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SIMULATION AND VERIFICATION OF HYBRID PROPULSION OPERATING BEHAVIOR

Abstract

The development of hybrid motors for use in transportation systems is accompanied by many tests and reworks, aiming at constant thrust and fuel burning rates over the axial length. This paper presents a study approach towards the simulation of hybrid propulsion systems with the objective to understand and predict their behavior. The research work on operational airborne hybrid propulsion systems with N2O and HTPB reactants started at the Wissenschaftliche Arbeitsgemeinschaft für Raketentechnik und Raumfahrt (Scientific Workgroup for Rocketry and Space Flight) at the Technische Universität München in 2009. First results were published in the article "HYPER-Development of a hybrid propulsion system for experimental rockets" at the IAC 2010.

In the last two years the hybrid rocket motor itself, as well as a test bench which was developed mainly in 2011, were built. The test bed for this hybrid rocket motor is capable of measuring pressure, temperature, oxidizer mass flow and total thrust up to 1kN. It also allows for testing of different feed systems for an experimental combustion chamber with various initial conditions referring to grain geometry and feed system pressure. The design evolution, which led to the final version of the test bench, will be described in detail, as well as the final design itself and its possibilities and advantages. After the development and construction of the hybrid rocket engine, further knowledge of the systems behavior and performance is needed to improve its performance and explain test anomalies. Therefore two projects will be introduced: Simulation of fluid dynamic and combustion processes of the combustion chamber and the development and implementation of a regression rate measurement technique for obtaining a time resolved measurement of the fuel mass flow. As simulation platform the open source CFD simulation toolbox OpenFOAM is used. The detailed simulation model, as well as its results compared to test data from engine tests of the hybrid rocket motor will be included in this paper. To perform that comparison, detailed knowledge of the regression rate is essential. Also, the steps taken during development and the

final design stage of a regression rate measurement device will be presented. Finally, future prospects for the development of the propulsion system and the rocket motor to achieve more efficiency and power will be pointed out.