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EXPERIMENTAL INVESTIGATION OF DIFFERENT PROPELLANTS AND EXPANDABLE GRAPHITE ADDITIVES FOR CONTROLLING ROCKET MOTOR THRUST

Abstract

Controlling rocket thrust may be done via propellant burning rate catalysts and enhancers. This paper presents an experimental investigation on manipulating the thrust of hybrid and solid motors by adding a small fraction of expandable graphite within the binder matrix. Expandable graphite is a form of intercalated graphite flakes, which upon heating change their appearance to elongated fibers/strings of substantially larger length and volume. A parametric study has been carried out to demonstrate how different types of EG combined with different propellant/binder formulations influence the burning rate. Expandable graphite types included a range of initial particle/flake size (from 100 to 500 micrometer) with different temperature of onset of expansion (from 150 to 300C). The propellant fuels/binders included polyester, HTPB, and paraffin wax. Earlier studies indicated that the addition of 5wt% of a specific type of EG (particle size 100-150 micrometer, onset of expansion at 200-230C) within a polyester grain in a hybrid motor, doubled the fuel regression rate, hence noticeably increasing the motor thrust. Exposing an EG-containing polyester slab to a flame revealed EG strings sticking out from the hot surface, thus increasing heat transfer to the bulk of the fuel, explaining the major increase in regression rate. On the other hand, the more flexible nature of HTPB caused the EG strings to lay on the surface, explaining the lesser effect on the burning rate. In solid propellants the effect of EG additive on the burning rate was dependent on the temperature of the initial expansion of the EG. For an effective influence, it had to relate to the burning propellant surface temperature. The crumbling of the surface layer due to EG swelling affected the burning rate as well via the increase in effective surface area. Combustion details have been demonstrated by high-speed video movies. The overall conclusion is that expandable graphite additive is an effective means for controlling the motor burning rate and thrust, and the specific EG and fuel/propellant combination can be tailored to yield optimal results.