Design Optimization of Convergent Conical Nozzle Using CFD

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A systematic computational examination of convergent-conical nozzle compressible flow dynamics utilizes geometric parameterization to achieve optimal exit velocity performance. Seven nozzle designs are analysed using Computational Fluid Dynamics (CFD) to understand how changes in length and divergence angle affect performance metrics relative to existing benchmarks. A series of simulations operates at a fixed Nozzle Pressure Ratio (NPR) of 4.0 while using a divergence angle of 40° to evaluate length effects across seven parametric configurations between 0.001524–0.00635 m. Evaluation results demonstrate that nozzle exit velocity shows a non-linear connection to nozzle length. From 0.001524 m to 0.00381 m the velocity reaches its highest point at 622.89 m/s before beginning a steady decrease after 0.00508 m. Flow length optimization demonstrates consistent importance throughout all case studies for achieving optimal balance between acceleration and drag effects. Flow behaviour depends directly on nozzle geometry because extended nozzle designs produce adverse pressure gradients which lead to flow separation events reducing system efficiency. The results demonstrate that precise nozzle design becomes critical in engineering high-speed applications utilized in propulsion systems and aerodynamic configurations. This research uses performance outcome correlations with geometric characteristics to build an empirical framework which provides engineers with practical principles for improving compressible flow system efficiency.

Convergent-conical nozzle, exit velocity, nozzle pressure ratio, nozzle angle