

SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
Small Launchers: Concepts and Operations (7)

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NUMERICAL INVESTIGATIONS ON THE AERODYNAMICS OF SHEFEX-III LAUNCHER

Abstract

SHEFEX (**SH**arp **E**dge **F**light **EX**periment) is a hypersonic research project initiated by German Aerospace Center (DLR) in 2002. The objective of this project is to investigate the hypersonic flight techniques with a re-entry vehicle launched by a sounding rocket. The first two experiments (SHEFEX-I and SHEFEX-II) were already conducted in 2005 and 2012, respectively. Currently, DLR is preparing the third experiment (SHEFEX-III). The SHEFEX-III launcher developing together with Brazil is planned to apply the hot separation technique for Stage 1/2 separation, which is different from the first two flights utilizing the cold separation supported by a spring mechanism.

The hot stage separation approach is to drop the consumed lowest stage directly by igniting of the upper stage motor. Usually, once the lowest stage is burning out, its thrust drops rapidly but can still support control forces, then the second stage is ignited and the two stages will be disconnected at almost the same time. Thereafter the staging is driven by the second stage motor: it exhausts gases into the inter-stage volume, which can form a high pressure region ahead the top of the first stage that pushes it away, and it also supplies thrust accelerating the upper-stage. To vent the exhaust gases from the continuing stage motor, it is planned to apply a kind of lattice inter-stage structure on the SHEFEX-III launcher.

The presence of the interstage adapter with open configuration and the procedures of hot stage separation cause serious aerodynamic problems. In this work the aerodynamic behaviors of SHEFEX-III launcher during boost flight and at the beginning of stage separation are investigated with the DLR Navier-Stokes code TAU: the aerodynamic characters of the rocket with and without lattice inter-stage structure are compared; the flow topology in the interstage region is analyzed; additionally the flow field of the rocket during the igniting process of the continuing stage motor is studied too. The igniting processes with different plume deflectors, which are set on the top of the first stage to guide the plume of continuing stage, are also simulated to help to design a compact interstage section. All the efforts are to support the developing work of SHEFEX-III launcher, especially for the design of a reliable staging procedure and the separation mechanisms.