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Characterization of a Single Injector GH_2-LO_2 for a 20 bar Cryogenic Chamber Test Facility

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Abstract

Now a days high performance liquid propellant rocket engines for transfer into orbit and space exploration have well-established cryogenic propellant combinations like liquid oxygen/gaseous hydrogen (LOX/GH2), due to their high specific impulse. In order to tackle complete combustion in rocket engines, the chamber temperature and pressure in LREs must be higher, which may exceed by far the safe operation temperature of all conventional liner materials currently in use. Wide range of heat fluxes are incident on the combustion chamber and the nozzle walls. To deal with such heat fluxes, different cooling techniques were employed, out of which a combination of film cooling and regenerative cooling are found to be effective one. The current study involves the numerical analysis of a rocket engine thrust chamber with a single coaxial injector which uses gaseous hydrogen as the fuel and liquid oxygen as the oxidizer with the help of CFD software package FLUENT. For the

GH2/LOX turbulent flame, the obtained results are compared with results from literature to verify the model and the numerical scheme. However a separate analysis is carried out to determine the optimum regenerative coolant mass flow rate and coolant initial temperature and it was found that the temperature of the combustion chamber outer wall reduces to an average value of 560 K. Therefore, in the present analysis, the outer wall temperature is taken as 560 K to bring in the effects of regenerative cooling of combustion in a typical film cooled cryogenic rocket engine thrust chamber considering the combustion of the fuel, heat transfer through the chamber walls and the fluid flow simultaneously.

Keywords: Computational fluid dynamics , Cryogenic rocket engine Combustion chamber, regenerative cooling, Film cooling.

INTRODUCTION

Hydrogen is considered as the most economic fuel in cryogenic rocket engine system because of its several advantages, when compared with hydrocarbons. It is because of its safety in transport, storage as well as high energy content.Two major research groups in Europe namely ONERA in France and DLR Lampoldshausen in Germany had experimentally investigated the CH4/O2 flames and H_2/O_2 flames:. Both ONERA's Mascotte test facility and the DLR's M3 combustion chamber test facility which initially were developed for experimental investigations of liquid oxygen/gaseous hydrogen combustion (LOx/H2) have been modified to allow for the study of LOx/CH4. In their studies, pressure ranges from 0.1 to 5.5MPa, the injection temperature for LOx is 85K, and for liquid CH4 it is 125K, hence both