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Experimental investigation of forced convective heat transfer coefficient in nanofluids of Al_2O_3/EG and CuO/EG in a double pipe and plate heat exchangers under turbulent flow

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ABSTRACT

Nanofluid is the term applied to a suspension of solid, nanometer-sized particles in conventional fluids; the most prominent features of such fluids include enhanced heat characteristics, such as convective heat transfer coefficient, in comparison to the base fluid without considerable alterations in physical and chemical properties. In this study, nanofluids of aluminum oxide and copper oxide were prepared in ethylene glycol separately. The effect of forced convective heat transfer coefficient in turbulent flow was calculated using a double pipe and plate heat exchangers. Furthermore, we calculated the forced convective heat transfer coefficient of the nanofluids using theoretical correlations in order to compare the results with the experimental data. We also evaluated the effects of particle concentration and operating temperature on the forced convective heat transfer coefficient of the nanofluids. The findings indicate considerable enhancement in convective heat transfer coefficient of the nanofluids as compared to the base fluid, ranging from 2% to 50%. Moreover, the results indicate that with increasing nanoparticles concentration and nanofluid temperature, the convective heat transfer coefficient of nanofluid increases. Our experiments revealed that in lower temperatures, the theoretical and experimental findings coincide; however, in higher temperatures and with increased concentrations of the nanoparticles in ethylene glycol, the two set of results tend to have growing discrepancies.

1. Introduction

With progresses of thermoscience and thermal engineering, many efforts have been devoted to heat transfer enhancement. Among them, application of additives to liquids is often involved. Since the flow media themselves may be the controlling factor of limiting heat transfer performance, solid additives are suspended in the base liquids in order to change transport properties, flow and heat transfer features of the liquids [1]. The term "nanofluid" is applied to a suspension of solid, nanometer-sized particles in conventional fluids; the most prominent features of such fluids include enhanced heat characteristics, such as convective heat transfer coefficient and thermal conductivity in comparison to the base fluid without considerable alterations in physical and chemical properties. This considerable increase in heat transfer may, under appropriate operational conditions, lead to decreased energy expenditure, decreased raw materials input, reduced size of equipment, and consequently, reduced expenses and increased system efficiency.

So far, due to associated technological problems, the majority of studies on heat transfer of suspension of metal oxides in fluids were limited to suspensions with millimeter or micron-sized particles. Such large particles may cause severe problems in heat transfer equipment. In particular, large particles tend to quickly settle out of suspension and thereby in passing through micro channels cause severe clogging and increase the pressure drop considerably. Furthermore, the abrasive actions of the particles cause erosion of components and pipe lines [2]. Choi [3] was the first to employ the nanometer-sized particles in conventional fluids and showed considerable increase in the nanofluid thermal conductivity. Lee et al. [4] investigated experimentally for the suspension of 4.0% volume 35 nm CuO particles in ethylene glycol and

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