PLASMA TESTS DEVELOPMENT FOR THERMAL PROTECTION SYSTEM DESIGN IN REAL FLIGHT CONDITIONS

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In the framework of planetary entry of space vehicles the heat shield design remains a crucial issue as it is illustrated by the current ESA EXPERT program. It results of a compromise between weight and safety. Thick enough to ensure the safety of the vehicle and the crew as well, the Thermal Protection System (TPS) must also be as light as possible to increase the payload carried by the vehicle. The design of this TPS can be studied at the VKI thanks to a facility such as the Plasmatron which is capable to reproduce the heat flux and chemical environment of real flight conditions. The purpose of this PhD project is twofold. A first part is dedicated to an accurate experimental procedure for the characterization of the environment created inside the Plasmatron. The goal of the second part is to propose an accurate method for the extrapolation of the data to real flight.

As to the characterization of the environment created inside the Plasmatron, enthalpy measurement and wall catalysis characterization are the main issues. On one hand, the enthalpy determination is based on a heat flux method with several hypotheses that cannot be assumed anymore in the design of light TPS for need of future missions. On the other hand, the wall catalysis effect is still badly measurable. This PhD project proposes new solutions to quantify both enthalpy and wall catalycity. At this stage of the project, significant progresses have been made and two original tools such as Minimax [1] and enthalpy probe [2] can now be proposed to measure these two quantities. Some results are shown in the figures below.

As to the flight extrapolation step, an empirical method is currently used at the VKI but its validity can be questionable especially in the range of low Reynolds numbers produced in the test chamber. This PhD proposes an inverse method [3] to answer to this third problem.



Figure 1: Enthalpy measurements and comparison

[1] H. Krassilchikoff, O. Chazot and J. Thömel, *Procedure for the determination of cold copper recombination efficiency*, EUCASS conference, Bruxelles, July 2006.

[2] H. Krassilchikoff and O. Chazot, Enthalpy determination for ground testing conditions in plasma wind tunnel., ESA congrex, Versailles, November 2008.

[3] H. Krassilchikoff, K. Bensassi, A. Lani, M. Panesi and O. Chazot, *Flight extrapolation at low Reynolds number*, EUCASS conf., Versailles, 2009.