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STATUS OF THE EVALUATION OF THE VINCI ROCKET ENGINE OXYGEN CHILL-DOWN WITH COMETE THERMAL-HYDRAULIC SOFTWARE.

Abstract

The chill-down phase is critical in the operation of cryogenic rocket engines, and this is particularly true for an upper stage, since any loaded fuel used to chill-down the engine is lost and does not contribute to the performance of the launcher.

The chill-down phase involves complex unsteady two-phase flows and a strong thermal coupling between the propellant and the engine components. In order to simulate this phase with the required accuracy, and to assess both its duration and the propellant consumption, ArianeGroup and its partner CEA have developed a simulation tool (COMETE) based on a co-simulation algorithm between the thermal-hydraulic code CATHARE developed by CEA and the mecano thermal code Samcef (Siemens Industry Software).

The CATHARE code, widely used for design and safety analyses in nuclear power plants, is used here to solve the complex Hydrogen and Oxygen two-phase flows observed during the rocket engine chill-down. Meanwhile, the Samcef code solves the thermal evolution of complex 3D parts such as the engine turbo-pumps and regenerative circuits of the combustion chamber. Both codes communicate with each other during the simulation through a strong coupling algorithm. CATHARE is currently being further developed for ArianeGroup application by CEA.

In the recent months, a particular effort was put on the computation of the chill-down of the LOX circuit of the Vinci® engine in order to improve again the prediction capability of the COMETE model. Chill-down simulations were run for the Oxygen turbo-pump of the Vinci engine in the "ground configuration" of the P4.1 test facility, and the results were compared to the available measurements and data, showing good agreement. At last, simulations were run in the "flight configurations" of the chill-down before the first and second boost of the engine (including in micro-gravity conditions).