EXPERIMENTAL & NUMERICAL INVESTIGATION ON EFFECT OF DIVERGENCE ANGLE FOR A CONVERGENT - DIVERGENT SOLID PROPELLANT ROCKET NOZZLE

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Keywords:

Turbulence Kinetic Energy (TKE); CD Nozzle, Solid Propellant

Introduction:

This project focuses on investigating the effect of varying divergence angles on the performance of rocket CD nozzles. Through a combination of simulations , this study aims to elucidate the relationship between divergence angle and nozzle efficiency. The CFD simulations will provide detailed insights into the flow dynamics and pressure distributions within the nozzle, while experimental tests will validate the simulation results and provide practical performance data. The objectives of this study include identifying the optimal divergence angle that maximizes thrust and efficiency, understanding the impact of divergence angle on flow separation and shock wave formation, and developing guidelines for the design of efficient rocket nozzles. The findings from this research will contribute to the advancement of rocket propulsion technology, providing valuable insights for engineers and designers in the aerospace industry.

Objectives:

- Study the effect of different divergence angle (8°, 10°, 12°, 14° and 16°) on thrust produced using Open Motor software

- ➢ Study the effect of different divergence angle on thrust produced using Ansys Fluent software.
- ➢ Design and fabricate a test setup to measure thrust produced by solid rocket motors
- ➢ Conduct experimental testing of nozzles with divergence angles of 8°, 10°, 12°, 14° and 16° to evaluate thrust performance.
- ➢ Perform a comparative analysis of simulated and experimental results to identify the optimal and most efficient nozzle divergence angle for thrust maximization.

Methodology:

1
- Theoretical calculations for the nozzle design, area ratio, pressure ratio.
- Model the rocket nozzle with varying divergence angles using SolidWorks.

2
- Perform CFD simulations in ANSYS Fluent to study flow characteristics and determine the optimal design.

3
- Select lightweight, heat-resistant materials for the nozzle and rocket body
- Fabricate solid-propellant grain using KNSB with appropriate safety measures and also the motor casing

4
- Assemble a test rig with a load cell to measure thrust during static firing.
- Conduct static firing tests for nozzles with the most optimal angle determined from CFD.

5
- Record thrust performance evaluation.
- Analyse test data to identify the relationship between divergence angle and thrust performance.

6
- Validate experimental results by comparing them with simulation data.
- Determine the divergence angle that delivers maximum thrust efficiency

Result and Conclusion:

It is concluded that optimizing the divergence angle to 12 degrees enhances the performance of the rocket nozzle using KNSB solid propellant. To verify the CFD results experimental test was conducted which the motor yielded a thrust of 180N and burn time was 8 seconds. There was an error around 9-10% in the CFD results and experimental results in all nozzles. This error highlights the various losses that contribute to performance discrepancies, including heat dissipation losses, turbulence-induced losses, and other inefficiencies.

Future Scope:

The future scope of this project includes:

1. Grain geometry configuration study
2. Nozzle configuration study
3. Propellant configuration study
4. Casting method can be explored