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EXPLORING THE COMPLEXITIES OF PINTLE INJECTORS FOR HIGH PERFORMANCE ROCKET PROPULSION AN ADVANCED NUMERICAL SIMULATION INVESTIGATION WITH EXPANSION DEFLECTION NOZZLE

Abstract

The Pintle injector is a highly efficient and versatile injection technology widely used in liquid rocket engines, including the Merlin engine for Falcon series launchers of SpaceX and the Lunar Module Descent Engine (LMDE). In this study, we conduct a numerical simulation to analyze the rotating flow observed during a cold flow experiment using water and air. The analysis is carried out using OpenFOAM and ANSYS to investigate flow separation and other relevant parameters.The Expansion Deflection Nozzle is a novel design that offers potential weight and length reductions, as well as an increase in specific impulse over traditional bell nozzles. In this study, we explore the use of this nozzle design in conjunction with the Pintle injector to enhance the overall performance of rocket propulsion systems.To verify the simulation results, we compare three types of experimental data, including velocity distributions of gas flows, spray angles, and liquid distribution. The results show a decrease in the atomization cone angle with an increase in the gas/liquid momentum ratio, which is consistent with both the experimental and numerical results.In conclusion, this study demonstrates the potential of using the Pintle injector with the Expansion Deflection Nozzle for rocket propulsion systems. The numerical simulation offers valuable insights into the flow dynamics and performance of the system, paving the way for future advancements in rocket propulsion technology.