mr. Renaud Barreteau
Snecma Propulsion Solide, France
Mr. François Buffenoir
Snecma Propulsion Solide, France

DEVELOPMENT AND TESTING OF CERAMIC MATRIX COMPOSITE (CMC) THERMAL PROTECTION SYSTEM FOR THE IXV EUROPEAN ATMOSPHERIC RE-ENTRY DEMONSTRATOR

Abstract

The Intermediate eXperimental (IXV) programme which aims at developing a demonstration vehicle that will give Europe a unique opportunity to increase its know-how in the field of advanced atmospheric re-entry technologies, has gained considerable momentum since the beginning of 2010 with the start of the detailed design phase that will be concluded in early 2011.

In this phase, Snecma Propulsion Solide, SAFRAN Group, has refined the design of the Windward C-SiC Thermal Protection System (TPS), and has also been entrusted by ESA and Thales-Alenia Space with the design of the Nose Assembly of the vehicle. The two subsystems cover the largest part of the most heated areas of the vehicle during the re-entry. The Nose, designed on a common technological basis with the Windward TPS, presents nonetheless some unique features. Its outer shell is made of a one-piece C-SiC part with a width of almost 1.4 m, which places it well beyond the range of size of C-SiC TPS parts manufactured and tested during the Generic Shingle, FLPP Material and Structure, and even X-38 programmes.

The detailed design phase comprised extensive thermal and thermo-mechanical analyses, small-scale tests on the various components of the Windward and Nose Assemblies, and large scale prototypes manufacturing. Among those tests, some are specifically made to assess the behaviour of the TPS during re-entry:

- Insulation layers: characterized to assess their the thermal conductivities and the specific heats.
- Active oxidation assessment of the CMC during re-entry: High heat flux are applied under different levels of pressures and the temperatures at which active oxidation occurs are recorded.
- Catalycity of the CMC material aimed at measuring the difference between the heat flux applied on CMC samples and the heat flux actually assessed on the sample. The difference between the two heat fluxes is assessed to be a heat flux decrease due to catalycity of the material.
- Permeability and venting tests, aimed at characterizing the amount of hot air than can go through the insulation layers and seals.
- Sneak flow tests: complementary to the permeability tests and aiming at characterizing the sneak-flow, which is the hot gas infiltration under the structure of the TPS, and which overheats the cold structure in a convective way. In addition, a sneak flow characterization approach is developed.

The present paper discusses the main outcomes of these activities and provides an up-to-date status of the design of both subsystems.