Navier-Stokes Computations and Experiment of The Supersonic Flows Over a Cylindrical Afterbody with Base Bleed

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One of the most important aerodynamic performance characteristics for projectiles is the total drag which can be typically divided into three components ; pressure drag(excluding the base), viscous skin friction drag, and base drag. In a range of supersonic flight speeds the base drag is a major contributor to the total drag and can be as much as 50%~70% of the total drag, depending on the afterbody configuration of projectiles. It is of especial importance to minimise this part of the drag.

An effective and efficient means of reducing the base drag is by base bleed. A gas flow is injected into the recirculating region immediately behind the base. This changes the structure of the flow field in the base region, leading to an increase in the base pressure. Thus the base drag of blunt afterbodies is significantly reduced. The drag reduction due to this base bleed at supersonic speeds has long received considerable interest in the past. Supersonic flow over cylindrical afterbodies with and without base bleed has to date been experimentally and numerically investigated by many researchers. The results showed the effect of base bleed on the base pressure for a range of Mach numbers from 1.50 to 3.0. For low Mach numbers an increase in base pressure was obtained with increasing mass flow rate of the bleed gas, but for higher Mach numbers the effect of base bleed of sonic gas jet was not yet clarified. For the sonic jet bleed, the base pressure can be strongly influenced by the flow conditions at the exit of bleed hole.

This paper describes computational and experimental investigations of the effect of the base bleed on the base region flow field and on the base pressure. Axisymmetric compressible Navier-Stokes equations were numerically solved using a fully implicit finite volume differencing scheme. Temporal derivatives were integrated using a multi-step Runge Kutta Scheme, and standard k-e turbulence model was used to close the governing equations. Computations were carried out based on a fine structured grid system of 2000×180 node points. Free stream Mach umber was changed in a range between 0.8 and 3.0. The mass flow of the sonic gas injection was varied to obtain a wide range of the flows from a moderate to a fully underexpanded state at the exit of a sonic nozzle. Wind tunnel experiments were conducted to validate the predicted results of the present computations. Both computational and experimental results were used to investigate the effect of gas injection on the base pressure and on the flow filed in the near base region at different free stream Mach number.