

A REVIEW ON IMPROVEMENT OF HEAT TRANSFER RATE BY PASSIVE METHODS

Moh Shahid Khan¹, Animesh Singhai²

¹MTEch Scholar, Department of Mechanical Engineering, TITR, Bhopal, India

²Professor, Department of Mechanical Engineering, TITR, Bhopal, India

Abstract – Our world has been affected up to a great extent by the worsening global warming phenomenon. Everyone is trying to lower its effects on the environment and to contribute to saving humanity. Optimizing the things that we all are having around us is our duty now. As we know that our life is highly influenced by thermodynamics or thermal energy in one degree or another in every perspective, so it's our duty to utilize the thermal energy in an optimum way. Heat Exchangers are the devices which are used to exchange the heat between two fluids at different temperature in an efficient manner. Since the heat exchangers are widely used in the industries and domestic applications. Our aim is to improve the efficiency of heat exchangers with the help of passive methods. Passive methods are the way to get higher effectiveness just by changes in geometry of the surface and the property of fluids. Corrugated surfaces play a key role in improving the rate of heat transfer. This research work is focused on the work that has been done in this field earlier and the probability of extension on their studies and researches which can be done.

Key Words: Heat Exchanger, Nanofluid, Heat Transfer, Thermal Energy, Effectiveness, Passive Methods, Corrugated Plate.

1. INTRODUCTION

Heat exchanger is a device which is used to transfer heat between two fluids at different temperature either by direct contact or indirect contact with the help of a separating wall made up of a highly conductive material. These are widely used in various industries, vehicles, engines etc and domestic applications as well. Global warming is a phenomenon which has made us realize the need for optimum usage of everything that we have. Every researcher is putting their efforts in the field of energy-saving and finding some ways that we can follow to make it reality. Utilizing thermal energy in an efficient manner is our prime focus here. Heat exchangers have already been one of the most talked topics among the researchers so a lot of work has been done in this field already and this research work is also aimed to acknowledge their efforts in this field.

There are two ways to improve the rate of heat transfer by active methods and passive methods. Active methods need some energy input to achieve higher efficiency and it has limitations to do it whereas passive methods don't need any energy input so researchers are more concerned

about these methods. It has also many constraints but still lots of scope to achieve higher efficiency for heat exchanging process. Technical constraints which are responsible for the improvement in the rate of heat transfer are surface area and overall heat transfer coefficient. Our focus is to study the relations and key features which can improve the rate of heat transfer by improving the heat transfer coefficient.

2. Literature Survey

The performance of heat exchangers may be improved by heat transfer improvement techniques for playing a particular heat-transfer duty. Improvement of the heat transfer allows the scale of the heat exchanger to be considerably shrunken. Many researchers have done their experiments and analysis over the factors which are responsible for improvement of heat transfer rate and the same has been discussed and reviewed here in this section.

Fluids, like water and engine oil, have poor heat transfer performance and so, high compactness and effectiveness of heat transfer systems are necessary to realize the desired heat transfer. Among the efforts for improvement of heat transfer, the applying of additives to liquids is critical [1,2]. The word nanofluid can be defined as a suspension of nano-sized solid particles in typical fluids; such fluids embrace increased heat transfer characteristics, like convective heat transfer. This hefty increase in heat transfer could result in remittent energy expenditure and raw material-input, also reduces the size of the apparatus and consequently reduces expenses and exaggerates system potency.

Primarily Choi [3] used the nanometer-sized particles in the typical fluids and showed improvement in heat transfer characteristics.

The majority of experimental studies on the applying of nanofluids at single-phase forced convective heat transfer are involved with streamline flow principally in outwardly heated circular tubes or micro-channels. Among the varied sorts of nanofluids used, metal oxides with partial volume concentrations are the foremost common, most likely because of their cheaper price [4].

Studies on heat transfer of suspension of metal oxides in fluids were restricted to suspensions with millimeter or micron-sized particles. Such giant particles

could cause severe issues in heat transfer instrumentation. Specifically, giant particles tend to quickly settle out of suspension and thereby passing through micro channels causes severe wearing and increase the pressure drop significantly [5].

Experimental investigation performed on the suspension of 4 percentage volume & 35 nm sized particles of CuO in ethylene glycol resulted in high improvement in the thermal physical phenomenon [6].

The investigation of 35 nm-sized Cu/deionized water nanofluid flowing during a tube with constant wall heat flux showed the improvement in Nusselt number compared to pure water for identical rate of flow by increasing the volume fraction of nanoparticles from 0.5% to 1.2% [7].

In another study, Al₂O₃/water nanofluid heat transfer in streamline flow underneath constant wall heat flux and reported a rise in the nanofluid heat transfer constant with Reynold's number and nanoparticle concentration significantly within the entrance region in which thermal developing length for nanofluid was larger than in case of pure water. **Wen and dingdong [8]**.

The numerical investigation for heat transfer of Al₂O₃/ethylene glycol and Al₂O₃/water nanofluids during a radial flow system showed improvement in heat transfer rate. Conjointly, researchers showed that wall shear stress improved with concentration and Reynold's number [9].

It had been reported by **Putra et al. [10]**, that natural convection heat transfer by applying nanofluid of Al₂O₃/water and CuO/water was not up to the mark as compared to the base fluid and all over that this might result in too many factors like the sinking of nanoparticles and speed distinction between nanoparticles and base fluid.

Thermo-physical properties of CuO nanofluid were measured and investigated the performance of nanofluid and compared it to the base fluid (i.e., water) by **Pantzali et al. [11]**.

The performance of a nanofluid containing carbon nanotubes resulted in improvement of the heat transfer which was observed as 3.5 times higher than the base fluid, which was studied by **Ding et al. [12]**.

Experimentation with Al₂O₃ and TiO₂ as nanofluids along with a shell and tube exchanging device [13] has shown that there's an optimum volume concentration for the maximum value of overall heat transfer coefficient. This optimum value of concentration differs fluid to fluid.

Thermo-physical properties are altered by the addition of nanoparticles, and fluid viscosity and the nature of flow, are the crucial parameters for determining the effectualness of nanofluid [14].

Further, the heat transfer rate and heat transfer constant during a PHE are above those use base fluid [15].

The work on two nanofluids specifically, Al₂O₃/EG and CuO/EG having concentrations 0.1, 0.5, and 1 percent respectively [16] have shown that the heat transfer constant or coefficient will increase with temperature and concentration each.

Al₂O₃/water of 6 volume percentage concentration in a fluid with Reynold's number greater than 100 but lesser than 500, temperature greater than 20°C but lesser than 40°C resulted that the performance of the PHE at a given rate of flow didn't improve with the fluid [17].

Shive Dayal Pandey, V.K. Nema [18]: The effects of nanofluid that is Al₂O₃ in water two, three and four vol.% and water as coolants on heat transfer, resistance losses, and loss of available energy during a counter flow corrugated plate device were by experimentation investigated. The desired properties of the nanofluid were measured. It had been determined that the heat transfer characteristics improve with the increase in Reynolds- and Peclet-number and with the decrease in nanofluid concentration. For a given heat load, the desired pumping power exaggerated with the increase in nanofluid concentration. Each power consumption and heat transfer rates were lower for water as compared to the nanofluid for flow rates of 2–5 LPM for hot and cold fluids. Further, for a given heat load the nanofluid needed a lower rate of flow however suffered a higher pressure drop than that for water.

3. CONCLUSIONS

From the above reviews, it's discovered that the impact of use of Al₂O₃/water nanofluid as an agent on the performance of a plate device (PHE) has not been tried for concentrations not up to 6 June 1944 and so the authors were intended to figure for lower concentrations to seek out if there existed any optimum concentration for this nanofluid during a PHE and build an analysis of available energy for the thought of vary of volume concentration and agent rate of flow for a given heat load.

Mainly researches on heat transfer coefficients are found for an unvarying wall temperature or an unvarying heat flux. The condition of constant wall temperature is idealized in heat exchangers with natural action like condensers. The boundary condition of constant heat flux finds application in electrically heated tubes and nuclear fuel components. However, the case of liquid-liquid heat exchange has not been studied well. In case the use of nanofluid for increasing the heat transfer rate by enhancement of the thermal conductivity of fluid has given better result, but when observed closely then found that there is more drop in fluid pressure from the inlet to outlet that means there is greater resistance to flow due to increase in friction which will damage the walls of the heat exchanger,

so in the long term it will not be good enough where we need to keep our system wear less also.

Shive Dayal Pandey and V. K. Nema improved rate of heat transfer by using Nano Fluid (Al₂O₃ in Water) but having more pressure drop consequently more power consumption and more wear friction factor. N. Putra, W. and Roetzel, S.K. Das showed that natural convection heat transfer by applying nanofluid of Al₂O₃/water and CuO/water was not up to the mark as compared to the base fluid. Also, this might result in too many factors like the sinking of nanoparticles and speed distinction between nanoparticles and base fluid.

REFERENCES

- [1] A.E. Bergles, Recent development in convective heat transfer augmentation, *Appl. Mech. Rev.* 26 (1973) 675–682.
- [2] A.S. Ahuja, Augmentation of heat transport in laminar flow of polystyrene suspension: I. Experimental and results, *J. Appl. Phys.* 46 (8) (1975) 3408– 3416.
- [3] S.U.S. Choi, Developments and Application of Non-Newtonian Flows, vol. 66, ASME FED V.231/ MD-V, New York, 1995, pp. 99–105.
- [4] Xiang-Qi Wang, A.S. Mujumdar, Heat transfer characteristics of nanofluids: a review, *Int. J. Therm. Sci.* 46 (2007) 1–19.
- [5] S. Zeinali Heris, M. Nasr Esfahany, S.Gh. Etemad, Numerical investigation of nanofluid laminar convective heat transfer through circular tube, *J. Numer. Heat Transfer, Part A: Appl.* 52 (2007) 1043–1058.
- [6] S. Lee, S.U.S. Choi, S. Li, J.A. Eastman, Measuring thermal conductivity of fluids containing oxide nanoparticles, *J. Heat Transfer* 121 (1999) 280–289.
- [7] Y. Xuan, Q. Li, Heat transfer enhancement of nanofluids, *Int. J. Heat Fluid Flow* 21 (2000) 58–64.
- [8] D. Wen, Y. Ding, Experimental investigation into convective heat transfer of nanofluids at the entrance region under laminar flow conditions, *Int. J. Heat Mass Transfer* 47 (2004) 5181–5188.
- [9] S.J. Palm, G. Roy, C.T. Nguyen, Heat transfer enhancement in a radial flow cooling system using nanofluids, in: *Proceeding of the ICHMT Inter. Symp. Advance Comp. Heat Transfer, Norway, CHT-04-121, 2004.*
- [10] N. Putra, W. Roetzel, S.K. Das, Natural convection of nanofluids, *Heat Mass Transfer* 39 (8) (2003) 775–784.
- [11] M.N. Pantzali, A.G. Kanaris, K.D. Antoniadis, A.A. Mouza, S.V. Paras, Effect of nanofluids on the performance of a miniature plate heat exchanger with modulated surface, *Int. J. Heat Fluid Flow* 30 (2009) 691–699.
- [12] Y. Ding, H. Alias, D. Wen, R.A. Williams, Heat transfer of aqueous suspensions of carbon nanotubes (CNT nanofluids), *Int. J. Heat Mass Transfer* 49 (1–2) (2006) 240–245.
- [13] B. Farajollahi, S.Gh. Etemad, M. Hojjat, Heat transfer of nanofluids in a shell and tube heat exchanger, *Int. J. Heat Mass Transfer* 53 (2010) 12–17.
- [14] M.N. Pantzali, A.A. Mouza, S.V. Paras, Investigating the efficacy of nanofluids as coolants in plate heat exchangers (PHE), *Chem. Eng. Sci.* 64 (14) (2009) 3290– 3300.
- [15] M.H. Fard, M.R. Talaie, S. Nasr, Numerical and experimental investigation of heat transfer of ZnO/water nanofluid in the concentric tube and plate heat exchangers, *Therm. Sci.* 15 (1) (2011) 183–194.
- [16] A. Zamzaman, S.N. Oskouie, A. Doosthoseini, A. Joneidi, M. Pazoouki, Experimental investigation of forced convective heat transfer coefficient in nanofluids of Al₂O₃/EG and CuO/EG in a double pipe and plate heat exchangers under turbulent flow, *Exp. Therm. Fluid Sci.* 35 (3) (2011) 495–502.
- [17] Y.H. Kwon, D. Kim, C.G. Li, J.K. Lee, D.S. Hong, J.G. Lee, S.H. Lee, Y.H. Cho, S.H. Kim, Heat transfer and pressure drop characteristics of nanofluids in a plate heat exchanger, *J. Nanosci. Nanotechnol.* 11 (7) (2011) 5769–5774.
- [18] S.D. Pandey, V.K. Nema, Experimental analysis of heat transfer and friction factor of nanofluid as a coolant in a corrugated plate heat exchanger, *Experimental Thermal and Fluid Science* 38 (2012) 248–256.