Visualization of Three-Dimensional Rocket Motor Flow Using Schlieren Photography

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Currently, rocket nozzles are designed in a bell shape and the key to the performance of the nozzle is its width. Under expanded nozzles prove optimal performance at low pressure (high altitudes) because the gas will be allowed to expand further. At high pressure (low altitudes), normal or under expanded nozzles prove optimal performance since the gasses are more tightly focused. Engineers use point design when designing these nozzles, meaning that they are built to be optimized at a certain altitude, but when the altitude and pressure changes, there is a large efficiency loss in that design. This project is attempting to test a different nozzle and it's efficiency if the altitude changes. It is hypothesized that the nozzle design known as an aerospike will remove the loss of performance and efficiency seen in the bell shaped nozzles, and prove optimal at every altitude and pressure. In order to test this, four different models, one of each nozzle- aerospike, under expanded bell, perfect bell, and over expanded bell- will be modeled and constructed using a 3D printer. Liquidized carbon dioxide will then be passed through each nozzle and the flow will be visualized using schlieren photography. The diameter of the nozzle will be compared to the diameter of the flow in order to see which one matches the closest. After experimentation was performed, it was found that the aerospike kept the flow the most efficient and tightly expanded. This finding is significant because it will allow rockets to be made more efficient, not only in power, but also in fuel consumption and it may help make rockets lighter.

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