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Characterization of Aerospike Nozzle Flows

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Abstract

Aerospike nozzles possess many qualities that make them more desirable and efficient than conventional bell-shaped rocket nozzles. Aerospike nozzles have been studied since the 1960s, but problems and limitations with experimentation often led to abandoning further efforts on aerospike nozzles and implementing much more familiar bell-shaped nozzles. In fact, aerospike nozzles have yet to be used in flight—they have only undergone ground testing. The goal of our research is to develop multiple additively manufactured aerospike nozzles and characterize the flow experimentally, numerically, and computationally. Schlieren photography and Particle Image Velocimetry (PIV) are used to experimentally characterize the flow, ANSYS CFD software and SolidWorks Flow Simulation are used to computationally analyze the nozzle flows, and hand calculations with the assistance of Matlab and Microsoft Excel are performed to analyze the nozzle flows numerically. Using these methods, we will study and compare the flows present in aerospike nozzles with a singular annular entrance as well as multiple orifice entries. To date, we have developed an experimental setup and procedure to study the nozzles we produce. Furthermore, using this setup we've successfully designed, manufactured, and analyzed a converging-diverging nozzle for our setup that produces supersonic flow—a necessary property of flow to accurately characterize nozzles use for aerospace applications. We hope that our research helps to develop a better understanding of aerospike nozzles and their many advantages over the bell nozzle, and motivates further research and eventually the implementation of aerospike nozzles in both aircraft and spacecraft.