Progress of Hybrid Propulsion Rocket Development at WARR

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Due to their relatively simple design and lower operational hazards compared to liquid or solid rocket motors, hybrid rocket propulsion systems are a popular research field among student groups. The Scientific Work Group for Rocketry and Space Flight (WARR) at the Technische Universität München has an extensive heritage in the design, construction and operation of hybrid propulsion rockets, which started with the implementation of the first German hybrid rocket "Barbarella" in 1962.

For the upcoming "Student's Experimental Rocket" (STERN) initiative, proposed by the German Aerospace Center (DLR), the WARR group can rely on its experiences obtained during the WARR-Ex 2 project, which yielded an experimental single-staged sounding rocket and the associated hybrid rocket engine HYPER I. This propulsion system utilizes self-pressurizing nitrous-oxide (N_2O) and solid HTPB grains to deliver a total impulse of 10 kNs, allowing the WARR-Ex 2 rocket to obtain a maximum altitude of about 5 km. In order to eliminate the need for two separate parachutes during the recovery phase of the flight, a reefing procedure is employed, which limits the area of the single recovery parachute until a certain threshold altitude is reached. Test firings of the engine have been concluded and show promising results [1]. After final tests of the entire flight system are conducted, the project will be completed by a launch under design conditions.

With funding from the German Aerospace Center within the STERN initiative and support from the Institute for Flight Propulsion (LFA) at TUM, the WARR will continue to expand its know-how in the design, implementation and operation of modern hybrid rocket systems. WARR's contribution to the STERN project will consist of a new experimental sounding rocket (WARR-Ex 3) designed for supersonic flight and a maximum altitude of 15 km, well exceeding the design requirements proposed by DLR. These flight parameters will be achieved by redesigning the propulsion system, resulting in a new engine designated HYPER II. While this new type of hybrid rocket engine will continue to use solid HTPB fuel, it will incorporate pressure-fed liquid oxygen (LOX) as oxidizer. The substitution of N_2O for LOX does not only promise higher specific impulse, but also introduces the students to the safe handling of cryogenic propellants, emphasizing the educational aspect of the STERN initiative.

The full paper will further present the results obtained from the WARR-Ex 2 project and give a more detailed outlook on the proposed WARR-Ex 3 sounding rocket being developed as part of the STERN framework.

References

[1] Zeiner, Metsker, Blum, Wagner, Krüger, Honecker und Eiringhaus, „Simulation and Verification of Hybrid Propulsion Operating Behaviour," in *63rd International Astronautical Congress - Student Conference*, Naples, 2012.