Performance Investigation of a Heat Exchanger using Nano-fluid

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Abstract

In many applications, micro-channel heat exchangers are primarily used, but researchers are actively trying to find new ways to increase the rate of heat transfer. Because of their excellent heat transfer efficiency, nano-fluids have become an appeal for micro-channel tubes that are known to fall under the classification of small and lightweight equipment. Liquids with the intervention of nanoparticles are commonly used in these lines as warmth bearer to increase the heat transfer rate of hot fluids as well as conductivity can also be extended by some techniques. In the present study, the performance evaluation of micro-channel heat exchanger using titanium oxide nano-fluid has been done and is also compared with water with variable flow rates and resulted in significant improvement in the heat transfer coefficient which has been achieved using the nanofluid as compared to that of distilled water.

Keyword: *Nanofluid, Nanoparticles, Heat Transfer*

1.1 Introduction

A heat exchanger is a thermal system that is used to exchange heat between two or more substitutes, with a high boundary between the fluids to avoid mixing. They are used in fields such as the electronics sector, the space sector, the chemical industry, etc. A nanoparticle is referred to as such particles which have a diameter of at least less than 100 nm. In several fields, nanoparticles are currently used, such as the electronic chip industry, optics, medical research, etc. Electronic chips are the most important item found in today's developing world. These chips play a major role, starting from a small alarm clock to a tank. Since these chips generate a lot of heat, a cooling agent or coolant is required. Therefore, these devices were invented to cool down the nanofluids to eliminate any risks. The nanoparticle demonstrates a phenomenal spike in the nanofluid's thermal conductivity when blended with a fluid basis. Be that as it might, precisely calculated single-stage heat movement coefficients will determine two-stage coefficients of heat movement.

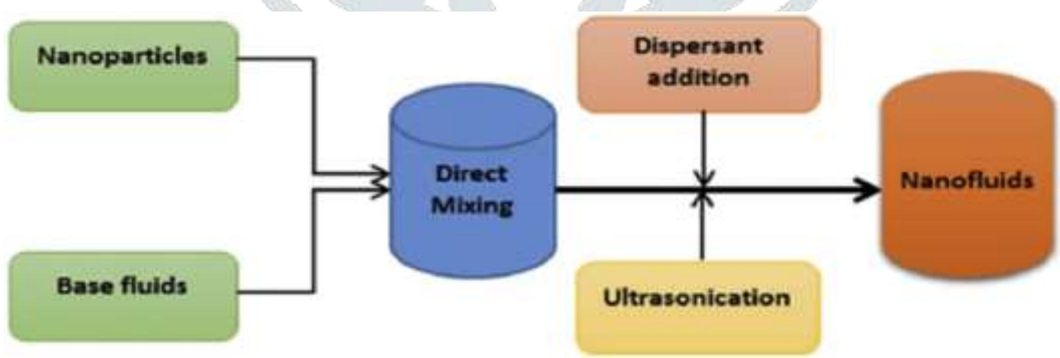

Fig. 1 Nano-fluid preparation using the two-step process

1.2 Literature Review

Taylor et al. [1] found tentatively that by utilizing nano-liquid of Al_2O_3- H_2O (0.01 % vol. conc.) framework execution is upgraded by 10.12 %. Yousefi et al. [2] investigated the effect of functioning liquid Al_2O_3-H_2O on the warm characteristics of a sun-powered gatherer with a level plate. As per their tests, by using 0.2 percent volume grouping of Al_2O3 nanofluid as contrast and water as working liquid, the gatherer efficiency increases by 28.3 percent. Meibodi et al. [3] tentatively suggested that with the mass stream intensity, the efficacy of level plate sunlight-based gatherer with SiO_2/ethylene glycol (EG)-H_2O nano liquid increases. The effect of CuO and water nano fluid on the warm action of a sun-based gatherer level plate was tentatively observed by Jabari Moghadam et al. [4]. In their analysis, in the water working liquid, 0.4 percent volume portion of nanoparticles were used, while the mass stream rate was 1-3 kg for each min. Polvongsri and Kiatsiriroat[5] included silver nano liquid in a sun-based gatherer level plate. Their exploratory findings revealed that silver nano liquid improves the warm appearance of the sun-oriented gatherer of the level plate when the upgrade is more at gulf temperature. The results of TiO_2 and H_2O nanofluid as a working liquid on a small sun-powered level plate collector were tentatively investigated by Chaji et al. [6]. They performed trials using nanofluid TiO_2 and H_2O and 15.7 percent increase in sun-based authority efficacy found In order to determine the ability to prepare a solar collector heat exchanger that can produce the desired yield temperature, Fezal et al. [7] tested various nanofluids. As per its performance, the best yield is given by Copper Oxide (CuO), Titanium Oxide (TiO_2) and Alumina (Al_2O_3). In functional terms, however, nanofluids (CuO and Al2O3) are the best heat flow solutions.

1.3 Experimental Setup and Methodology

The scale of the plate is (100 mm x 555mm) where the square channel (1.5 mm x 1.5 mm) has been sliced to follow the mini-channel heat exchanger requirements (3 mm x D_h > 20 μm). Aluminum is the material of the selected plate since the weight of aluminum is half that of copper for equivalent thermal conductivity and it is comparatively less costly. Pump, four-way valve, arduino, mini-channel plate setup

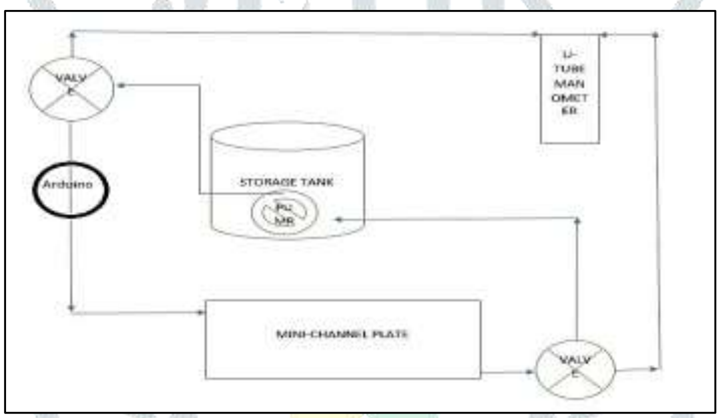

Fig. 2 Experimental Setup

In the case of nano-fluid, a tank in which fluid is contained and pumped is built in order to flow the fluid and minimize aggregation. The fluid flows through the arduino-passing tubing, which gives the flow rate per hour in cubic meters. It reaches the four-way valve after Arduino, where the flow is diverted in two directions, including the U-tube manometer and the Micro-channel panel. By using a heating unit, the mini-channel plate is heated to 40^oC. Fluids now leave the other segment to draw heat from the mini-channel plate and travel through the four-way valve and are redirected again in two ways, including the U-tube manometer and the storage tank. The pressure differential between the mini-channel plate inlet and outlet is measured using the U-tube manometer C. Working fluid (4 cubic meters) is made to flow into the aluminum plate channel that is completely sealed with tempered glass from the storage container. The flow is regulated by the ball valve and then passes through the flow sensor to calculate the pressure differential around the plate by the four-way valve in which one attachment goes to the aluminum plate and another to the U-tube manometer. Experiment performed with 20 per hour in cubic meters, 28 per hour in cubic meters and 36 per hour in cubic meters. Temperatures at inlet and outlet are measured by digital thermometer and flow rate measured by flow sensor

1.4 Results and Discussion

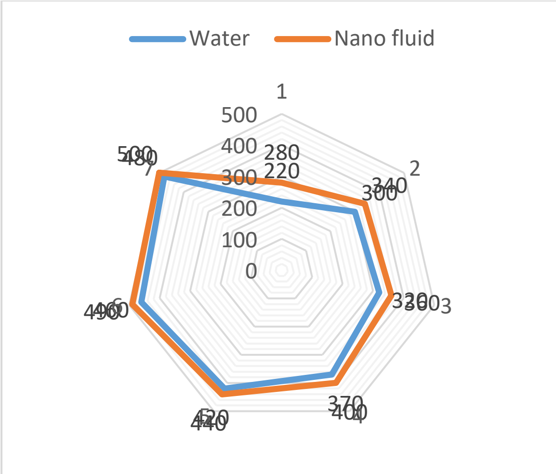

Fig. 3 Pressure Drop v/s Re

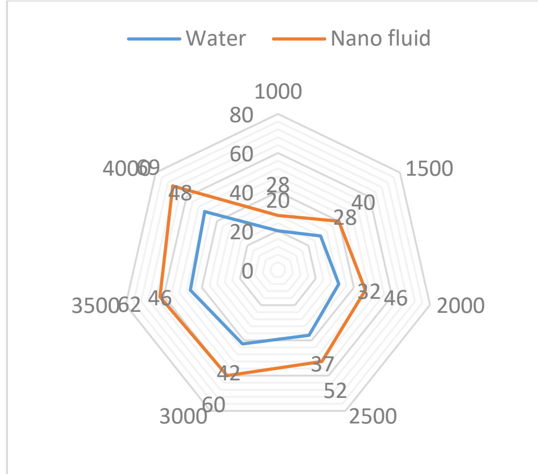

Fig. 4 Nu v/s Re

It has been shown from experiments that the pressure decrease in the nanofluid is more than water because the density of the nanofluid is more than water. It has also been shown that, due tp flow velocity, the pressure drop increases with increases in Reynolds number. It has been found from experimental investigations that the value of Nusselt increases with increases in the Reynolds number since nano particle thermal conductivity is high. Aluminum nano particles are being used in this experiment. The value of Nusselt is often shown to be higher than vapor. It indicates an increased heat transfer rate when nanofluid is used relative to water.

1.5 Conclusions

In this experiment, we have found that when nanofluids are used, there is hike in the heat transfer rate. Also, the thermal conductivity of fluids containing suspended solid metal particles is expected to improve dramatically relative to standard fluids. Compared with distilled water, a major increase in the heat transfer coefficient was obtained using the nanofluid. Because of flow velocity, it has been shown that pressure drop increases with increases in Reynolds number.

References

[1] Taylor RA, Phelan PE, Otanicar TP, Walker CA, Nguyen M, Trimble S, Prasher R. Applicability of nanofluids in high flux solar collectors. Journal of Renewable and Sustain Energy.2011; 3: 023104.

[2] Yousefi, Tooraj, et al., An experimental investigation on the effect of pH variation of MWCNT–H2O nanofluid on the efficiency of a flat-plate solar collector, Sol. Energy 86 (2) (2012) 771–779.

[3] Saleh Salavati Meibodi, et al., Experimental investigation on the thermal efficiency and performance characteristics of a flat plate solar collector using SiO2/EG–water nanofluids, Int. Commun. Heat Mass Transf. 65 (2015) 71–75

[4] Ali Jabari Moghadam, et al., Effects of CuO/water nanofluid on the efficiency of a flat-plate solar collector, Exp. Therm. Fluid Sci. 58 (2014) 9–14.

[5] Sarawut Polvongsri, Kiatsiriroat Tanongkiat, Enhancement of flat-plate solar collector thermal performance with silver nano-fluid, Second TSME International Conference on Mechanical Engineering, Krabi, Thailand, 2011

[6] Hossein Chaji, et al., Experimental study on thermal efficiency of flat plate solar collector using TiO_2 and water nanofluid, Modern Appl. Sci. 7 (10) (2013) 60.

[7] M. Faizal, et al., Energy: economic and environmental analysis of metal oxides nanofluid for flat-plate solar collector, Energy Convers. Manage. 76 (2013) 162–168.