Experimental and Numerical investigation of Heat transfer enhancement using Al_2O_3-Ethylene Glycol/Water Nanofluids in Straight Channel

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Abstract- A study of computational fluid dynamics has been conducted to study the characteristics of the heat transfer and friction factor of Al_2O_3/Ethylene glycol-water nanofluid flowing in straight channel. The three dimensional realizable k–ε turbulent model with enhanced wall treatment was utilized. As well as were used Temperature dependent thermophysical properties of nanofluid and water. The evaluation of the overall performance of the tested channel was predicated on the thermo-hydrodynamic performance index. The obtained results showed that the difference in behaviour depending on the parameter that has been selected to compare the nanofluid with the base fluid. In addition, the friction factor and the heat transfer coefficient increases with an increase of the nanoparticles volume concentration at the same Reynolds number. The penalty of pressure drop is negligible with an increase of the volume concentration of nanoparticles. Conventional correlations that have been used in turbulent flow regime to predict average heat transfer and friction factor are Dittus-Boelter and Blasius correlations, for channel are also valid for the tested nanofluids which consider that the nanofluids have a homogeneous fluid behave.

Keywords- Nanofluid; Heat transfer; Straight channel; Ethylene glycol; ANSYS FLUENT

1. INTRODUCTION

Using heat transfer enhancement techniques, can improve thermal performance of a tubes. The heat transfer techniques can be classified in to three broad techniques: Passive techniques that do not need external power such as rough surfaces, swirl flow devices, treated surfaces, extended surfaces, displaced enhancement devices, surface tension device, coiled tube and additives such as nanoparticles: Active technique that need external power to enable the wanted flow modification for increasing heat transfer such as electrostatic fields, mechanical aids, jet impingement, suction, injection, surface vibration, and fluid vibration: Compound technique is the mix of two or more of the techniques that mentioned above at one time. There are many applications of heat transfer augmentation by using nanofluids to get the cooling challenge necessary such as the photonics, transportation, electronics, and energy supply industries [1-7].A double tube coaxial heat exchanger heated by solar energy using Aluminium oxide nanofluid presented experimentally and numerically by [8]. Forced convection turbulent flow of nanofluid (Al_2O_3 / water) with variable wall temperature inside an annular tube has been experimentally investigated by [9]. The results shown due to the nanoparticle presence in the fluid the heat transfer has been enhanced. Horizontal double-tube heat exchanger counter turbulent flow studied numerically by [10, 11]. The study has been included both experimental and simulation by FLUENT software. The results showed that significant of the nanofluid in heat transfer enhancement and also, good agreement with other experimental data. The turbulent flow of nanofluids (TiO_2, Al_2O_3 and CuO) with different volume concentrations flowing through a duct under constant heat flux condition with two-dimensional model has been analysed numerically [12]. The effects of nanoparticle volume concentration (1-10% Al2O3) in base fluid of ethylene glycol-water mixture was studied in both numerically and experimentally, where the results showed that with an increase of particle concentration at constant Reynolds number the enhance of heat transfer rate increased considerably [13].

In the current study, the enhancement of heat transfer in the straight square channel is carried out. The CFD analysis by ANSYS FLUENT15 software using the finite volume method is adopted. The heat flux, Reynolds numbers and the Al_2O_3 volume concentration are ($5000 W/m^2$), (10^4-10^5) and (2, 3 and 4%) respectively. The nanofluids of Al_2O_3 dispersed to (60:40%) Ethylene Glycol water are utilized. Results were validated by comparison with experimental data in the literatures.

2. EXPERIMENTAL PROCEDURE

A. Nanofluid preparation