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Title

Design of the regenerative cooling system for a 4kN LOX/Ethanol student-built liquid rocket engine

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Abstract

PERSEUS is a European project led by students and operated by CNES, the French space agency. The aim is to allow students to engage in space related activities and gain valuable experience that will train them prior to beginning their professional activities in this sector. In this context, the Supaero Space Section technical club of ISAE SUPAERO is involved in the design of the next generation LOX/Ethanol liquid rocket engine MINERVA to be used in the sounding rocket ASTREOS 2 under development.

The design of a regenerative cooling system is a building block within the vision of launcher reusability laid out by CNES as part of the evolutions of the Astreos student-built rocket. To carry out this vision, a cooling channel design and optimization tool has been developed with the objective to minimize the pressure losses while keeping the combustion wall temperature under the maximum allowable value and the coolant bulk temperature below saturation. In fact the main technical challenge is to maintain the coolant below its critical heat flux limit and preserve its heat absorption capability. 1D heat transfer has been assumed using hot gas convection and radiation, wall conduction and coolant convection. To account for nucleate boiling of the ethanol, a two-phase convective heat coefficient is computed along the channel and critical heat is calculated using peer reviewed correlations in the literature [1,2]. Hot gas and coolant thermodynamic properties were estimated using the NASA RocketCEA and CoolProp libraires respectively [3,4]. Conservation of mass, momentum and energy of the coolant was guaranteed by implementing the 1D Navier-Stokes equations. It is the objective for this tool to be used generically within PERSEUS based on chamber dimensions, propellants and target engine performance.

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