ACTIVATION OF MICROMETRIC ALUMINUM-METAL OXIDES MIXTURES BY MECHANICAL MILLING

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Metals are widely used in space propulsion to increase rocket performance. Nowadays the most used metal in this field is micrometric aluminum (μAl) since it is stable, available, cheap and non-toxic. However, μAl is also affected by different drawbacks such as difficult ignition and tendency of its particles to stick together forming burning droplets of melt metal (agglomerates). These problems cause a depletion of real performance evaluable in about 10% of the ideal gravimetric specific impulse [1]. A strong reduction of performance losses is obtainable using new energetic materials such as nanoaluminum (nAl) and activated aluminum (aAl). Substitution of μAl with nAl has proven to be very interesting from the performance point of view. In fact, high specific surface of this kind of powder enhances its reactivity assuring an increment of burning rate and decreasing condensed combustion product size. Unfortunately, active metal content of Al powders decreases progressively when particles tends to become nanometric, consequently reducing the ideal specific impulse; moreover nAl is responsible for a progressive increment of uncured compound viscosity related with the amount of embedded powder [2]. Another way to reduce losses is to activate μAl; since the powder is kept micrometric, it maintains a higher metal content with respect to nanopowders contemporarily reducing manufacture problems. The main task is to enhance powder reactivity increasing the specific surface and/or coating particles with proper substances. Mechanical activation through high energy ball milling has proven to be suitable both for ignition temperature and activation energy reduction [3].

This work proposes a characterization of new activated powders obtained by mechanical milling. Standard space grade μAl with 30 μm spherical shape particles is mixed with metal oxides and activated in a centrifugal ball mill. Metal oxide selection is based on the study of free Gibbs energy and equivalent thermite theoretical enthalpy of reaction. Various milling time and metal to oxide ratio have been considered. Resulting powders are characterized in terms of particle size, morphology, composition, ignition temperature, and active aluminum content. Particle size is measured through a laser granulometer in order to analyze the effects of ball milling while SEM is used to obtain information on morphology and superficial behavior of activated powder particles. Active metal content has been computed measuring H_2 evolution consequent to the insertion of activated powders in a NaOH-water bath. Finally, powder reactivity in air at 1 bar is obtained exploiting ignition test at high heating rate (300 K/s) through a proprietary hot wire technique.

References

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