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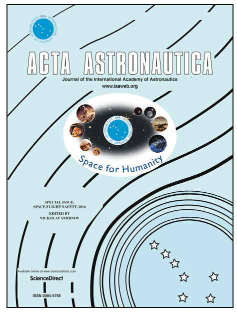

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Numerical Investigation of over Expanded Flow Behavior in a Single Expansion Ramp Nozzle

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Abstract

The single expansion ramp nozzle is severely over-expanded when the vehicle is at low speed, which hinders its ability to provide optimal configurations for combined cycle engines. The over-expansion leads to flow separation as a result of shock wave/boundary-layer interaction. Flow separation, and the presence of shocks themselves, result in a performance loss in the single expansion ramp nozzle, leading to reduced thrust and increased pressure losses. In the present work, the unsteady two dimensional compressible flow in an over expanded single expansion ramp nozzle has been investigated using finite volume code. To achieve this purpose, the Reynolds stress turbulence model and full multigrid initialization, in addition to the Smirnov's method for examining the errors accumulation, have been employed and the results are compared with available experimental data. The results show that the numerical code is capable of predicting the experimental data with high accuracy. Afterward, the effect of discontinuity jump in wall temperature as well as the length of straight ramp on flow behavior have been studied. It is concluded that variations in wall temperature and length of straight ramp change the shock wave boundary layer interaction, shock structure, shock strength as well as the distance between Lambda shocks.

Key words: Finite Volume Code; Single Expansion Ramp Nozzle; Wall Temperature; Length of Straight Ramp; Separated Flow

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