

Mechanical Engineering Thesis Defense

Numerical Simulation of Entrainment and Recirculating Flow at the Base of an Aerospike Nozzle with Supplementary Base Flow

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abstract

The aerospike nozzle is one type of nozzle in the class of altitude compensating nozzles studied for rocket powered vehicle applications. Altitude compensating nozzles have the characteristic that their exhaust plumes are optimally expanded at all atmospheric pressures encountered during ascent. Owing to their higher trajectory-averaged thrust efficiency compared to conventional bell nozzles, aerospike nozzles have been studied extensively and are often base-lined in many single stage to orbit (SSTO) designs. During its ascent through the atmosphere, a launch vehicle equipped with an altitude compensating nozzle design will require less propellant mass for a given velocity increment, or ΔV , than a vehicle utilizing a conventional bell nozzle. An optimally contoured annular spike nozzle is very long, making cooling and launch vehicle packaging difficult. These spike nozzles are often truncated, to make them more practical for launch vehicle applications. Truncation of the spike nozzle leads to pressure loss under the base, which in-turn decreases the overall thrust produced by the rocket nozzle. To overcome this loss, a technique called base bleed is implemented in which a secondary jet is made to flow through the base of the truncated portion. Few design rules for the requisite mass flow rates and flow characteristics exist. This thesis uses dynamic pressure contour plots to determine the ideal base bleed mass flow rate necessary to avoid base recirculation and associated base suction in 10%, 20% and 30% truncated aerospike nozzles.

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