CURRENT CHEMICAL ROCKET TECHNOLOGY CONSISTS OF 3 MAIN TYPES BASED ON THEIR FUEL SOURCE: SOLID, LIQUID, AND HYBRID. HYBRID ROCKETS DESCRIBE A ROCKET ENGINE POWERED BY A COMBINATION OF GAS, SOLID, OR LIQUID PROPELLANTS. IN MY CASE I USED SOLID ACRYLIC AND GASEOUS OXYGEN. HYBRID ROCKET ENGINES ARE BECOMING INCREASINGLY ATTRACTION TO AEROSPACE GROUPS AS THEY ARE GENERALLY SAFER THAN SOLID PROPELLANTS AND SIMPLER THAN A LIQUID ENGINE. VIDEO LINK TO THIRD ENGINE TEST:

https://drive.google.com/file/d/1B5aXtoeE2lOrqkAvS7aZv5TF🍃fqcTfDX/view?usp=sharing

NOZZLES GIVE ROCKET ENGINES THEIR POWER BY INCREASING VELOCITY OF THE AIRFLOW TO SUPersonic SPEEDS. IN THE BOOK ROCKET PROPULSION ELEMENTS BY GEORGE P SUTTON, A CONVERGING ANGLE OF 60 DEGREES AND DIVERGING ANGLE OF 15 DEGREES IS CONSIDERED OPTIMAL.

OVERVIEW

The study was intended to look at nozzle characteristics and determine how changing aspects of a nozzle affected rocket thrust. To test the nozzle, I spent the first semester designing a polymethyl-methacrylate/Oxygen hybrid rocket engine to use as the testing vehicle. I spent the second semester 3D-printing nozzles for compressed air analysis.

RESEARCH

CURRENT CHEMICAL ROCKET TECHNOLOGY CONSISTS OF 3 MAIN TYPES BASED ON THEIR FUEL SOURCE: SOLID, LIQUID, AND HYBRID. HYBRID ROCKETS DESCRIBE A ROCKET ENGINE POWERED BY A COMBINATION OF GAS, SOLID, OR LIQUID PROPELLANTS. IN MY CASE I USED SOLID ACRYLIC AND GASEOUS OXYGEN. HYBRID ROCKET ENGINES ARE BECOMING INCREASINGLY ATTRACTION TO AEROSPACE GROUPS AS THEY ARE GENERALLY SAFER THAN SOLID PROPELLANTS AND SIMPLER THAN A LIQUID ENGINE. VIDEO LINK TO THIRD ENGINE TEST:

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Nozzles give rocket engines their power by increasing velocity of the airflow to supersonic speeds. In the book Rocket Propulsion Elements by George P Sutton, a converging angle of 60 degrees and diverging angle of 15 degrees is considered optimal.

PROCEDURE

ROCKET ENGINE IGGITION AND FORCE TESTING THE DIFFERENT NOZZLES REQUIRED DIFFERENT PROCEDURES.

IN ORDER TO EXAMINE SPECIFIC CHARACTERISTICS, I KEPT ALL OTHER ASPECTS CONSTANT. I EXAMINED 5 CHARACTERISTICS OF THE NOZZLE: DIVERGING CROSS SECTION AREA, CONVERGING CROSS SECTION AREA, DIVERGING HALF ANGLE, CONVERGING HALF ANGLE, AND THROAT SMOOTHNESS AS A RESULT OF FILLETING.

TO TEST THE THRUST PRODUCED, I DESIGNED AND 3D PRINTED A CLAMP STYLE TESTING RIG THAT FITS ON TO A VERNIER “FRICTIONLESS” CART. THE CART IS PLACED ON A VERNIER TRACK AND A FORCE SENSOR IS PLACED BEHIND IT. THE NOZZLES ARE DESIGNED SO THAT A QUICK CONNECT AIR COMPRESSOR LINE CAN FIT INTO IT. COMPRESSED AIR IS RELEASED AT 50 PSI AND THE FORCE IS TRACKED BY LOGGER PRO.

ANALYSIS (BRIEF)

IN TOTAL, I EXAMINED 32 DIFFERENT NOZZLES. IN THE FIGURES ABOVE, THRUST IS GRAPHED ON THE Y AXIS IN NEWTONS AS A RESULT OF THE VARIABLE CHARACTERISTIC WHICH IS GRAPHED ON THE X AXIS.

INTERESTING PIECES IN THE DATA:
- THRUST DECREASED AS DIVERGING CROSS SECTION DIAMETER INCREASED, BUT THRUST INCREASED AS THE DIVERGING ANGLE INCREASED.
- WHEN VARYING THE ANGLE OF CONVERGENCE, THE THRUST PEAKED TWICE.

RESULTS/CONCLUSION

THE “INTERESTING PIECES” CAN BE EXPLAINED IN NASA’S ARTICLE ON NOZZLE DESIGN. AFTER GAS PASSES THROUGH THE NOZZLES THROAT AND INTO ITS DIVERGING SECTION, THE FLOW EXPANDS TO SUPERSONIC SPEEDS. HOWEVER THIS PROCESS ONLY OCCURS WHEN THE INITIAL FLOW IS SUPERSONIC. THE FLOW OF COMPRESSED AIR WAS SUBSONIC, AND AS A RESULT THE GAS EXITING THE DIVERGING NOZZLE HAD LESS VELOCITY.