Paper ID: 60601
oral
student

IAF SPACE PROPULSION SYMPOSIUM (C4)
Liquid Propulsion (2) (2)

Author: Mr. Nathan Radomski
The Ohio State University College of Engineering, United States, nearadomski@gmail.com

Ms. Joyce Smith
The Ohio State University College of Engineering, United States, smith.11109@osu.edu
Mr. Harry Byers
The Ohio State University College of Engineering, United States, byers.232@osu.edu
Mr. Thomas Margevich
The Ohio State University College of Engineering, United States, margevich.3@osu.edu
Mr. Tyler Hoffman
The Ohio State University College of Engineering, United States, hoffman.1083@osu.edu
Ms. Rachita Puri
The Ohio State University College of Engineering, United States, puri.52@osu.edu
Dr. John M. Horack
The Ohio State University College of Engineering, United States, horack.1@osu.edu
Dr. Elizabeth Newton
The Ohio State University, United States, newton.387@osu.edu

COMPUTATIONAL FLUID DYNAMICS MODEL FOR AN ADDITIVELY MANUFACTURED LIQUID BI-PROPELLANT COAXIAL SWIRL INJECTOR

Abstract

The goal of this project was to prove the validity of using computational methods to aid in the design of bi-propellant rocket injectors, specifically coaxial swirl injectors and additively manufactured injectors. With more of the aerospace industry making a push to 3D print engine components, having a verified model to estimate the performance of additively manufactured injector plates can greatly reduce the required time and resources required to develop and manufacture bi-propellant rocket injectors. Furthermore, many of the methods that are used to model flow through additively manufactured components are proprietary, thus a secondary goal of this project was to make this information more accessible.

Computational Fluid Dynamics (CFD) simulations were conducted using ANSYS Fluent software to model flow through individual additively manufactured liquid bi-propellant coaxial swirl injector elements designed for a liquid oxygen and ethanol engine. The purpose of these simulations was to predict the performance characteristics of multiple iterative designs, including the estimated pressure drop across each element and mass flow rates. These were 2-D axisymmetric swirl simulations using a Shear-Stress Transport (SST) κ-ω model, and accounted for the estimated surface roughness of the walls for both engineering resin printed using Stereolithography (SLA) technology and Inconel 718 printed using Direct Metal Laser Melting (DMLM) technology, as well as the estimated boundary conditions for the inlets and the working fluid (mass flow rate, pressure, density, etc.). The simulations used water as the working fluid for simplicity due to experimental validation limitations. The 2-D axisymmetric swirl solution was obtained by first using the estimated experimental boundary conditions and conducting an axisymmetric simulation to obtain a solution without rotation or swirl effects. Then, the axisymmetric results were used as the initial conditions for the axisymmetric swirl simulation. A solution for the swirl velocity was found, therefore establishing the field of rotation throughout the domain, then this swirl velocity was

fixed, and the momentum and continuity equations for the flow were solved, therefore establishing the axial and radial flows resulting from the rotation due to the swirl velocity. To complete the continuous phase flow simulations, all of the equations were then simultaneously solved to obtain the fully coupled 2-D axisymmetric swirl solution. Cold-flow testing using a pressure-fed water system and Schlieren imaging were used to update and improve the CFD model and test the validity of the CFD result.