TRANSITION AND SHOCK WAVE – BOUNDARY LAYER INTERACTION IN HYPERSONIC FLOWS

Cem Ozan Asma, Turkey
Supervisors: D. Fletcher & S. Paris

Aerodynamic heating has always been a problem during reentry of space vehicles at hypersonic speeds. One of the critical areas in the design of hypersonic vehicles is the aerodynamic heating of control surfaces. The purpose of this work is to study transitional shock wave – boundary layer interactions; i.e. cases where the boundary layer is laminar at separation and transitional or turbulent at reattachment. For this purpose, experiments have been performed in the Mach 6 Hypersonic H–3 Wind Tunnel Facility of the von Karman Institute. Axisymmetric cone–flare models with interchangeable nose sections suitable for this purpose are used to obtain fully laminar, fully turbulent and transitional reattachment flows. Infrared thermography is used to measure the surface temperature of the model during the tests. Schlieren pictures are taken at different test conditions to provide flow visualization and to verify the state of the flow at the reattachment location. Numerical solutions are also performed using a Navier–Stokes flow solver to provide additional information about the laminar test cases. By varying the freestream Reynolds number, it is possible to have both laminar and turbulent interactions on the same model. The main objective of this study is to quantify the heat flux for transitional flow at reattachment. Between laminar and turbulent states, the flow close to reattachment is transitional and the heat flux can be as high as in the fully turbulent case. The locations of separation and reattachment points calculated using different techniques are compared and it is seen that infrared thermography gives more accurate results compared to Schlieren photography. The change in the heat transfer rate when passing from laminar flow to turbulent flow is clearly seen by the help of the infrared camera measurements. It is observed that for transitional flow on the flare, the heating rate may be as severe as in the turbulent case. Moreover, the location of maximum heating can be different in transitional cases, compared to laminar and turbulent cases.