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EMPIRICAL REVIEW ON CAR RADIATOR BY USING NANOFLUIDS

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ABSTRACT

Nanofluid is a new type of heat transfer fluid with superior thermal performance characteristics, which is very promising for thermal engineering applications. In this study, effect of adding nanoparticles to the base fluid (water) in radiator for the purpose of increasing the heat transfer rate. By means of this, thermal efficiency can be improved, then reduction in fuel consumption and decrease in the pollutant emissions. And the thermo-physical properties of nanoparticles are thermal conductivity, specific heat, density, viscosity it can be measured at different volume concentration at various temperature ranges.

Key words: *Nano fluids, Thermal efficiency, Radiator, Heat transfer enhancement*.

INTRODUCTION

The radiator is an important accessory of vehicle engine. Normally, it is used as a cooling system of the engine and generally water is the heat transfer medium. Heat transfer improvement can be made by increasing (i) heat transfer area, (ii) temperature, and (iii) heat transfer co-efficient [1]. However, technologies have already reached their limit for the cases (i) and (ii). Recently many researchers found that dispersing nanosized particles into the liquids result in higher heat transfer co-efficient of these newly developed fluids called nanofluids compared to the traditional liquids [2].

Nanofluids were developed recently by suspending solid particles (ranging from 10 nm to 100nm) in a base fluid, these fluids have displayed better thermal characteristics and exhibited excellent heat transfer properties even at low concentration of nano particles in base fluid.In current era, a large number of experimental investigations are being performed on the properties of nanofluids. Thermal conductivity of metallic and oxide nanofluids was measured for a wide range of particle size and volume fraction as a function of temperature. Metallic nanofluids showed higher enhancements compared with the oxide nanofluids.

THERMO-PHYSICAL PROPERTIES OF NANOFLUIDS

THERMAL CONDUCTIVITY

Since then, many investigations were carried out by a number of researchers on the thermal conductivity of various nanofluids . Lee et al. [3] experimentally studied the mixture of ethylene glycol and CuO nanoparticles of 35 nm size at the concentration of 4.0 vol.% and found a 20% increase in thermal conductivity.

Yu et al. [4] experimentally investigated that, the thermal conductivity of nanofluid strongly depends on nanoparticle volume concentrations and it increases nonlinearly with the increase of volume concentration and the enhanced thermal conductivity was found to be 26.5% at 5.0 vol.% concentration.Duangthongsuk and Wongwises[5] experimentally investigated that the TiO_2–water nanofluid offered 3–7 % higher thermal conductivity than base fluid for 0.2 to 2.0 vol.% of TiO_2 nanoparticles.

Maxwell model [6] was used to determine thermal conductivity of the nanofluid

$$=K_L \times \frac{K_S + 2K_L + 2(K_S - K_L)\Phi}{K_S + 2K_L - (K_S - K_L)\Phi} K_{nf}$$

VISCOSITY

Viscosity of nanofluids is a parameter as crucial as thermal conductivity for the thermal performance investigation. Therefore, minimization of viscosity is also a critical factor in addition to the augmentation of thermal conductivity.Nguyen et al. [7] experimentally investigated the effect of volume concentration and temperature on the dynamic viscosity of Al_2O_3–water nanofluid and found that viscosity of the nanofluid considerably increases with the increase of particle volume concentrations, but it decreases with the increase of temperature.Wang et al. [8] investigated the viscosity of Al_2O_3–water nanofluid prepared by mechanical blending with particle size of 28 nm at 5 vol.% concentration and viscosity increased by 86% compared to the base fluid. They also investigated Al_2O_3/ethylene glycol nanofluid and found a 40% increase in viscosity.

$$\mu_{nf} = \mu_w (123\Phi^2 + 7.3\Phi + 1)$$

DENSITY

Density of a fluid is another important thermophysical property.Pak and Cho [9] for the first time, measured the density of Al_2O_3 and TiO_2 with distilled water and found that density of nanofluid increases with the increase of nanofluid.

$$\rho_{nf} = \Phi\rho_p + (1 - \Phi)\rho_w$$

SPECIFIC HEAT

To study the energy performance, specific heat of nanofluid must be determined.The specific heat of nanofluids depends on different parameters such as type, size and volume concentration of nanoparticles and base fluids at different temperatures.

Pak and Cho [9] first reported that the specific heat of Al_2O_3– water and TiO_2–water nanofluids decreases with the increase of particle volume concentration. Vajjha and Das [10] measured the specific heat of three nanofluids containing Al_2O_3, ZnO and SiO_2 nanoparticles. They also discovered that the specific heat value decreases as the volumetric concentration of nanoparticles increases but the specific heat of those nanofluids increases with the increase of temperature.

$$(\rho c_p)_{nf} = \Phi(\rho c_p)_p + (1-\Phi)(\rho c_p)_w$$

Where,

Φ- volume concentration

ρ_p-Density of nanoparticles

ρ_w-Density of water

ρ_{nf}-Density of nanofluids

K_L=Thermal conductivity of water

K_s=Thermal conductivity of nanoparticles

K_{nf}=Thermal conductivity of nanofluids

μ_w=Dynamic viscosity of water

μ_{nf}=Dynamic viscosity of nanofluid

NANOFLUIDS IN RADIATORS

Peyghambarzadeh et al. [11] tested a car radiator using Al_2O_3/water based nanofluids. The volumetric concentrations were varied in a range of 0.1-1%. A maximum heat transfer enhancement up to 45% at 1% volumetric concentration was recorded.Hussein et al. [12] tested TiO_2 and SiO_2 water based nanofluids in a car radiator under laminar flow regime. Volumetric concentration and fluid inlet temperature was changed in a range of 1-2% and 60-80 C. Maximum enhancements of

11% and 22.5% in comparison with pure water were obtained for TiO_2 and SiO_2 nanofluids respectively.

Elias et al. [13] reported findings about thermal conductivity, viscosity, specific heat and density of Al_2O_3 nanofluids in water and ethylene glycol used as coolant in car radiator. Volume concentration and coolant temperature were kept up to 1% and 50C respectively. Viscosity, thermal conductivity and density of the nanofluids were found to increase whereas specific heat of nanofluid was found to decrease with increasing volumetric concentrations.

Peyghambarzadeh et al. [14] tested a car radiator for CuO and Fe_2O_3 water based nanofluids at three volumetric concentrations of 0.15, 0.4 and 0.65%. Reynolds number was varied from 50 to 1000 and coolant inlet temperature was changed from 50 to 80 C. Both nanofluids showed a 9% increase in overall heat transfer coefficient compared with water. Naraki et al. [15] reported experimental results for CuO/water nanofluids tested under laminar flow regime in a car radiator. Volumetric concentration was varied from 0 to 0.4% and inlet temperature was changed from 50 to 80 C. An 8% increase in overall heat transfer coefficient compared with water was reported for 0.4% vol. nanofluids.

Choi [16] reported a study regarding fuel saving in automobile by the use of nanofluids and they reported to have heat transfer enhancement by more than 10% at 0.5 vol.% of 2 nm gold nano particles.Xie et al. [17] reported heat transfer enhancement using nanofluids of Al_2O_3, ZnO, TiO_2 and MgO with a mixture of water and ethylene glycol of 55% and 45% respectively. Al_2O_3, MgO and ZnOnanofluids showed superior increment in heat transfer compared to TiO_2 nanofluids.

EXPERIMENTAL SETUP

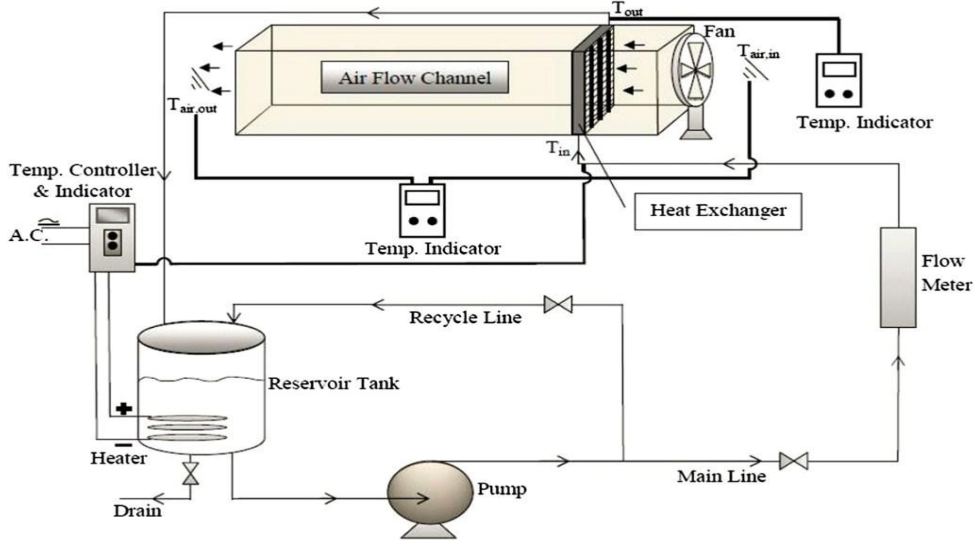
The schematic of experimental system used in this research includes flow lines, a reservoir tank, two heaters, a centrifugal pump,flow meter, a forced draft fan, an air flow channel, a temperature controller, four thermocouples and a cross flow heat exchanger. The test section is a cross flow heat exchanger (an automobile radiator) which was installed inside the air flow channel. Nanofluid passes through the vertical tubes with stadium-shaped cross section. The fins and the tubes are made with aluminum.For cooling the liquid, a forced draft fan (Techno Pars 1400 rpm) which is capable of adjusting the air flow speed from low to high, was installed close and face to face to the radiator at the beginning of the air flow channel and consequently air and water have indirect cross flow contact and there is heat exchange between hot water flowing in the tube-side and air across the tube bundle.

The pump gives a constant flow rate of 0.6 m^3/h, the flow rate to the test section is regulated by appropriate adjusting of a globe valve on the recycle line. The working fluid fills 35% of the reservoir tank whose total volume is approximately 20:l (height of 30 cm and diameter of 30 cm).

The total volume of the circulating liquid is constant in all the experiments. Five layer insulated tubes (Isopipe 0.75 in diameter) have been used as connecting lines and covered with glass wool to reduce heat loss to the surrounding.

A flow meter (Technical Group LZM-15Z Type) was used to control and manipulate the liquid flow rate with the precision of 0.006 m^3/h. For heating the working fluid, two electrical heaters (6000 W) and a temperature controller were used to vary the temperature between 40 and 80 C.

Four RTDs (Pt-100U) were implemented on the flow line to record air flow and radiator fluid inlet and outlet temperatures. The temperatures from the thermocouples were measured by four digital multimeters, SU-105PRR, SAMWON ENG, with an accuracy of 0.1 C.



CONCLUSION

This review paper shows clearly about the thermo-physical properties of the nanofluids and the theoretical calculation to find the heat transfer rate of the radiator, Nanofluid preparation and experimental setup of the system. Finally that the overall heat transfer coefficient of nanofluid is greater than that of conventional fluids and therefore the total heat transfer area of the radiator can be reduced.

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