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SPACE PROPULSION SYMPOSIUM (C4)
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DEVELOPMENT OF A NEW-GENERATION AMMONIUM NITRATE-ALUMINUM PROPELLANT FOR THE STRATOS II ROCKET

Abstract

After breaking the European altitude record for experimental rocketry with the Stratos I rocket in March 2009, its creators, students of Delft Aerospace Rocket Engineering (DARE) set a new goal: to reach space with a student-built rocket. The first step to that goal is the Stratos II rocket, which will bring a scientific payload to an altitude of 50km and return it safely to earth. As the performance of the propellant previously used by DARE is insufficient to achieve this objective, a new solid rocket propellant needs to be developed, with the following requirements:

- Specific impulse >185s [sea level];
- Non-toxic, environmentally non-hazardous constituents and reaction products;
- High mass density;
- No High Energetic (HE) components, to reduce the risk of detonation;
- Cost <50 euros/kg.

The first part of the research consisted of mainly theoretical study for the most effective, safe, and amateur-friendly propellant. The result was a composite propellant with ammonium nitrate (AN) as oxidizer, aluminum powder as fuel, an epoxy binder, and several burn rate modifiers. This propellant was called Alan-5. Simulations for this propellant predicted a high performance: a characteristic exhaust velocity (c*) of 1464m/s, yielding a theoretical specific impulse (at a pressure expansion ratio of 30) of 226s. The atmospheric and pressurized burn tests showed the formulation to be promising. However, they also revealed problems characteristic of other AN-based propellants, namely poor ignitability, low regression rate, hygroscopicity, and surface oxidation [Olthof et al, 2010]. Therefore, new variations of the propellant were investigated. As a result, a new ammonium nitrate/aluminum propellant formulation, with greatly improved burn behavior and good mechanical properties, was developed.

This paper describes the process leading to the final propellant formulation. Firstly, the theoretical study of alternative binders and burn rate modifiers is detailed. This is followed by atmospheric burn test results, from which the formulation for the next generation propellant, Alan-7, was selected. Subsequently, atmospheric burn-tests were conducted, from which the performance coefficients (c*, a, n) were verified. Using these coefficients, a small-scale motor was produced in order to determine the specific impulse that can be attained with the propellant. Additionally, small-scale motor tests were conducted to gather information about the type of materials and techniques necessary for making a full-scale Alan-7 motor. Based on the outcomes of these tests, a motor for the Stratos II rocket will be produced, powerful enough to attain the goal of the project.