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Optimization and Performance Analysis of Convergent Divergent Nozzles

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Abstract

Convergent-divergent nozzles (CDN), commonly used in rocket engines, jet propulsion, and industrial gas turbines, are essential for accelerating fluid flow to supersonic speeds. This paper investigates the optimization and performance analysis of these nozzles, focusing on factors such as nozzle geometry, pressure ratios, and boundary conditions. Optimizing these parameters enhances nozzle efficiency, reduces energy losses, and ensures stable supersonic flow. Geometric optimization involves refining the nozzle's contour to reduce flow separation and minimize shockwave formation, particularly in the divergent section. Additionally, achieving an optimal pressure ratio between the inlet and outlet plays a significant role in maximizing exhaust velocity and minimizing shock-induced losses. Performance analysis is conducted through computational fluid dynamics (CFD). Simulations are used to predict flow characteristics, Mach number distributions, and shock locations, while experimental tests validate these models by measuring parameters such as thrust, exhaust velocity, and specific impulse. By combining these techniques, the study provides comprehensive insights into the behavior of convergent-divergent nozzles under various operating conditions. The results contribute to the design of more efficient propulsion systems, emphasizing the importance of nozzle optimization in enhancing the performance of aerospace and industrial applications involving high-speed fluid flow.

Keywords
Performance analysis, efficiency, convergent-divergent nozzle, CFD