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Author: Mr. Kacper Kaczmarek
Students Space Association, Warsaw University of Technology, Poland, kacper.kaczmarek3.stud@pw.edu.pl

Mr. Mateusz Krasuski
Students Space Association, Warsaw University of Technology, Poland, mateusz.krasuski2.stud@pw.edu.pl
Mr. Maciej Michałów
Students Space Association, Warsaw University of Technology, Poland, maciej.michalow.stud@pw.edu.pl
Mr. Arthur Pazik
Students Space Association, Warsaw University of Technology, Poland, arthur.pazik@gmail.com
Mr. Nezar Sahbon
Students Space Association, Warsaw University of Technology, Poland,
nezar_ammar_miloud.sahbon.stud@pw.edu.pl
Mr. Piotr Umiński
Students Space Association, Warsaw University of Technology, Poland, uminakpl@gmail.com
Mr. Piotr Rodo
Students Space Association, Warsaw University of Technology, Poland, piotr.rodo.stud@pw.edu.pl
Mr. Mateusz Sochacki
Warsaw University of Technology (WUT), Poland, msochacki@meil.pw.edu.pl

APOGEE OPTIMISATION OF A HYBRID SOUNDING ROCKET

Abstract

Sounding rockets can have various objectives, which can include reaching the highest possible velocity or an altitude within certain bounds. In order to best fulfil said mission objective, certain performance parameters must be either theoretically, or experimentally investigated.

The Students' Space Association at Warsaw University of Technology has been developing the Twardowsky hybrid sounding rocket for Spaceport America Cup, an international student rocketry competition. The main competition objective is to reach an apogee as close to a predefined one as possible. An additional objective of the Twardowsky rocket is to deploy scientific experiments in the form of CanSats. In the following paper, the approach to apogee optimization utilized by the Students' Space Association for the purpose of fulfilling the competition requirements by the Twardowsky rocket will be presented.

The hybrid rocket engine used to power the Twardowsky rocket was designed in such a way that allows it to reach an altitude much higher than the one predefined by the competition rules. Changes needed to reduce the total impulse delivered would require the structure of the engine to be modified, which would in turn require additional funding and effort. Bounded by the manufacturing technologies used, the fuel grain geometry made of HTPB is also not suitable for changes.

The only parameter of the propulsion system that can be adjusted right before the launch is the amount of the oxidizer (nitrous oxide) taken on board. It results in changing the total impulse delivered by the engine. Thanks to this characteristic of a hybrid engine, it is possible to perform a single-parameter optimisation aimed at reaching the predefined apogee. This process is simpler and more cost-effective than introducing structural changes to the engine itself.

The main software used to determine the apogee reached is an in-house-developed six-degrees-of-freedom flight simulation program — SKA Rocket Flight Simulation (SKA RFS). The required aerody-

namic parameters were determined through a CFD simulation campaign conducted in Ansys® Fluent 2020R2. The engine performance parameters were also determined using an in-house-developed program — SKA Rocket Propulsion Analysis Tool (SKA RPAT).

Within this paper an optimisation of the Twardowsky rocket apogee will be conducted. Several cases will be investigated with different oxidizer mass in each. After calculating the engine performance using SKA RPAT, mission profiles will be determined using SKA RFS. Thanks to this, an optimal amount of the oxidizer for the desired apogee will be chosen.