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NUMERICAL MODELLING APPROACH FOR THE DEVELOPMENT OF AN ORBITAL-SCALE HYBRID PROPULSION ENGINE

Abstract

HyPrSpace has developed a novel orbit-capable hybrid propulsion system with a simplified and compact design, delivering versatile engines that can complete an array of objectives. The company's first full-scale demonstrator called Terminator, is a 100kN-class engine (Φ1m x 6m) and serves as a stepping stone for the development of our orbital rocket engines. This work presents the global numerical methodology adopted at HyPrSpace for guiding the Terminator engine sizing and subsequent engine developments.

The strategy has been to split the efforts between two numerical models established and validated with state-of-the-art research of solid-fluid rocket engine combustion and further verified with full-scale engine static fires. Fine flow dynamics and combustion of this engine were studied with a commercial CFD software. The focus was emphasized on modeling interactions between surface chemistry of the solid fuel and gas, and the contribution of soot radiation on fuel surface incident heat flux throughout the length of the engine. In parallel, a 0D/1D chemical equilibrium hybrid engine code called HEAT (Hybrid Engine Analysis Tool) has been developed to provide fast predictions of sizing choices while retaining key physics. The CFD and HEAT results were continuously compared and demonstrated close agreement regarding average regression rates and engine chamber pressures. Numerical replication of experimental results found in the literature has been part of the process for the validation of both codes and cross-code verification has also been performed. The outcome is an established numerical strategy allowing both highly accurate physical modeling of our hybrid engine and propulsion-system-wide parametric studies retaining essential engine phenomenon.

Key words: hybrid rocket engine, numerical modelling, orbital launcher, soot radiation