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Numerical analysis of changes in the flow nature in a sonic flow with corrugated ribs

International Journal of Thermofluids • Article • 2025 • DOI: 10.1016/j.ijft.2025.101307

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Abstract

The study of turbulent flow at high inertia levels remains an area of investigation with the advent of the space shuttle and the design and development of supersonic/hypersonic missiles and aircraft. When the flow gets separated, there is an abrupt rise in the relief to the flow, resulting in a low-pressure recirculation region at the blunt base of the shells, rockets, and missiles. This study aims to assess the effectiveness of passive control as a corrugated rib at Mach unity for a pipe of diameter 25 mm for a length-to-diameter ratio (L/D ratio) = 1 to 6. The study was conducted for a nozzle pressure ratio of 1.5 to 5. At sonic Mach number, when the passive control is placed at various locations in the duct, the optimum location and height of the rib seem to be L/D = 0.5,1, 2, and 5 mm, resulting in a base pressure almost three to four times the ambient pressure where the flow from the nozzle sees corrugated part of the rib which sheds secondary vortices due the presence of the sharp corners. The control is adequate for the three mm height of the rib, but the maximum gain is at L/D = 2, and for other locations of the rib, the change in the pressure at the recirculation region is insignificant. The base pressure values remain the same when the rib is further moved downstream at L/D = 3 and 4, and the rib position variation is ineffective. Hence, based on the mission's needs, one can select the size and position of the rib. Therefore, any increase in base pressure will enhance the range of missiles, rockets, aircraft bombs, and artillery

shells, leading to enormous savings in fossil fuels, a reduction in carbon emissions, and a reduction in global warming. © 2025 The Author(s)

Author keywords

Corrugated ribs; Expansion level; L/D ratio; Sonic mach number; Sudden expansion

Indexed keywords

Engineering controlled terms

Aerodynamics; Bombs (ordnance); Fighter aircraft; Fossil fuels; Location; Rocket nozzles; Space shuttles; Supersonic aircraft

Engineering uncontrolled terms

% reductions; Base pressure; Corrugated rib; Design and Development; Expansion level; Length to diameter ratio; Passive control; Recirculation regions; Sonic mach number; Sudden expansion

Engineering main heading

Global warming; Mach number; Rockets

Funding details

Details about financial support for research, including funding sources and grant numbers as provided in academic publications.

Funding sponsor	Funding number	Acronym
Prince Sultan University See opportunities		

Funding text

This research is supported by the Structures and Materials (S&M) Research Lab of Prince Sultan University, and the authors acknowledge Prince Sultan University's support in paying the article processing charges (APC) for this publication.

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