SIMULATION OF MARS ENTRY CONDITIONS IN A COMBINED PLASMA - PARTICLES FLOW WITH PRE-COOLED SAMPLES

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Recent plans in Europe and elsewhere include technology developments for a sustained exploration of Mars with landers and the use of aerocapture techniques. Hence a better understanding and simulation of Mars entry have to be performed. A major concern is the presence of dust in the Martian atmosphere until a fairly high altitude that would foster some erosion of the heat shield of a vehicle in its high-speed entry phase. Also the fact that the vehicle is entering with its heat shield at very low temperature can cause some damage through a thermal shock in the TPS (Thermal Protection System) material.

The objective of this project is to account for the feasibility of the VKI Minitorch ICP (Induction Coupled Plasma) wind tunnel to simulate Mars entry conditions as realistically as possible, combining sudden temperature changes, realistic heat flux and eroding particle flow.

The approach followed was to first make a thorough literature study to identify previous work in this field and to reference as complete as possible the parameters of a real Mars entry, such as Martian atmosphere with its temperature, pressure and dust profiles; typical entry speeds; altitude profiles; heat fluxes and particle impact energy. From this, the desired conditions to be simulated in the VKI Minitorch were extracted.

Next, the required subsystems for particle injection and pre-cooling were identified, previous set-ups were improved, tested and calibrated. A set of industrial powders were obtained and a selection was made concerning practical injectability and matching of theoretical kinetic energy levels of real flight. CO_2 Plasma test runs with a central jet meant to contain particles were achieved by E. Boschek last year and were completed with CO_2 plasma test runs testing the pre-cooling system.

The feasibility study showed through extrapolation to flight that an interesting area for Mars aerocapture was covered and that the range of simulated parameters covers a fair part of the real flight parameters. This gave an encouraging result concerning the ability of the VKI Minitorch to simulate dusty Mars entry conditions.

Figure 1 : Particle injection system testing

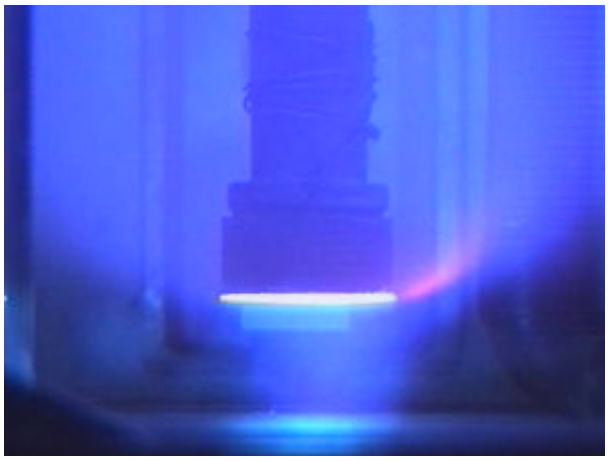

Figure 2: CO_2 Plasma testing with pre-cooling (ablation visible)