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Numerical simulation of hypersonic flow over highly blunted cones with spike

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ABSTRACT

In this paper, effectiveness of aerodisk/aerospike assemblies as retractable drag-reduction devices for large-angle blunt cones flying at hypersonic Mach numbers is simulated numerically at various angles of attack. Different lengths of spike have been chosen to investigate the effect of the aerospike on the surrounding flowfield of nose cone. The compressible, 3-D full Navier–Stokes equations are solved with $k-\omega$ (SST) turbulence model for free stream Mach number of 5.75 and different angles of attack namely 3, 7, 10, and 12. The visualized shock structure and the computed drag on the blunt cone with aerospike agree well with the experimental result. The effect of reattachment of point on the surface convective heat-load reduction is investigated for different kind of spikes with varying length to diameter ratio. Additional modifications to the tip of the spike are examined in order to obtain different bow shocks, including a cut spike, and a flat and hemispherical aerodisk mounted on the tip of the spike. The numerical results presented the pressure distributions and the surface heat reduction for different type of spike. Some discrepancies existed, especially on the length of the recirculation region.

1. Introduction

High speed vehicles are designed to withstand severe aerodynamic heating conditions. Such vehicles include hypervelocity projectiles, re-entry vehicles and hypersonic aircraft. Maximum heating and the consequent potential for material erosion are a typical problem associated with the nose-region of the blunt body. Several techniques have been developed with the target of significantly reducing the aerodynamic drag of blunt nose cones. Various techniques such as concentrated energy deposition along the stagnation streamline, retractable aerospikes ahead of the blunt body, forward-facing jet in the stagnation zone of a blunt body, and also supersonic projectiles fired in the upstream direction from the stagnation zone are being evaluated by many research groups around the world for keeping the drag of the blunt body to acceptable levels during its atmospheric ascent [1,2]. Nevertheless, out of all of the investigated drag-reducing techniques, the use of a forward-facing spike attached to the nose cone of the hypersonic vehicle appears to be the most effective and simplest method.

The experimental investigations of the flowfield around a spiked–blunt body began in the 1950s. Stalder and Nielsen [3] examined the heat transfer and the pressure distribution of a hemisphere cylinder equipped with a sharp aerospike. Their tests were conducted with a maximum Mach number of 5.04 and thus slightly grazed the hypersonic regime. Their best configuration delivered a drag reduction of 45%. Moreover, when the flow is supersonic, that is, at a Mach number of about 2, the recirculation area in front of the dome was not

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