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Author: Dr. Jens Fridh
Royal Institute of Technology (KTH), Sweden, jensa@kth.se

Dr. Jan Östlund
GKN Aerospace Engine Systems, Sweden, Jan.Ostlund@gknaerospace.com

CONJUGATED HEAT TRANSFER MEASUREMENTS WITH METHANE IN ROCKET NOZZLE COOLING CHANNELS

Abstract

A propulsion system using hydrocarbons, liquid or hybrid is a challenge for today's rocket and space propulsion systems. It is of strategic importance that the industry and academia develop necessary knowledge of the heat transfer characteristics and material degradation at relevant operating conditions. Here the focus is on methane in gas phase as a coolant for rocket nozzle walls of sandwich structure. Before combustion the fuel is lead through cooling channels in the rocket nozzle. Methane undergoes thermal decomposition at high temperatures that leads to coking of cooling channels, which is affected by the amount of nickel in the surrounding material. This investigation focuses on nickel-alloy steels and typical cooling geometries used in the rocket nozzle where the methane is in gas phase. A combination of conjugate heat transfer calculations and experiments in a dedicated test rig at KTH, Sweden is performed in order to characterize methane's impact on the nozzle cooling characteristics in terms of heat transfer, coking and pressure loss. In the viable design finally chosen for the test rig, the methane can be pre-heated from 273 to 655 K at pressure levels between 10 to 200 bars and enters the final heater that simulates the heat load from the flame-side with electric cartridges heating a well-insulated copper block. The heat flux is between 1 to 7 MW/m2 for cooling channel flows representative to the ETID nozzle. The design and commissioning of the test facility were presented at the Space Propulsion conference in Seville 2018. This paper focuses on the initial measurement outcomes using methane of 99.95