OFF-STAGNATION POINT TESTING IN PLASMA WIND TUNNEL

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The high amount of heat that is transferred to the Thermal Protection System of a space vehicle during the descent phase into the atmosphere is one of the critical aspects to be considered for an optimum design. Ground testing, together with proper methodologies, makes possible the reproduction of real flight conditions for the design of TPM.

Up to now, analyses of the heat flux have been done at the stagnation point at the VKI. Within the long term purpose of extending the current methodology to the region downstream of the stagnation point, the aim of this project is to analyze the flowfield around a hemispherical nose cylinder in a plasma wind tunnel. With this objective, new experimental tools have been designed and tested, and numerical simulations have been used for the description of the boundary layer features in the experimental case.

New measurement probes to determine the distribution of heat flux and pressure along their surface in the Plasmatron test chamber have been developed, and multiple tests have been done in order to make an analysis of dependence of the heat flux, with the operational conditions. Numerical simulations with the VKI's code ICP have been done for different purposes. Numerical results allow computing the distribution of heat flux along the probe for its comparison with the experimental one, showing a good agreement between both non dimensional distributions. Analysis of numerical boundary layer profiles allowed discussing about the applicability of a VKI boundary layer solver, which has been demonstrated to be a valid tool in the special case of the stagnation point. Comparison of numerical boundary layer profiles from ICP computations in the real case of a plasma jet and in an ideal uniform flow allowed proposing a possible strategy to locally characterize the thermal BL using the available BL solver. Those comparisons lead to the conclusion that the real dynamic boundary layer cannot be properly reproduced following the proposed strategy and a solver in which higher order BL equations are implemented is required. But however, the BL code could be used to characterize locally the thermal BL in a certain location in the real plasma jet since the comparison of the temperature profiles of the jet and the uniform flow showed a good agreement in the region close to the wall. Consequently, the heat flux in the off stagnation region could be simulated with this existing tool. Simulations were also used for the determination of the flow properties at the outer edge of the boundary layer at the stagnation point, following the hybrid methodology applied at the VKI.

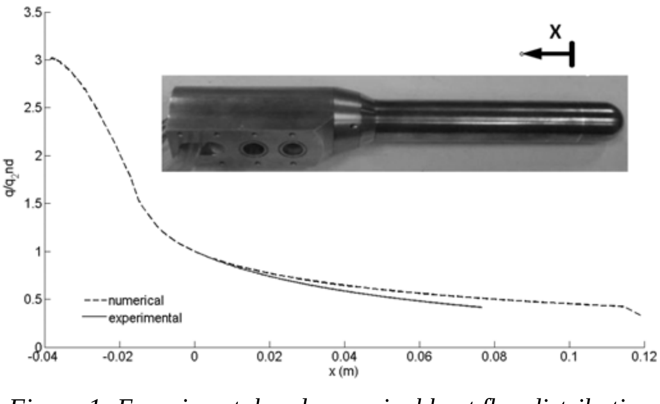

Figure 1: Experimental and numerical heat flux distribution

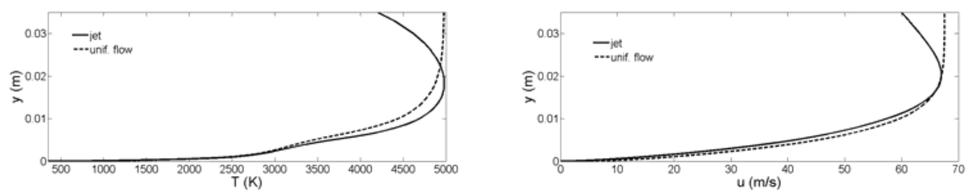

Figure 2: Comparison of dynamic and thermal BL profiles in a plasma jet and uniform flow