Analysis of flow characteristics around sharp, blunt, and bulb-shaped missile nose geometries

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Shetty, Shamitha [a]; Nagarkar, Kavana [b]; Khan, Sher Afghan [c]; Aabid, Abdul [d]; Baig, Muneer [d]

[a] Department of Mathematics, Nitte Meenakshi Institute of Technology, Nitte (Deemed to be University), Karnataka, Bangalore, 560064, India

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Abstract

The current study investigates the aerodynamic characteristics of three distinct missile nose cone geometries: sharp, blunt, and bulb-shaped under supersonic conditions at Mach numbers 2.4, 2.8, 3.2, and 3.6. The primary objective is to analyze key parameters, such as lift and drag coefficients, and compare the findings with values reported in existing literature. The research aims to explore the flow physics responsible for variations in drag force as the missile nose shape is altered. Supersonic missile design has drawn significant interest, with improving performance remaining a critical focus for researchers and engineers. One of the main challenges in achieving better performance is mitigating the high drag forces experienced at these speeds. The research employs two-dimensional computational fluid dynamics simulations using the standard k-epsilon turbulence model in ANSYS Fluent. Key parameters such as drag coefficient, lift coefficient, and pressure distribution are analyzed to understand the impact of nose shape on aerodynamic efficiency. Results indicate that the sharp nose geometry exhibits significantly reduced drag compared to the blunt and bulb configurations due to streamlined shock wave interactions and reduced pressure concentration at the nose tip. Conversely, while producing higher drag, the blunt shape offers better heat dissipation potential due to increased surface exposure. This study fills a gap in the literature by conducting a detailed comparative analysis of unconventional nose shapes at high Mach numbers. The findings contribute to improved missile nose design by balancing drag reduction and thermal management in high-speed flight regimes. The study concludes that minimizing the missile's exposed surface area to the freestream and shock interactions effectively reduces drag, as smaller surface areas diminish shock interaction and associated drag forces.

Author keywords

Computational fluid dynamics (CFD); Drag reduction; Missile aerodynamics; Nose cone geometry; Shock wave interaction; Supersonic flow

Indexed keywords

Engineering controlled terms

Aerodynamic drag; Computational geometry; Drag coefficient; Lift; Mach number; Missiles; Nose cones; Shock waves; Supersonic aerodynamics; Supersonic aircraft; Supersonic flow

Engineering uncontrolled terms

% reductions; Computational fluid; Computational fluid dynamic; Cone geometry; Drag forces; Fluid-dynamics; Keys parameters; Missile aerodynamic; Nose cone geometry; Shock wave interaction

Engineering main heading

Computational fluid dynamics; Drag reduction

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Corresponding authors