CATALYCITY EFFECTS IN PLASMATRON TESTS

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When a space reentry vehicle enters the upper layers of a planetary atmosphere, a massive amount of flow kinetic energy in the hypersonic free stream is converted to internal energy across a bow shock wave. High temperatures can be reached in the shock layer near the nose, promoting the dissociation and ionization of the gas, that becomes a partially ionized plasma. From the design perspective of the reentry vehicles, special attention must be paid to the requirements of heat flux allowed at the stagnation point of the body. This design condition is more critical in chemical reacting flows, because some surface materials can catalyze the chemical mechanisms to enhance the rate of recombination of species striking the surface. This induces the release of their heat of reaction, in addition to the conductive heat transfer.This phenomenon must be analyzed in order to characterize the TPS (Thermal Protection System) materials. The wall catalycity or recombination probability is defined as a parameter for this purpose.

Because inflight testing of new TPS materials is prohibitively expensive, laboratory experiments must be performed and extrapolated to the flight conditions. The way to proceed is by applying a numerical & experimental hybrid methodology. A tuning of numerical and experimental results must be performed in an iterative way to identify the laboratory conditions. The present DC project is dealing with this methodology with a special insight to the low catalycity materials.

The high enthalpy conditions in the laboratory (Plasmatron and Minitorch facilities) have been identified under this methodology. The results are presented in abacus, plotting the heat flux vs. the temperature at the wall, with a parametric representation in terms of wall catalycity. It is observed a high sensitivity of the results to distinct models for the diffusion terms and chemical reaction rates tested in the particular conditions of cold wall and low catalycity. This demonstrates the necessity of performing experiments under this situation. A quartz probe, manufactured at the IPM (Institute of Problems in Mechanics of Moscow), was used for this goal. As a product of the systematic identification of the conditions in the Plasmatron and Minitorch facilities, special emphasis has been paid to the heat flux normalized with an effective radius and the stagnation pressure. Finally, the project is ended with the extrapolation of the results to flight conditions.

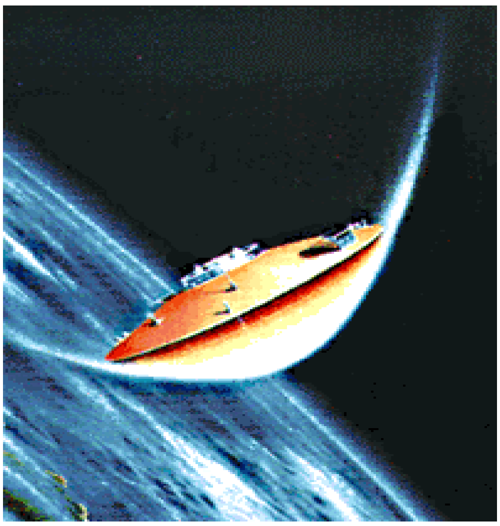

Figure 1: ORex Reentry Experimental Vehicle (OREX)

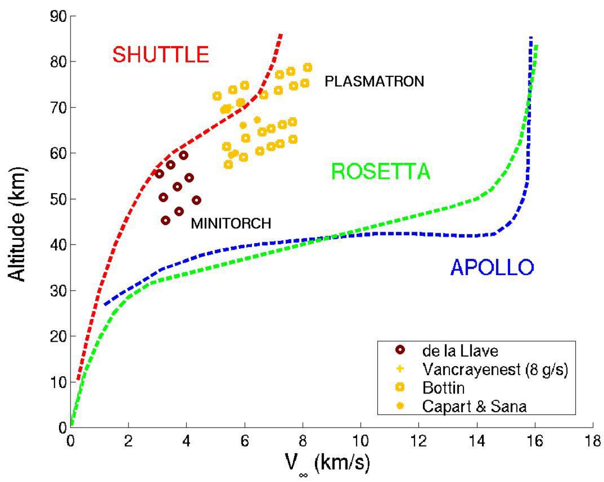

Figure 2: Ground to Flight Extrapolation