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Study of effect of flow parameters on base pressure in a suddenly expanded duct at supersonic mach number regimes using CFD and design of experiments (Article)

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Abstract

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Effectiveness of active control of micro jets has been examined by conducting experiments through an abruptly expanded axi-symmetric duct in a view to control base pressure. For this purpose, 1mm orifice diameter micro jets have been deployed at an interval of 900 along the exit diameter of the nozzle. The experiments have been conducted by considering three flow parameters at three levels. Mach number (M), length to diameter (L/D) ratio and area ratio (AR) are the three parameters used to conduct and analyze the flow experiments. Base pressure is considered to be the response variable. The experimentation has been carried out for two cases, i) without active control; ii) with active control. An L9 orthogonal array has been implemented to plan the experiments. It is observed that the control becomes effective for lower area ratios when compared to the higher ones. In addition to this, at high area ratios suction at the base decreases and hence base pressure continuous to diminish with increasing L/D until it reaches a value of L/D=6. The obtained experimental results are subjected to multiple linear regression analysis and Analysis of variance (ANOVA). The performances of the two linear regression models were tested for their prediction accuracy with the help of 15 random test cases. It is observed that, both linear regression models for base pressure without and with control are statistically adequate and capable of making accurate predictions. Furthermore, this work also concludes that, Mach number is the most significant factor affecting base pressure followed by area ratio and L/D ratio for both cases of experimentation. The obtained experimental results are further validated by CFD analysis and are found to be in good concurrence with each other.

Author keywords

Analysis of variance | Area ratio | Base pressure | Length to diameter ratio | Mach number

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