INVESTIGATION OF HEAT TRANSFER CHARACTERISTICS OF KEROSENE BASED NANOFLUIDS

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By

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ABSTRACT

The study intends to explore the potential application of employing kerosene based nanofluids in regenerative cooling channels of semi-cryogenic rocket engine for augmenting the heat transfer. Alumina nanoparticles and Graphene Nano Platelets (GNP) are dispersed in kerosene to prepare kerosene based nanofluids. Thermo-physical properties of the nanofluids are estimated and their convective heat transfer characteristics are investigated in turbulent flow regime using simulated experiments to evaluate the augmentation in heat transfer in coolant channels. Various combinations at different particle concentrations are analyzed to ascertain the relative effectiveness of nanofluids for nozzle cooling application. The study also brings out appropriate surfactants and its optimized quantity in conjunction with the effective techniques for mixing for the preparation of a highly stable nanofluid.

In the current study, kerosene-alumina nanofluid is prepared and characterized with varying particle loadings of 0.05vol% to 1.0vol%, in steps, for two different catalogue particle sizes of 13 nm and 50 nm. Oleic acid, as a surfactant, is found to be suitable to stabilize kerosene-alumina nanofluid and an optimum surfactant to particle volume ratio is determined for enhanced stability of nanofluid. Particle size measurement using Dynamic Light Scattering (DLS) technique and thermal conductivity measurement using Transient Hot Wire (THW) method is used to determine the stability of nanofluid with time. Subsequently, heat transfer studies show significant increase in thermal conductivity and viscosity of kerosene-alumina nanofluid with particle loading. Maximum enhancement of 33% in thermal conductivity and 22% in viscosity is observed for 13 nm particle size nanofluid at 1.0vol% particle concentration at room temperature. Higher thermal conductivity and viscosity of nanofluid at elevated temperature for nanofluids with smaller size nanoparticles, indicates significant role of particle Brownian motion in nanofluid.

Experimental investigation of turbulent convective heat transfer behaviour of nanofluid is determined using horizontal circular test section configuration in a closed loop test setup. The effects of particle size, volume fraction and Reynolds number on convective heat transfer performance and pressure drop are determined using a uniformly heated test section. Heat transfer performance of the nanofluid is evaluated based on identical Reynolds number, Peclet number, velocity and constant pressure drop conditions. The experimental results reveal that the heat transfer properties of kerosene-alumina nanofluid are significantly high as compared to pure kerosene. Higher heat transfer coefficient is noticed for larger particle size nanofluid as compared to smaller size though the measured thermal conductivity is higher for lower particle size nanofluid. The observed trend is corroborated with the hypothesis of boundary layer disruption caused by bigger sized particle during flow of nanofluids. The experiments also highlight the significant role of Prandtl number in convective heat transfer of nanofluids. A homogeneous fluid correlation which accurately predicts heat transfer coefficient and pressure drop for nanofluids is also presented in the work.

Further in the study, stable kerosene-GNP nanofluids at 0.005, 0.02, 0.05, 0.1, 0.2 weight percentage (wt %) and specific surface area (SSA) values of 300, 500, 750 mm^2/g are prepared using ultrasonication and steric stabilization technique. Oleylamine is found to be the suitable surfactant for the maximum stability of nanofluid. Similar to the kerosene-alumina nanofluid, augmentation in thermo-physical properties are found for higher SSA kerosene-GNP nanofluid. 23% enhancement in thermal conductivity and 8% increase in viscosity at room temperature are observed for 750 SSA, 0.2 wt% kerosene-GNP nanofluids. The study shows only marginal effect of temperature on the thermal conductivity of kerosene-GNP nanofluid as compared to kerosene-alumina nanofluid. The behaviour observed is attributed to the percolation mechanism related heat transfer phenomenon in kerosene-GNP nanofluid. Experimental study on convective heat transfer performance of the nanofluids at turbulent flow regime show significant improvement in heat transfer performance of kerosene-GNP nanofluid as compared to pure kerosene. Higher enhancement convective heat transfer coefficient is observed for higher SSA nanofluid. Correlations for friction factor and Nusselt number are determined using experimental data. Merit number which is used to determine the total heat transfer performance shows the utility of these nanofluids as heat transfer fluids.

The current study clearly brings out the method of synthesis of stable kerosene-alumina and kerosene-GNP nanofluid and their augmentation in enhanced thermo-physical properties. Detailed experiments carried out to understated the influence of various parameters on thermal performance of kerosene based nanofluid gives immense scope and advantage for the potential use of these nanofluids as a coolant in the regenerative channels of semi-cryogenic engine thrust chamber which could lead to significant payload advantage.