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IXV Re-entry Demonstrator: Windward and Nose Assemblies CMC Thermal Protection Systems –Analysis and Tests from Development to Qualification

Florent GIRARD*, Céline JUILLARD†,
Herakles, Safran group, Le Haillan, France & ISAE-ENSMA Student, Poitiers, France

Abstract

The Intermediate eXperimental Vehicle (IXV) is an atmospheric re-entry demonstrator, developed within the FLPP (Future Launcher Preparatory Program) and funded by ESA. The main aim of the project is to develop a demonstration vehicle that will give Europe a unique opportunity to increase its knowledge in the field of advanced atmospheric re-entry technologies. The current baseline for the thermal protection of the windward area and the nose assembly is a CMC-based Thermal Protection System (TPS). This key technology will be demonstrated in real conditions through the flight of this ambitious vehicle.

The high-temperature resistant Ceramic Matrix Composite (CMC) TPS will provide a non-ablative outer mould line (OML) which will enable an enhanced aerodynamic control. Both nose and windward TPS assemblies make extensive use of SepcarbInox® CMC. The justification of their design relies on mechanical and thermo-mechanical analysis, as well as development and technological tests. Some of these tests are especially performed to assess the behaviour of the TPS during re-entry. The paper will focus on the following topics:

- Assessment of CMC active oxidation during re-entry. High heat fluxes were applied under different pressure levels during tests performed at VKI (Belgium) in order to record the temperature at which active oxidation occurs.
- Catalycity of the CMC material. The aim of these tests, performed at VKI (Belgium), was to record the heat-flux applied on CMC samples and the one actually measured on these samples. Knowing the difference between these two heat-fluxes, the decrease due to catalycity of the material can then be determined.
- Aero-thermal justification. The thermal justification mainly requires to investigate radiation, conduction and convection heat transfers. The heating due to gas entrance inside the TPS needs also to be taken into consideration. That is why sneak-flows have to be measured and analysed. Before future qualification tests, a test campaign including elementary tests (thermal characterisation, contact thermal resistances) and technological tests (conductivity through CMC leg, Sneak-Flow characterization) was performed at ISQ.
- Thermo-mechanical characterisation. Qualification tests will be performed to study the OML deformations which is a key parameter for the IXV trajectory control during re-entry. Tests configurations especially focus on stress and step&gap requirements.

The paper describes the tests configurations, the tests conditions and the available tests results. It also shows how these test campaigns enable to assess the TPS thermal and thermo-mechanical behaviour during re-entry.

* Design Lead Engineer, High Temperature Composites, Herakles, Safran group, Le Haillan, France
† Design Engineer, High Temperature Composites, Student ENSMA, Poitiers, France