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NUMERICAL SIMULATION OF GRAIN'S DYNAMIC REGRESSION PROCESS FOR N2O/HTPB HYBRID ROCKET MOTORS

Abstract

Hybrid rocket motors using nitrous oxide (N2O) in combination with Hydroxyl-Terminated Polybutadiene(HTPB) based fuels have been of high interest for several years, due to their high safety, good controllability and non-toxic characteristics. For these motors, grain design is one of the most crucial elements which have deep influence on their performance. However, it is relatively difficult to obtain detailed information about how the designed grain evolves through testing technique. Therefore, a numerical method was developed here to simulate the dynamic regression process of the grain in a N2O/HTPB hybrid rocket motor. In this method, the diffusion combustion is described by a global chemical kinetics, combined with turbulentκ-ε model and the eddy-dissipation model. The regression rate is determined by both an energy balance at the burning surface and an Arrhenius-type expression (r=Aexp(-E/RTs)), which comes from conductive-heating fuel pyrolysis experiments. Moreover, in order to make each point at the burning surface regress independently with time, dynamic meshes with control algorithm was adopted as well. Finally, in order to verify the method above a small-scale N2O/HTPB hybrid motor was built up. It consists of pressurized system, liquid-N2O tank, injector, combustion chamber with grain, nozzle and etc. The motor was tested and the measured data was compared with its simulation results, especially the grain's surface profile in the end. From the comparison, it shows that method established is reliable and accurate enough. Furthermore, as this method is based on fundamental physics instead of motor-specific correlations, it is applicable to many different hybrid rocket configurations and will benefit their grain design and optimization.