COMBUSTION ANOMALIES IN SOLID ROCKET PROPELLANT

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Solid rocket propulsion systems present a well known and high reliable technology hugely employed since several decades in space applications.
Even if this technology has already received and still receives great attention, some aspects still show a lack of knowledge; one of these areas concerns anomalies of the propellant steady burning rate.
The hump effect consists in a difference between the actual burning rate and the predicted one with the common trend of a lower pressure at the initial and final portions of the pressure vs. time history and a higher pressure at the mid-web [1]. This kind of ballistic phenomena have been investigated in the past leading to exclude both the length-to-diameter ratio and web thickness of a motor as causes of the problem [2]. Previous research activities have pointed out that, due to the non-Newtonian behavior of the propellant slurry, manufacture and casting processes greatly affect this anomaly [3].
Ammonium Perchlorate (AP) particles orientation is dependent on the manufacture/casting procedure. In fact pouring the propellant slurry in a mandrel-in-place mold generates AP particles alignment along region of high shear stress, producing a certain pattern of the propellant. On the contrary, plunging the mandrel inside the propellant already poured tends to totally destroy the original orientation of the casted propellant, thus reducing the hump effect [4].
The orientation of the AP crystals has a direct influence on the burning rate, thus on the hump effect. Indeed the thermal conductivity of AP crystals is much higher than the thermal conductivity of the binder, so crystals orientation influence the thermal sensitivity of the propellant, increasing its local burning rate [5]. Aluminum particles do not show any influence on this anomaly.

References

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