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Effect of ribs in a suddenly expanded flow at sonic Mach number

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Abstract
This study aims to assess the influence of a rib on the base pressure and the flow development in an abruptly expanded duct at sonic Mach number. Initially, the simulations were done to validate the experimental results, keeping all the parameters the same. Accordingly, a duct-of-area ratio of 6.25 was considered for validation. Five ribs of aspect ratios 3:1, 3:2, and 3:3 were used as a first step, and simulations were performed for the same nozzle pressure ratios. Results indicate that for an area ratio of 6.25, there is a continuous decrease in the base pressure despite the nozzles being highly under-expanded. The lower aspect ratio of the rib tends to reduce the base pressure, whereas a higher aspect ratio effectively increases the base pressure for an area ratio of 6.25. Later simulations considered a single rib instead of five ribs, varying the rib's heights from 1 mm to 5 mm. Results show that the base pressure increases considerably when rib heights are 4 mm and 5 mm. The influence of ribs at two duct diameters (25 mm and 18 mm) is studied to assess the impact of a decrease in the area ratio and, hence, a decrease in the relief available to the flow. Results of duct 18 mm show that passive control becomes very effective when a rib of 3 mm height is located at a 3D position. The differences in the base pressure, velocity, and pressure field for each case are explored. The simulation results indicate that the rib breaks the primary vortex at the base and forms multiple vortices. Turbulent kinetic energy increases in the presence of ribs more than without a rib. © 2024

Author Keywords
Base pressure; Flow characteristics; Nozzle pressure ratio; Rib geometry; Suddenly expanded flow

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