STUDIES OF WALL TEMPERATURE EFFECTS ON SHOCK-WAVE/ BOUNDARY LAYER INTERACTIONS IN HYPERSONIC FLOWS

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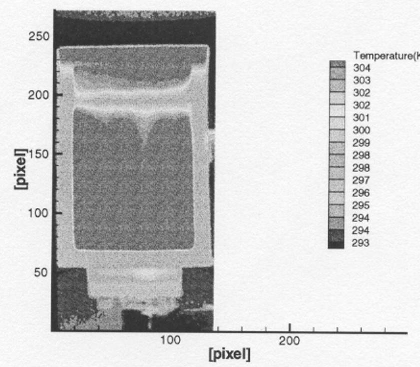
Aerodynamic heating has always been a problem for reentry vehicles that fly at supersonic and hypersonic speeds. One of the areas most affected by the aerodynamic heating is the region of the control surfaces (such as the flap of a wing). Due to the presence of a boundary layer, there exists a region of subsonic flow near the wall, through which information can be propagated upstream. For a high enough flap deflection angle, the oncoming boundary layer faces an adverse pressure gradient, which causes the flow to separate. A recirculation bubble, bounded by a separation shock and a reattachment compression shock, forms in the vicinity of the hinge line.

In this work the main interest is the investigation surface temperature effects on heat flux and flow topology near the separation and reattachment points. To perform experiments with different surface temperatures a new model is constructed for use in a hypersonic (M=6), perfect gas wind tunnel facility (VKI-H3). The model is a flat plate with a ramp, which is used to simulate the geometry of a deflected body flap. An important goal of this research is the investigation of the Stanton number (non-dimensional heat flux) distribution for laminar, transitional and turbulent flow conditions on the ramp. Based on the measurement of the surface temperature with the infrared camera; it is possible to calculate the heat flux from the surface and thus evaluate quantitatively the Stanton number distributions for this geometry.

The model is designed to be heated to different temperature levels by electrical resistances with a uniform temperature distribution. The new model provided elevated temperatures with a change in temperature from point to point never more than a few ^0C, while proving to be extremely robust. The flow topology around the model is investigated and quantitative measurements of heat flux have been achieved. The separation point is located at $31.5 \pm 1.5mm$ and the reattachment point at $53 \pm 1mm$. These results are validated comparing them with thin film oil technique. Tests are carried out with different wall temperatures and laminar, transitional and turbulent flows are identified. Negligible heat flux is found for the 500K wall temperature (as expected since it is very closed to stagnation temperature). The destabilizing effect of elevated temperature is shown for the 400K tests. It is possible to see laminar flow for 300K 11bar case and transitional and turbulent flows for 21bar and 31bar cases.

(a)



(b)

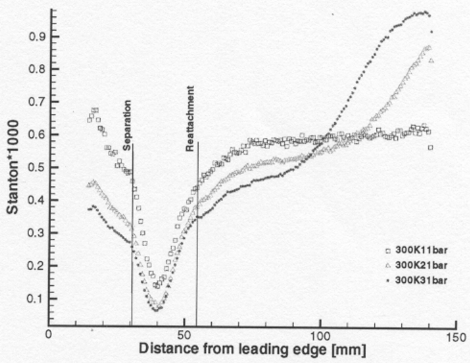


Figure1: (a) IR image of the model in the flow – (b) Stanton number distribution