Design and Optimization of Toroidal Aerospike Nozzle

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The main goal of every rocket engine is to generate a lot of heat and pressure and then convert that into workable thrust. The problem is most rockets don't solve pressure discrepancies at various altitudes. My project aimed to solve for these discrepancies by designing and optimizing a toroidal aerospike nozzle. Firstly, to optimize the nozzle ramp contour I designed a program that will use Rao's Optimum Thrust Method to generate the contours for a plug nozzle. I then 3D printed various nozzles using that contour, experimenting with truncation percentage. I tested these 3D printed models in a wind tunnel to measure the effectiveness. I used a manometer and force load cell to measure the forces and pressure acting upon the object. The results indicated that the optimized aerospike nozzle featured Rao's contour with 60% truncation. When originally comparing the nozzles as a function of the Voltage and the Force applied on the nozzle by the wind, there was no statistically significant difference between 60% and 80% truncation. Using the other data points gathered, the nozzles were compared as a function of Reynold's Number and the Drag Coefficient, this showed the 60% model offered a statistically significantly lower drag coefficient at all quantifications of turbulence and as an extension all the speeds. This design allows for altitude compensation, meaning that it can adapt to all altitudes and not lose efficiency in any atmosphere. The truncation also allows for a decreased weight which will allow for a better performance.