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CHARACTERIZATION OF SUPERCRITICAL PROPERTIES IN ATOMIZATION AND SPRAY CHARACTERISTICS OF A FUEL CENTRED PINTLE INJECTOR IN A 10KN REGENERATIVE COOLED PRESSURE FED ENGINE USING LIQUID METHANE AS FUEL

Abstract

Liquid Methane has shown good promise as an alternate option to rocket fuel currently in use today. Better specific impulse than RP-1 and higher density than liquid hydrogen makes Methane – Lox combination suitable for future rocket booster engines. The main objective of this paper is to study the effect of the super-critical properties in atomization and spray characteristics of a fuel centered pintle injector in a 10kN regenerative cooled pressure fed engine. Methane when used as the regenerative coolant, will be in super-critical phase during injection into the combustion chamber. Super-critical phase of methane will enter the combustion chamber at a higher velocity, posing a problem in the zone of effective mixing with liquid oxygen in pintle type of an injector. This requires careful modelling of fluid properties, which in turn will greatly affect the atomization, droplet size and mixing. GERG- 2004 equation of state is used to calculate the fluid properties and a modified direct numerical simulation model is adapted to simulate the injector flow field for various momentum ratios. An experimental injector is developed and experiments with cryogenic nitrogen and helium as stimulants are carried out at same conditions considered in numerical simulations. The effect of momentum ratio is studied by varying the fuel and oxidizer injection velocity. The results of numerical simulation are compared with the experimental values and it is found to be satisfactory. Based on the results a semi empirical design methodology is developed for the further improvements. The detailed results are outlined in the full paper.