CALIFORNIA STATE SCIENCE FAIR
2002 PROJECT SUMMARY

Name(s)
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Project Number
S0115

Project Title
The Effect of Mass Flux on the C* Efficiency of Aluminized Grains in an N(2)O-Fed Hybrid Rocket Motor

Abstract

Objectives/Goals
The objective was to determine if the combustion efficiency of a N2O-fed, aluminized hybrid rocket motor is dependant on the propellant mass flux inside the motor ports.

Methods/Materials
After a substantial amount of research, a 300 lb thrust, 3.5 inch diameter, 2-port hybrid rocket motor was designed, machined, cast with fuel, assembled, safety tested, fired, and then analyzed. The operating parameters of the motor were designed to start at a high mass flux (1.0 lb/sec/in^2) and end at a low mass flux (0.15) in a single test. The motor was instrumented for N2O tank weight and pressure, motor thrust, and chamber pressure. Data was collected during the burn and analyzed afterwards.

All of the motor components were scratch-built from aluminum tube and plate, stainless steel, and graphite bar stock. The fuel was cast with a rubber binder and (10% by weight) 3-micron aluminum powder. The stand was welded steel, and the feed system was assembled from a stainless tank, purchased valves and fittings, and salvaged high-pressure hose.

Results
Motor performance exceeded my expectations and ran smoothly over the whole range of mass flux. The injector flowed more N2O than anticipated, resulting in a higher thrust (360 lbf) and higher than planned, initial mass flux (1.3). Nevertheless, my combustion, or C* efficiency, averaged about 84% over the whole burn, despite having an injector starting to burn through at 1.5 seconds. The injector did not completely fail, and the motor continued to burn well until the end of the 4-second burn.

Conclusions/Discussion
From the post-test analyses, I can conclude that C* efficiency, good motor stability, and high performance is more a function of proper motor and injector design than mass flux.

Summary Statement
My project showed that hybrid rocket motors can be operated at high propellant mass flux, delivering high fuel burn rate, high performance (C* efficiency), and stable motor chamber pressure, provided the injector and motor are well designed

Help Received
My father answered my questions and helped me anchor the thrust stand into the concrete pad at the test site. My mother helped me design the display board.