SPACE PROPULSION SYMPOSIUM (C4)
Propulsion System (2) (2)

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CHARACTERIZATION OF THE BALLISTIC PROPERTIES OF THE NOVEL ALAN-7 SOLID ROCKET PROPELLANT

Abstract

A novel ammonium nitrate based solid rocket propellant, named ALAN-7, has been recently developed by Delft Aerospace Rocket Engineering (DARE), an amateur rocket organisation of Delft University of Technology students. The goal of DARE is to design, build and launch amateur rockets and to give students the opportunity to apply the knowledge obtained during their study by building rockets, thus giving members hands-on experience with space projects.

The ALAN-7 propellant formulation consists of ammonium nitrate as an oxidizer, aluminium as fuel and a polymer binder system. It is optimized for achieving the highest altitude with the least amount of propellant, and fulfils all requirements on mechanical strength and usability by a student association.

During a preliminary test campaign on the ALAN-7 propellant, it was found that this new propellant has a performance comparable to commercially available alternatives. However, at the same time, it is safer to use and produces less toxic exhaust gases. In order to use this propellant in a rocket motor, the next step is represented by the determination of its ballistic characteristics and, in particular, its regression rate as a function of the chamber pressure. Although some standardized test methodologies (such as the so-called "strand burner" test) are available to this respect, they are not always able to accurately reproduce the operating conditions in a rocket motor. For this reason a dedicated test apparatus, called Ballistics Evaluation Motor (BEM), has been developed during the final M.S. thesis of the first author. The BEM consists of a reusable casing, a pyrogen igniter and a replaceable nozzle, and is equipped with all the necessary systems to enable safe operations.

The paper will illustrate the main outcomes of a test campaign conducted on the ALAN-7 propellant in the BEM test apparatus. In particular, it has been demonstrated that the test stand allows for safe, fast and easy testing of propellant formulations and geometries under realistic rocket motor conditions, although there is still room for improvements of the setup. By applying a Non-Parametric Burn-rate Estimation (NPBE) method, the ballistic characteristics of the propellant have been obtained. It has been found that the ALAN-7 propellant is characterized by moderate regression rates within a suitable pressure range. However, it has also been found that the pressure exponent of ALAN-7 is relatively high, which may lead to complications in the design of solid rocket motors using this kind of propellant.