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# NUMERICAL SIMULATION OF THE TRANSITION PROCESS IN A HYBRID ROCKET MOTOR

**Abstract**

A hybrid rocket uses both a liquid and a solid as propellants. In the typical classical hybrid system, the fuel is a solid and the oxidizer is a liquid. Because of its inherent distinguishing advantages, such as safety, simplified throttling and shutdown, grain robustness, propellant versatility, low cost, high reliability, and nontoxicity, hybrid rocket motors have been studied and developed over decades."Beihang-3 (BH-3)", which is a hybrid rocket designed and built by graduate students from School of Astronautics in Beihang University, i.e. Beijing University of Aerodynamics and Astronautics, has a transition process during the whole flight trajectory. The mass flow of oxidizer is changed after the first three seconds to achieve the suitable thrust. This makes it very different from "BH-2" sounding rocket. The main objective of this paper is to predict the detailed combustion and aerodynamic characteristics of the transition process of "BH-3", using a comprehensive, physics-based mathematical model. The two-dimensional unsteady code is used to simulate the transition process. The governing differential equations include the continuity, momentum, energy, and chemical species equations. Regarding the blowing effect, the low Reynolds number k-$\varepsilon$ model is employed. 90% hydrogen peroxide (HP) and Hydroxyl terminated polybutadiene (HTPB) are chosen as propellants. HP is assumed to be decomposed to be water vapor and oxygen. HTPB is then considered to be pyrolysed to be 1,3 butadiene. The combustion of the gasified solid fuel is represented by gas phase chemical reaction equations consisted of nine species, thirteen elementary reactions. It follows the Arrhenius law. The results show that the proposed comprehensive mathematical model can successfully predict the characteristics of the field of the transition process. The simulation results are in good agreement with the test data. Furthermore, the numerical analyses are conducted on different cases, and the effects on the combustion flow fields of these factors are obtained, which can be very beneficial for the design of hybrid rocket motors.