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Corresponding author: BIERWAGEN Nora M.
e-mail of corresponding author: nora.bierwagen@dlr.de
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Title

Particle-based modeling of the unsteady flow in a high-test peroxide catalytic chamber

Authors

Nora M. BIERWAGEN [1], Stefan May [1], Thino Eggers[2], Andreas Ohndorf [1], Christian Mundt [3]*

** Corresponding author*
[1] Responsive Space Cluster Competence Center, German Aerospace Center (DLR), 29328 FASSBERG, Germany, nora.bierwagen@dlr.de stefan.may@dlr.de andreas.ohndorf@dlr.de
[2] Institute of Aerodynamics and Flow Technology, German Aerospace Center (DLR), 38108 BRAUNSCHWEIG, Germany, thino.eggers@dlr.de
[3] Faculty of Aerospace Technology, Institute for Thermodynamics, Universität der Bundeswehr München, 85577 NEUBIBERG, Germany, christian.mundt@unibw.de

Abstract

The AHRES (Advanced Hybrid Rocket Engine Simulation) software tool, developed by the department Spacecraft of the DLR Institute of Aerodynamics and Flow Technology, is a pre-design software for complete hybrid rocket engines. The calculations of the software are validated with experimental data from ground tests at the DLR site Trauen (Germany) and numerical simulations of the inner flow and combustion with the DLR TAU-Code. The submodule SHAKIRA (Simulation of High-test peroxide Advanced Catalytic Ignition system for Rocket Application) of the software AHRES calculates the decomposition process inside the catalytic chamber of a hybrid rocket engine [1, 2].

For the optimal design of catalytic chambers to achieve the best performance, the unsteady flow in the cold start phase is very important. One option of the software is to design a monopropellant engine, which will reach the full thrust after the cold start phase, while a hybrid rocket engine requires a defined temperature to ignite. This temperature can be achieved during the cold start phase, but most mathematical models for the design of catalytic chambers consider the steady-state flow conditions only.

To overcome this shortcoming, a particle-based mathematical model is proposed. It contains a one-dimensional approximation of the flow with heat transfer in the chamber wall and the catalytic material. It is designed for packed bed reactors with spherical granulated catalytic materials and is customized for high-test peroxide as fluid.

With such an improved model [3], the unsteady flow in the cold start phase can be analyzed. The temperature increase over the time and the mass fraction of the chemical components are useable for a better understanding of the process inside and a precise design of new catalytic chambers with an improved functionality.

References

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