An Investigation Into The Applicability Of Commonly Used Evaluative Expressions In Swirl Atomizers For Cryogenic Conditions

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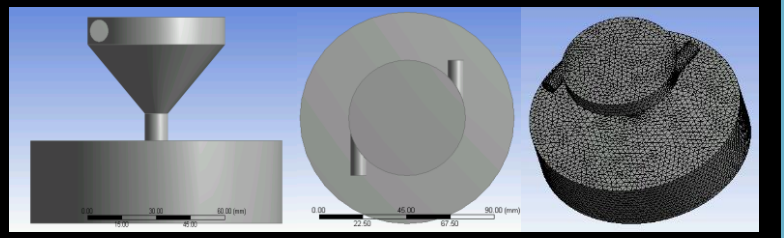
INTRODUCTION

- Simplex-Swirl Atomizers are commonly designed and analyzed with a set of expressions that have been standardized over the last 30 years. Hybrid rockets use Simplex-Swirl Atomizers for liquid oxidizer injection, but this is done at temperatures and geometric configurations that were not considered in the derivation and development of these expressions.
- Aim: To determine if these expressions remain valid under the conditions present in hybrid rocketry.

METHODS

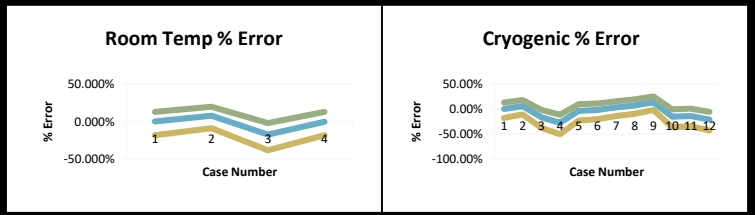
- Analytical predictions were made and compared to experimental data from multiple sources to establish expected accuracy.
- Experimental data for cryogenic fluids was compared to analytical results to determine accuracy of expressions for this case.
- Computational Fluid Dynamics (CFD) simulation was prepared and run for a large geometry configuration and compared to analytical results.



[Fig 1] Side View of CFD Geometry [Fig 2] Top View of CFD Geometry
[Fig 3] CFD Mesh in Isometric View

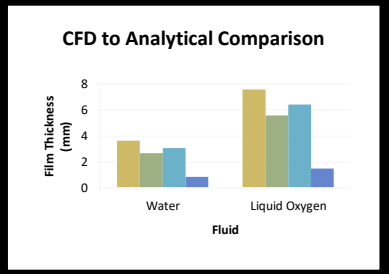
RESULTS

- Comparing the experimental results using cryogenic fluid to the analytical values showed the same level of accuracy as for room-temperature fluids. (for Figs. 4, 5, and 6, the copper is the Rizk and Lefebvre analytical result, the green is the Suyari and Lefebvre analytical result, and the blue is the Wimmer and Brenn analytical result)



[Fig 4] Comparison of analytical and room temp experimental values
[Fig 5] Comparison of analytical and cryogenic experimental values

- CFD simulations showed large deviations between the analytical results and the simulated results, indicating that the analytical expressions are likely not valid for large geometry atomizers. (In Fig. 6, the purple is the CFD result)



[Fig 6] Comparison of analytical and CFD values

CONCLUSIONS

- The analysis of experimental results show that the common analytical expressions for evaluating Simplex-Swirl Atomizers remain similarly valid for the use of cryogenic fluids as they are in analyzing room temperature fluids
- The results of CFD simulation indicate that the analytical expressions do not appear to be valid for the large geometries used in hybrid rocketry.
- Further experimental research should be done in order to validate the findings with respect to large geometry Simplex-Swirl atomizers..