EUCASS 2013

Abstract

FP7 HISP program: Selection of reference missions and definition of propellant requirements

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The aim of the HISP project is to develop a high performance solid propellant with a specific impulse similar or higher than MMH/NTO, and about 10% higher compared to AP/Al/HTPB. This will be achieved using the following high energy density materials Ammonium dinitramide (ADN), Glycidyl azide polymer (GAP), Aluminium hydride (AlH_3) or aluminium (Activated ,nano)

The first task was to select suitable reference missions and to define propellant requirements. The propellant requirements identified will guide the propellant development in the project to select a suitable formulation.

The three reference missions selected were:

- Upper stage of Vega launcher
- Apogee/deorbitation motor
- Mars ascent vehicle

Based on ADN and GAP and an energetic fuel (Aluminium or Alane), two "Ideal" propellants were defined. Their potential performance increases were quantified in respective mission and some of their required properties were identified. The most important properties are:

- Burning rate
- Mechanical properties
- Specific impulse

The first mandatory point is to be able to obtain a propellant with a basic burning rate in the range of 7 to 15 mm/s at 7 MPa. This range could probably be extended for some applications when high acceleration can be accepted.

The second prerequisite is to obtain a propellant with good mechanical properties, at least of the level of classical HTPB propellants, to enable a case bonded grain. For space applications end burning grain will also be a common situation even if relatively low burning rate propellants are achievable, so an axis of work would be to look for propellant with mechanical properties much better than the current one so to be able to realize full bonded end burning grain and to avoid complex and heavy systems of internal insulation.

These requirements satisfied, the only important parameter is the level of practical specific impulse. With the formulations understudy the performance gain could be dramatic with a potential increase up to more than 30% of the payload of the Vega Launcher by replacing only the propellant of the third stage. For a Mars Ascent vehicle the saving on the lift-off mass could be also impressive but in such an application (launcher of small size) to obtain compatible burning rate level is of first importance and a more detailed system analysis has to be performed.

Note: The gain on reference missions were be studied using design tools and trajectory codes (earth to orbit or trajectory from Mars to a Rendez-vous orbit) or ΔV analysis. This implies not only propulsion system design but the complete spacecraft must be taken into consideration. The computational design tools to be used in the work include an in-house model, for solid rocket motor design (SOME), an in-house model for liquid rocket engines (PLISE), and a computer code PERFOL for trajectory calculations developed by the company SISOP for The Inner Arch