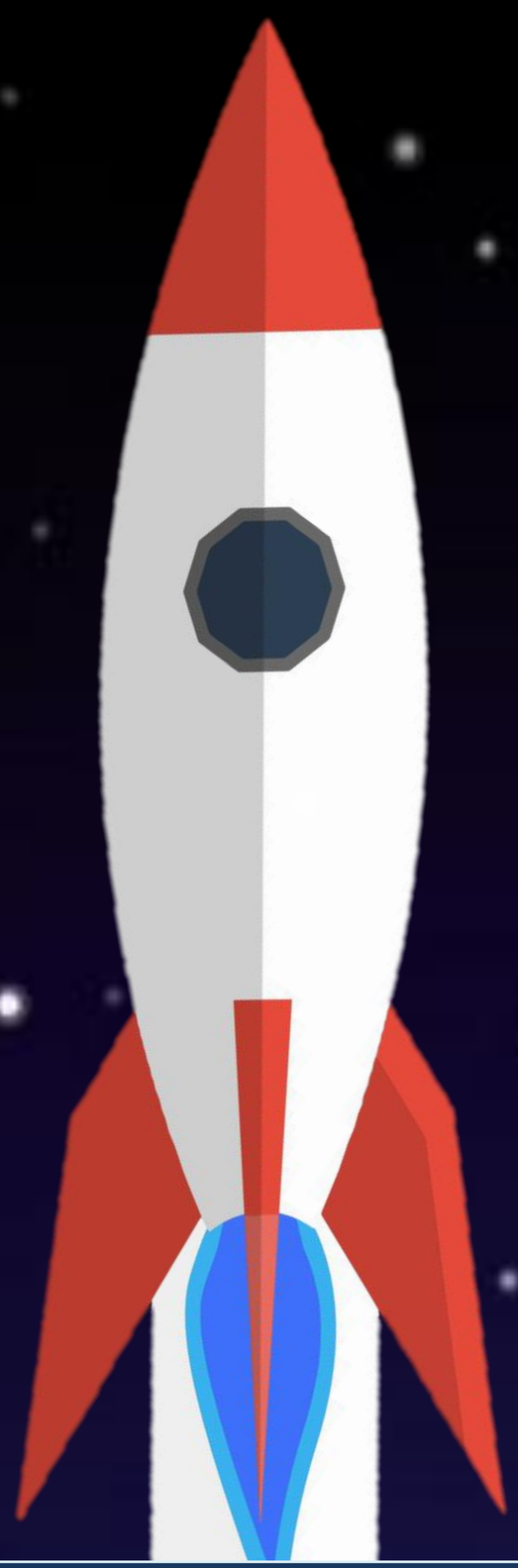
Temperature Sensitivity Test of Paraffin Hybrid Rockets

Matt Nurick, Aviel Ratson and Rona Razel
Supervisors: Daniel Komornik, Ph.D. Candidate and Prof. Alon Gany
Faculty of Aerospace Engineering – Technion, Israel, July-August 2018



Abstract

The purpose of our research was to analyze the influence of the fuel's initial temperature on the performance of hybrid rockets combusting paraffin wax with gaseous oxygen. About 20 paraffin engines were casted and tested at initial temperatures of -20°C and +30°C.

Introduction

A hybrid rocket is a motor that combines fuel in a solid state and oxidizer in a gaseous or liquid state. These rockets exhibit unique advantages, such as improved safety.

Experimental Tests

The preparation for the experiments included casting 17 fuel grain molds and pouring melted wax inside of it to solidify (Fig 1). Figure 1 also presents a fuel grain before and after firing. Figure 2 displays a layout of the experimental setup.

Fig. 1 – Mold preparation, casting, before firing, after firing (from left to right).

Fig. 3 – Hybrid rocket firing test

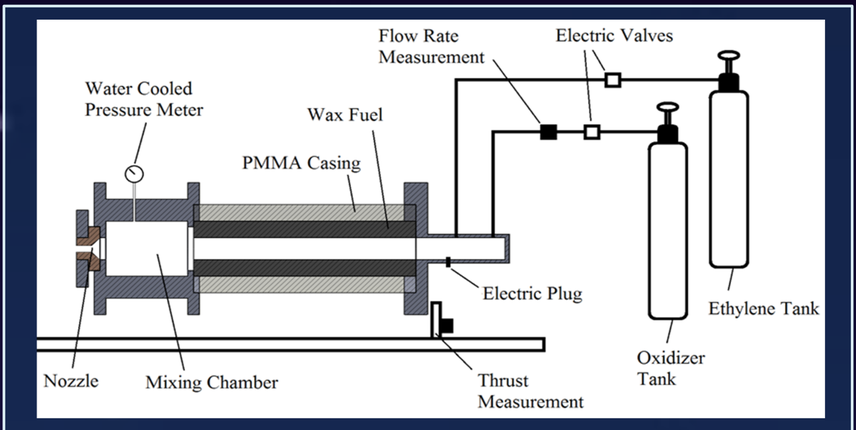


Fig. 2 – Experimental set-up

Results

Regression rate is the speed at which the fuel is consumed. Fig. 4 shows that the hot engines have a higher regression rate than their corresponding cold engine. (The pairs are represented with the same marker shape).

Fig. 5 indicates that the hot and cold pairs have a very similar specific impulse, which is the change in momentum per unit of fuel. This means that the initial temperature of the fuel doesn't significantly influence the rockets' performance.

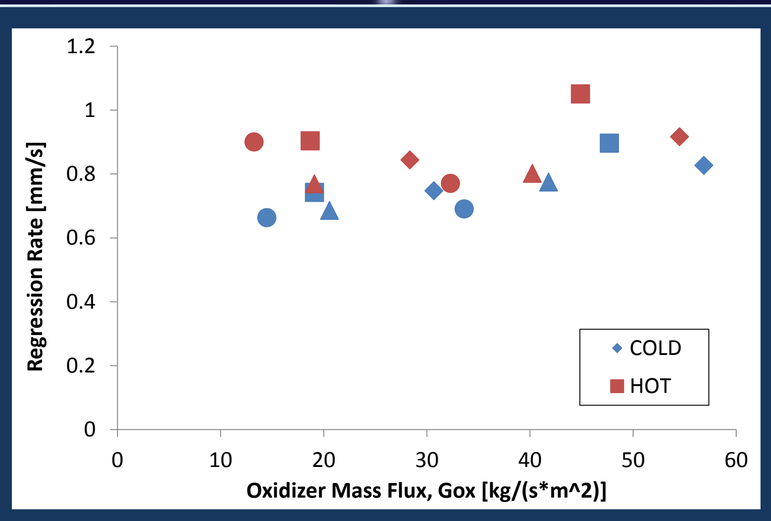


Fig. 4 – Regression rate as a function of oxidizer mass flux.

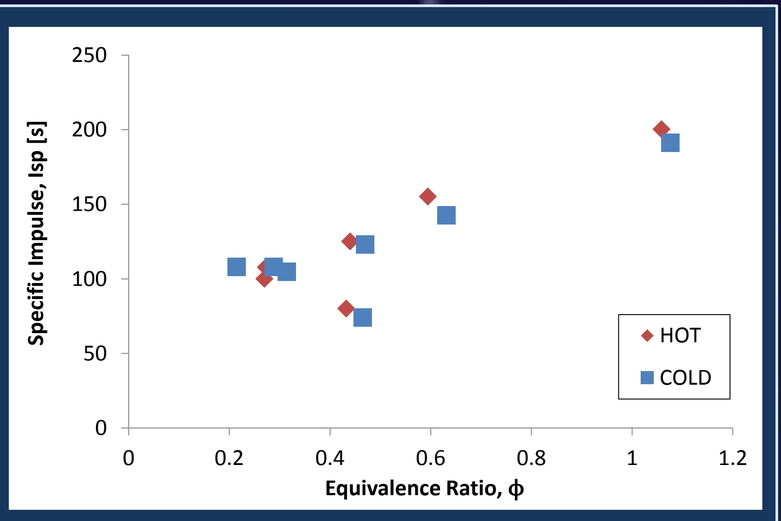


Fig. 5 – Specific impulse as a function of equivalence ratio.

Conclusions

Fig. 3 displays a static firing test. Data revealed a significantly different regression rate between the hot and cold engines (Fig. 4). This is a logical result as cold engines require more thermal energy to evaporate the wax. However, the difference in performance was negligible (Fig. 5). Therefore rockets can be used in various locations across the globe without its performance being affected by the region's climate.

Video and Calculator App

On the website you can view the videos of our firing tests as well as our app which calculates essential values that are required for testing.

Use the QR code or visit:
goo.gl/R8wCUq

Acknowledgments

We would like to thank Daniel Komornik, PhD Candidate, Prof. Alon Gany, and Prof. Benveniste (Benny) Natan for hosting and guiding us through our research in their laboratory. We would also like to thank the foundations and donors for their generous support of the SciTech program.

References

1. Altman, D. and Holzman, A., "Overview and History of Hybrid Rocket Propulsion", in: Fundamentals of Hybrid Rocket Combustion and Propulsion, Progress in Astronautics and Aeronautics, Vol. 218, AIAA, pp. 1-36, 2007.