Designing a Single Part 3D Printed Aerospike Thrust Chamber Assembly

Hansen, Dallan (School: Weber High School)

The bell nozzle is the most common rocket nozzle design, but it is optimized for a single altitude and therefore operates below peak efficiency during most of flight. The aerospike is an altitude compensating nozzle shaped like an inverted bell nozzle, allowing for maximum efficiency across all altitudes. While aerospikes have been tested, none have been flown for various reasons, such as weight, cooling complexity, and manufacturing difficulty. New advances in 3D printing technology address many of these limitations, as it allows the complicated geometries needed for aerospike rocket engines to be easily manufactured out of high strength alloys. The aim of this project was to design, manufacture, and evaluate a 3D printed aerospike thrust chamber assembly with regenerative cooling channels, injectors, and an aerospike nozzle.Injector performance was tested using compressed air and a spigot to evaluate atomization characteristics. The aerospike nozzle and a conventional control nozzle were mounted to a pressurized system and placed on a scale to measure relative thrust. Flow behavior was analyzed using a schlieren imaging system to observe characteristic shock wave structures. The injectors achieved effective atomization, and schlieren imaging revealed shockwave patterns consistent with aerospike flow behavior. Thrust measurements were inconclusive, and the regenerative cooling channels were designed but not validated. These results demonstrate the feasibility of additively manufacturing aerospike thrust chamber assemblies, as well as their potential for use in the near future in spaceflight applications such as SSTO’s.

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