52nd IAF STUDENT CONFERENCE (E2)
Student Team Competition (3-GTS.4)

Author: Mr. Michal Zawadzki
Politecnico di Torino, Italy

Mr. Orlando Nardo
Politecnico di Torino, Italy
Mr. Emir Topakci
Politecnico di Torino, Italy

A MODERN APPROACH TO DESIGN AND OPTIMISATION OF THE CAVOUR SOUNDING ROCKET FINS SET

Abstract

The topic of the presentation is the design and optimisation strategy used to develop the fins set of the Cavour sounding rocket, made by students of Politecnico di Torino. The mission of the rocket was to accurately reach an apogee of three kilometres, independently of location and weather conditions. One of the key steps to achieve this goal was a detailed analysis and alleviation of an aeroelastic phenomenon observed during transonic velocities called fin flutter. As a result of the analysis, the team was required to further optimise the joining arc - the component that connects the fins with the body tube of the rocket.

Fins are flat structures extending from the body of a rocket to provide stability during flight. The Cavour rocket has removable fins which are more complex to design than epoxied fins. However, they offer multi-mission capability and are easily replaceable in case of any structural damage. Cavour's fins are made of Onyx polymer reinforced with continuous carbon fibres. The distribution and orientation of the fibers were chosen based on fin flutter analysis to minimise effects on the rocket's stability.

The joining arcs connect the four fins to create a unique assembly directly inserted into the rocket's body tube. The arcs need to be stiff enough to withstand the stresses from the fins and the motor to which they are attached. A topology optimization workflow has been utilized to achieve optimal stiffness and weight, followed by a static and modal analysis to ensure that the joining arcs do not resonate with the fins. Based on the results of the performed analyses, the team proposed an innovative design approach. The joining arcs were 3D printed with Onyx polymer reinforced with continuous carbon fiber near the contact surfaces with the fins.

It was found that the proposed configuration fulfilled the requirements established by the previous analyses which was confirmed by three successful launches. The modal analysis showed that natural frequencies of the joining arcs with high participation factors should significantly differ from those obtained from the analyses of fin flutter. This result has been experimentally confirmed during three successful launches. The assembly remained rigid, and the mounting place of the fins assembly didn't affect the performance of the fins.

The work performed by the student team was recognized by the jury of the Spaceport America Cup 2023, and the team received the Dr. Gill Moore Award for Innovation.