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DEVELOPMENT OF A SOLID PROPELLANT TO ACCOMPLISH THE GOAL OF REACHING SPACE BY A STUDENT-BUILT ROCKET

Abstract

Following the success of Stratos I, the rocket that broke the European amateur altitude record in March 2009, its designers at Delft Aerospace Rocket Engineering (DARE) began looking for new challenges. As a result, DARE has committed itself to the goal of designing, building, and launching a rocket capable of bringing an object into Space. All of the rocket's components, even the motors and propellant, will be designed and built by students. The performance of the propellant previously used by DARE will not suffice for this goal. Therefore, the development of a new high-performance, amateur-friendly, and safe solid rocket propellant has begun.

Propellant requirements:

- Specific impulse $>$ 185 s [sea level, ISA]
- Low sensitivity to shock, impact, heat
- Non-toxic, environmentally non-hazardous constituents and reaction products
- Easy to manufacture, without specialized tools.
- Cost $<$ 50 euros/kg.

The first part of the propellant development is mainly theoretical. A thorough literature study was performed to identify and analyze the propellants that have been used by amateur rocket enthusiasts so far. This was followed by a trade-off between possible oxidizers, fuels and binder systems. The most promising oxidizer, fuel and binder system were chosen and combined into a working propellant composition. After that, some catalysts were added to ensure a stable burning behavior. This composition was then analyzed using propellant performance prediction software, to find the optimum ratio of constituents. A first, theoretical prediction of performance characteristics like burning temperature and exhaust gases was made as well. Finally, a suitable manufacturing method is elaborated.

The second part of the propellant development is the test phase. First, some samples of the propellant are produced and tests are performed to study the atmospheric burning behavior of the propellant as well as its mechanical properties. Following this, a test device, the so-called "two-inch bomb" is designed and manufactured in order to study the high-pressure burning behavior of the propellant. From the pressurized burn tests, values for the burn rate coefficient and exponent can be determined, which are inputs needed to design a motor for the propellant. If the results of all tests are satisfactory, a classification test is performed, so that the propellant is given an official UN number, and can be manufactured and transported according to regulations.