Experimental Test of a Paraffin Aluminum Hybrid Rocket

Yael Arbel, Olivia Chen, Joshua Daniel Margolis and Elisha Issac Ness
Supervisors: Daniel Komornik, Ph.D. Candidate and Prof. Alon Gany

Faculty of Aerospace Engineering – Technion, Israel, August 2017

Introduction

Rockets produce thrust via combustion which releases chemical energy and is then converted into kinetic energy at the nozzle. Hybrid rocket have been covered in literature [1]. This rockets have fuel and oxidizer separated (see Fig. 1) and in different states (solid and gaseous in our case).

A previous theoretical research determined that adding aluminum to hybrid rockets enhances performance (see Fig. 2 – density specific impulse, $\rho \cdot Isp$, is a parameter of energetic performance while minimizing rocket volume). This research investigated that theory by experimentally testing a series of engines both with and without aluminum.

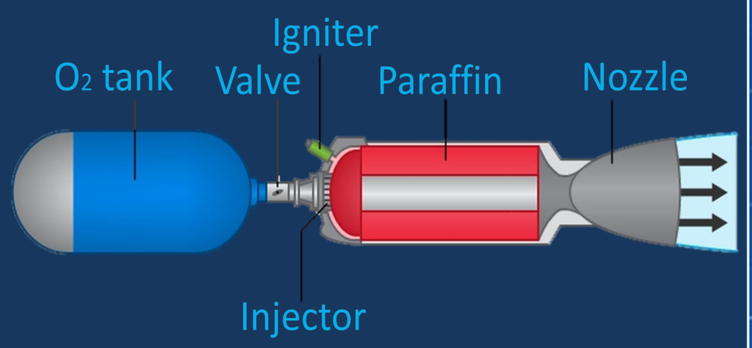

Fig. 1 – Schematics of a Hybrid Rocket

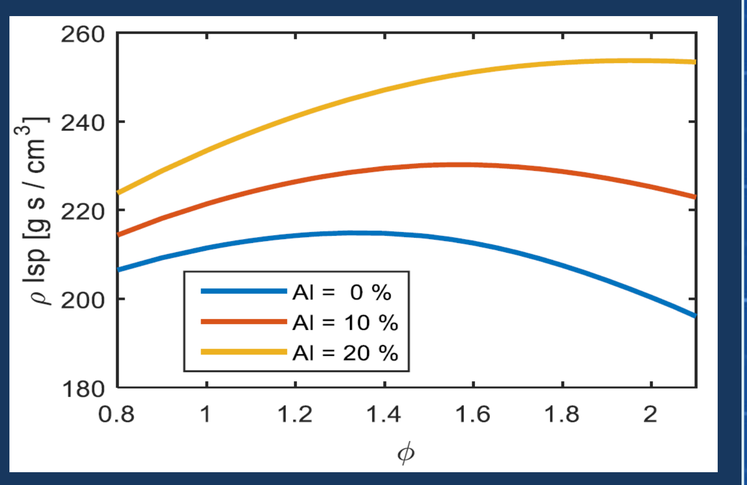

Fig. 2 –Theoretical performance improvement by adding aluminum [2]

Experimental Tests

Experiments of oxygen and paraffin wax both with and without aluminum were performed on the experimental set-up presented in Fig. 3.

Each motor had to be prepared as a mold (Fig. 4a) and casted with melted fuel into it (Fig. 4b). Figure 4c shows an engine before being tested and Fig. 4d shows one after.

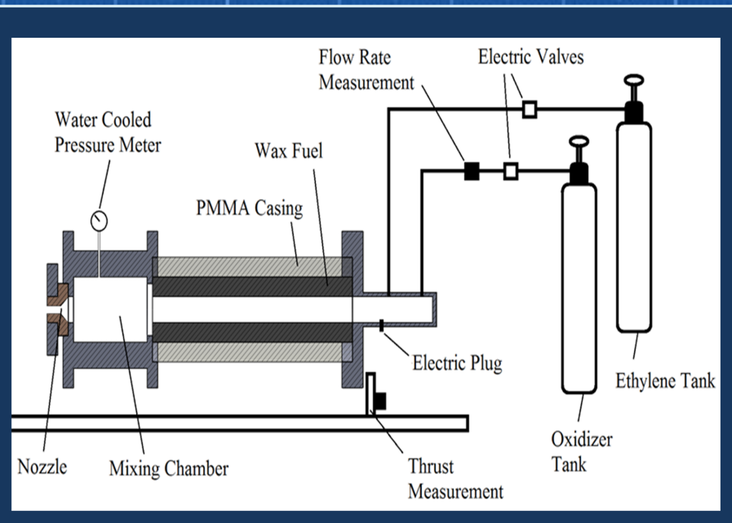

Fig. 3 – Experimental Set-up

Results

As it is shown in Fig. 5, the density specific impulse was enhanced by the addition of nano-aluminum to the paraffin wax.

This density specific impulse is a common parameter used in the rocket industry to quantify the energetic performance of a motor while considering its size/volume (smaller volume means higher density).

Fig. 6 presents a static firing test.

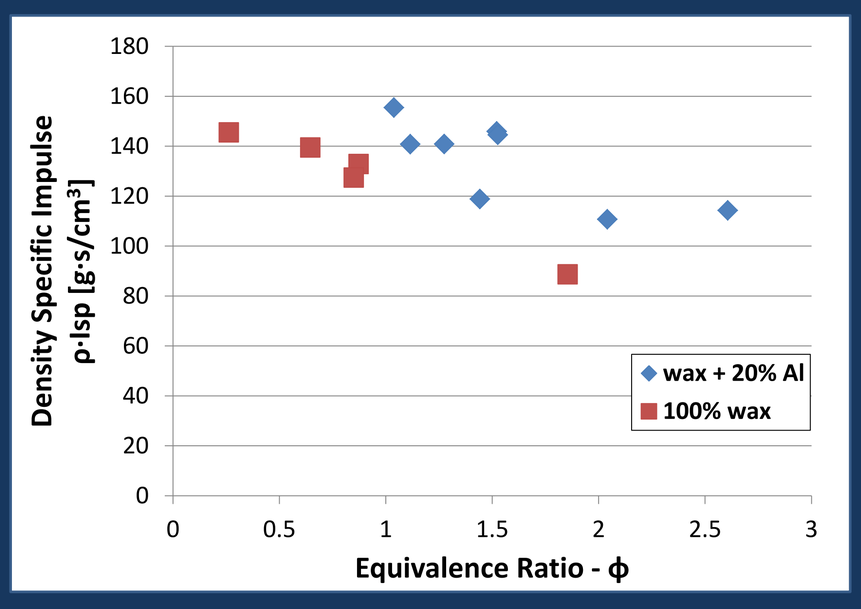

Fig. 5 – Density specific impulse as a function of the equivalence ratio

Fig. 4a – Mold preparation

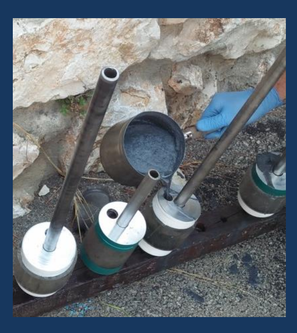

Fig. 4b – Casting

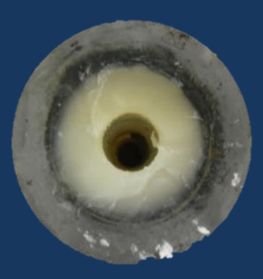

Fig. 4c – Before firing

Fig. 4d – After firing

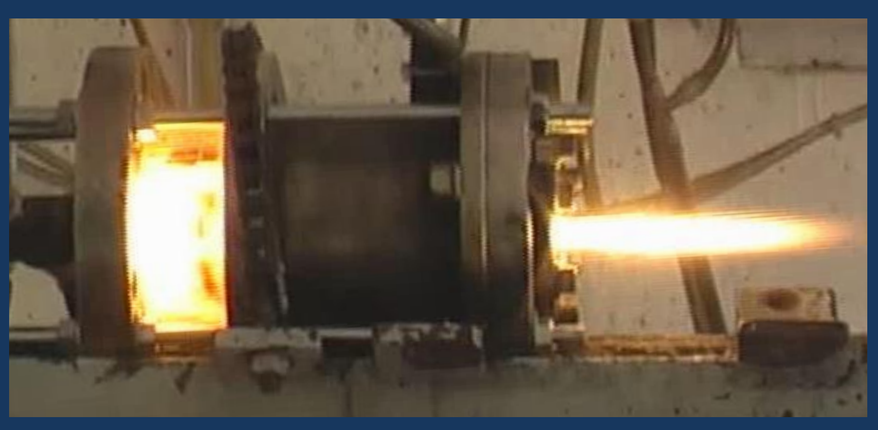

Fig. 6 –Hybrid Rocket during Firing Test

Conclusions

Adding aluminum allowed for an enhanced rocket which has potential to become a standard in the hybrid-rocket industry.

The process of incorporating the aluminum is inconvenient as the casting is more complex. It would be a more expensive operation for the rocket industry.

Depending on the needs of the rocket, the additional effort might be beneficial.

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.

2. Komornik, D. and Gany, A., “Thermochemical computations of a Paraffin-Aluminum Hybrid Rocket”, Proceedings of the 34th Israeli Conference of Mechanical Engineering, Haifa, 21-22 November 2016.

Acknowledgments

We would like to thank Daniel Komornik, MSc, 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.