The Optimization of Rocket Nozzle Performance

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The student varied the diverging length, angle, and exit area of five rocket nozzles in order to optimize their performance. Controlling how the propellant expands is key to optimization. It was hypothesized that the nozzle with a 13 degree angle and the greatest diverging distance and exit area would yield the greatest impulse. Data was collected by firing the rockets downward into a test pad outfitted with a Force Plate to measure thrust. The thrust of the nozzles was analyzed after a total 24 trials. Contradicting itself, the output varied without any apparent trend. The concept of expansion explained this phenomenon. The D12-0 engine was naturally under-expanded at normal pressure, and over-expansion was seen in the longer nozzles. Therefore, nozzle shape is optimized by an angle of 13 degrees but also by correctly expanding the stream based upon pressure (done by adjusting the length with a fixed angle). Expansion is correct when the back-pressure is equivalent to the exit-pressure of the propellant, so all of the expansive forces are directed to nozzle walls. The hypothesis was rejected due to the fact that longer diverging length didn't always provide greater thrust output. Sources of error included erosion to form after repeated trials, and temperature variations, but were proven minute. With a betterment of 16% over the control, design clearly impacts the output- and is the simplest way to maximize the efficiency without changing weight. It will assist us in reaching further, through space ambitions or aircraft design.