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Hypersonic Air-breathing and Combined Cycle Propulsion, and Hypersonic Vehicle (7)

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NUMERICAL ANALYSIS OF AEROSPIKE NOZZLES FOR AIR-BREATHING COMBINED CYCLE PROPULSION ENGINES

Abstract

As the world is shifting towards hypersonic flight, increasing demand for aircrafts that can operate at greater speeds and in larger flight envelopes has consequently brought in a need for air-breathing propulsion, that is efficiently operable through a larger flight envelope. Turbine-based Combined cycle propulsion is a promising technology aimed at seamlessly transitioning between subsonic and supersonic flight while airborne, capable of potentially propelling vessels to hypersonic speeds. By separating the working fluid and the fuel, combined cycle engines can achieve much higher specific impulses than their orthodox turbojet siblings. The change between turbojet and ramjet is a phenomenal breakthrough in aviation technology, which will pave way to astounding developments in short periods of time. However, an aspect of engines most affected by altitude and speed is the nozzle, whose parameters greatly affect the power efficiency of the engine. While most modern jet engines having a converging-diverging nozzle configuration can control the nozzle diameter automatically, this will not be sufficient at a wider range of altitudes to obtain optimum expansion. Aerospike nozzles capitalise on the decrementing ambient pressures which result as a consequence of changing atmospheric conditions. Their atypical geometry ensures the optimum expansion of exhaust flow regardless of ambient flow, without the need for complex nozzle systems. Such nozzles can significantly improve thrust efficiency and power, lower fuel consumption and lower launch costs for high-altitude vehicles. In this paper, a comparative analysis of a conventional convergent-divergent nozzle and an aerospike nozzle has been performed numerically, with the parametric data of exhaust flow being sourced from existing commercial jet engines. This paper mainly employs simulating the exhaust flow in both the nozzles by utilizing fundamental software packages such as Ansys Workbench, where parameters like engine efficiency and flow characterisation have also been mapped over a good range of operational conditions. The results obtained in this paper determine that the Aerospike nozzle can be investigated for future applications in turbojet engines.