Control of Recirculation Flow Near the Step in Supersonic Stream

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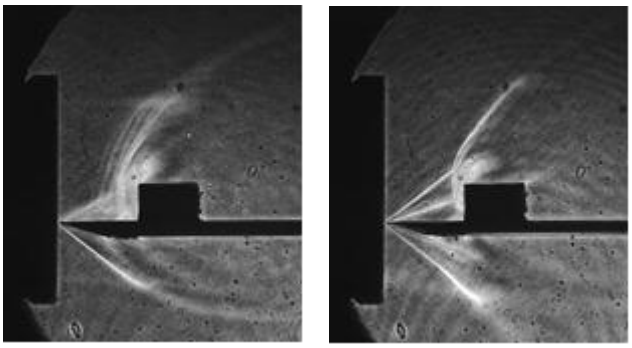
Supersonic flow over protruded into main stream parts of an aircraft is often characterized by the presence of a separation zone. At hypersonic speeds a presence of separation zone near undeveloped tail spread of extended bodies of revolution can sufficiently compromise the flight control. Features of the flow in vicinity of steps of different geometric configurations at Mach numbers M>1 were investigated in the past decades widely in Russia and all over the world. One of the well-known studies at this field is [1].

In present experimental study ways to reduce the characteristic dimensions of separation zones using gas permeable inserts as well as perforated inserts upstream the step for Mach numbers in the range of 2 to 5 (see Fig. 1) are under consideration. Experiments were carried out in ITAM SB RAS at a pulse-operation wind tunnel for M = 5 and intermittent one for M = 2-3. Both facilities had an exhaust to a vacuumed tank. Stagnation pressure varied from 1 to 6 bar, the stagnation temperature was of 300 K. For flow visualization we used a shadow scheme with adaptive imaging transparency, as a sensor it was a PCO 1200hs speed camera. The studies were conducted in a wide range of geometrical parameters of a model. The model layout is demonstrated in Fig.2. We have varied the length of the plane in front of the step L and the height of the step h. As a gas permeable insert with length of x it was a housed cut for appropriated size from nickel highly porous cellular material or a surface perforated by apertures of optional diameter. It was shown that the placement of gas permeable inserts or perforated plates significantly reduced the size of the recirculation zone formed in front of the step.



a) b)

Fig.1 Flow near the step, M=2: a) without insert; b) with mounted insert

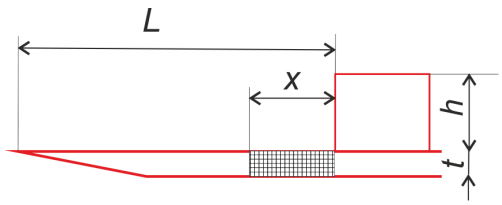


Fig. 2 A model of the step

Having positive experimental experience in plasma control of high speed flows [2] we discuss ways of using a gas discharge, initiated near the step, in order to reduce the characteristic dimensions of the recirculation zone or eliminate it. Experimental data gained with the initiated discharge upstream the step are also under consideration.

References

1. Chang P. K. Separation of Flow. Pergamon, New York, 1970.
2. Fomin, V.M., Lomanovich, K.A., Postnikov, B.V. Control of Self-oscillation Regimes in Impact Supersonic Jets Using Crossed Electromagnetic Field. AIAA Paper 2011-3918.