ACTIVE BOUNDARY LAYER TRIP FOR SUPERSONIC FLOW

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The last decade has been full of excitement and success for the hypersonic community with the different Scramjet ground tests and launches. These flight tests have pushed further the limits and yet, the hypersonic community is facing a considerable amount of problems that have to be investigated before a commercial scramjet-propelled plane allows flights from Brussels to Sydney in 2 hours. Ideally, a Scramjet is capable of self-starting over a wide range of angles of attack and Mach number. In order to ensure that the intake will be self-started, a solution is to ensure that the boundary layer over the inlet ramp is fully turbulent, hence reducing the risks of chocked flow conditions. Most of the research has issued efficiency of roughness trips to trigger the boundary layer. While such trips are efficient at triggering the transition, they cannot overcome the drawbacks of a turbulent boundary layer. At hypersonic speeds, heat transfer, as well as drag, dramatically increases, and in a Scramjet engine, on average 40 % of the overall drag is due to skin friction.

This study investigates the possibility to trigger transition using perpendicular air jets on a flat plate placed in a hypersonic cross-flow. Experiments were conducted in the VKI hypersonic blow down wind tunnel H3. The H3 facility is mounted with a Mach 6 contoured nozzle and provides flows with Reynolds numbers in the range of $10x10^6$/m to $30x10^6$/m. The model consists of a flat plate manufactured with a built-in settling chamber equipped with a pressure tap and a thermocouple to monitor the jet conditions. A first flat plate was manufactured with a Plexiglas black coated top, for surface heat transfer measurement using an infrared camera. On a second model an upilex sheet equipped with 30 thin film gages was glued, allowing heat transfer measurement up to 60Khz. The temperature of the jet and its potential effect on the transition onset location has been investigated.

The cross flow conditions have been varied and a Mach number of 6 kept constant. The flow topology was studied using fast schlieren techniques and oil flow, and then correlated to CFD computations in order to gain a better understanding. An infrared camera has been used to estimate the heat transfer on the model. Additionally, thin film gages were used to track the apparition and growth of turbulent spots within the cross flow.

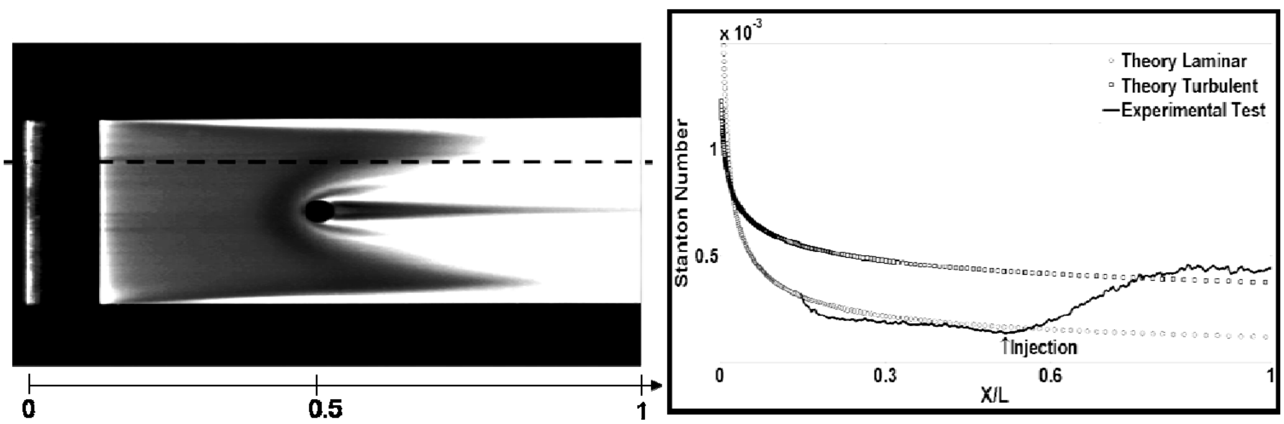

Figure 1: Heat transfer on a flat plate at Mach 6, injection ratio 180