A Review on Experimental Study of Heat transfer using Nanofluids in Double-pipe Heat exchanger

Krishna R. Patel[1] Prof. S.M. Bhatt[2] Sejal Patel[3]
[1]M.E Student [2]Professor [3]Lecturer
[1,2,3]Department of Mechanical Engineering
[1,2]Sal Institute of Technology and Engineering Research, Ahmedabad
[3]Government Polytechnic, Himmatnagar

Abstract— Nanofluids, suspended particles in base fluid have been paid wide attention due to its superior thermos physical properties compare with conventional fluids. The enhancement in heat transfer using these nanofluids is very surprising and become an interest of researchers. This paper presents an exhaustive review of this studies of heat transfer in nanofluid in double-pipe heat exchanger. This review and suggestions could be useful in theoretical and experimental studies in the area of heat exchanger and its application.

Keywords: Nanofluid, Double-pipe heat exchanger, Heat transfer, thermal conductivity

I. Introduction

A. Nanofluid:

Transfer of heat energy is widely used in industrial processes. Heat transfer can be done by conduction, Convection and Radiation. There are many thermal systems are used for heat transfer purpose. In that systems for enhancing the heat transfer some methods are used like using of extended surfaces(fins), dimensional changes of some parts of thermal systems, using vibration method and using micro channels for cooling. But due to their limitations a new concept is used for enhancing the heat transfer which is Nanofluid. Nanofluid, suspension of metal or non-metal Nano-sized particles into the base fluid, named by Argonne National Laboratory (ANL), USA. [1] Water, ethylene glycol or oil can be used as a base fluid. Nanofluids have variety of applications like, chemical industries, Environmental, Pharmaceutical, Bio-chemical, heat transfer application in mechanical engineering, and Electrical cooling systems, etc.

B. Heat exchanger:

Heat exchanger is a device, which transfers the heat from hot fluid to cold fluid, by direct or indirect contact. Heat exchangers are widely used in industrial processes for heat transfer, like Cooling of oil, Refrigeration and Air-conditioning, cryogenics, heat recovery systems, automobile engineering, manufacturing processes, power industries, nuclear systems, fossil boilers, steam condensers, cooling towers, and food industries, etc. There are wide range in heat exchanger. A double pipe heat exchanger consists of one pipe placed concentrically inside another of larger diameter pipe to direct the flow from one section to the next. A double pipe heat exchanger is a low cost, which increase reliability by restricting mixing of two fluid for exchanging heat.

Double-pipe heat exchanger classified as follows:

1) Parallel flow type double-pipe heat exchanger
2) Counter flow type double-pipe heat exchanger

Nowadays, Heat exchangers in heat transfer using Nanofluids is very popular for application in industries. In this paper, we studied about Double-pipe heat exchanger using different kind of metal based Nanofluids. And studied the papers of enhancement of heat transfer using nanofluids.

II. Reviwed Pappers

[2] The first paper we have reviewed is, "An Experimental Study of Counter Flow Concentric Tube Heat Exchanger using CuO / Water Nanofluid", International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181, Vol. 2 Issue 6, June – 2013.

An experimental study is carried out to investigate the effect of nanofluid used in counter flow concentric tube heat exchanger. The heat transfer co-efficient and friction factor is investigated under turbulent flow regime. Also, the effect of mass flow rate of cold fluid and hot fluid the heat transfer co-efficient had investigated. The test section had inner tube made of copper with 9.35 mm inner diameter and outer tube made of stainless steel with 33.5 mm diameter. The Cuo nanoparticles prepared by wet chemical method.

The experimental results following data are investigated.

1) Effect of mass flow rate of cold fluid on overall heat transfer co-efficient
2) Effect of Reynolds number on Nusselt number of nanofluid using different correlations
3) Effect of mass flow rate of cold fluid on convective heat transfer co-efficient
4) Effect of mass flow rate on effectiveness

It is concluded that the heat transfer co-efficient in the range of 3.45- 9.5% is increased due to usage of CuO/water Nanofluid instead of conventional fluid say water. The heat transfer co-efficient is increase with increase of mass flow rate. Friction factor of water and nanofluid is approximately same under turbulent flow conditions.

[3] The second paper we have reviewed is, "Heat transfer enhancement in a double-pipe heat exchanger using nanofluids", Proceedings of the 17th ISME Conference ISME17, October 2015, IIT Delhi, New Delhi, ResearchGate.

An experiment had conducted in a double-pipe heat exchanger using Cuo, Mgo, ZnO nanofluids at different volume concentration. The heat transfer co-efficient, Nusselt number and overall heat transfer co-efficient are estimated for different mass flow rate of cold water. Results are compared with base fluid water. In a double-pipe heat exchanger, the diameter of inner pipe is 0.625 inch made from mild steel and the diameter of outer tube is 1.5 inch made from steel. Device is composed of 2 sections in series. The length of each section is 1 meter.

The experiment did with Cuo, MgO, ZnO nanofluids of volume concentration 0.05% and 0.1% respectively. It is concluded that at particle volume concentration of 0.05% Cuo nanofluid is overall heat transfer co-efficient 2286.95 W/m^2

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K and for water is 1398.48 W/m^2 K for 0.0727 kg/s mass flow rate, which is 62% more than water's overall heat transfer co-efficient.

[4] The third paper we have reviewed is, "Water to Nanofluids heat transfer in concentric tube heat exchanger: Experimental study", ELSEVIER, Procedia Engineering 51 (2013) 318 – 323

In this paper, an experimental setup is conducted of concentric tube heat exchanger for water to nanofluid with various volume concentrations. Here the overall heat transfer co-efficient was found out using Al_2O_3 nanofluid with volume concentration of 2-3%. In this work the thermal performance of concentric tube heat exchanger using nanofluids based coolants is examined. And the study covered thermal conductivity and convective heat transfer coefficient based performance of concentric tube heat exchanger using nanofluid. Thermal conductivity is very important factor in convective heat transfer, since lower thermal conductivity of heat transfer fluids restrict cooling and heating performance and it is increased by nanofluids. The Al_2O_3 nanofluid is prepared by two step method. For the preparation of this nanofluids with different concentration, the alumina Nano powder was dispersed in water with the help of sonication. And then alumina powders were added to double distilled water act as base fluids. Then it is dispersed by magnetic stirring. The suspension was then homogenized by the use of a high intensity ultrasonic system. For alumina water suspensions and sonication was employed for 2 hours. The test section made of tube side 6 mm diameter and outer side pipe diameter is 16 mm. Length of the tube is 1000 mm. Nanofluids flow inside the inner tube and hot fluid flows in annulus side.

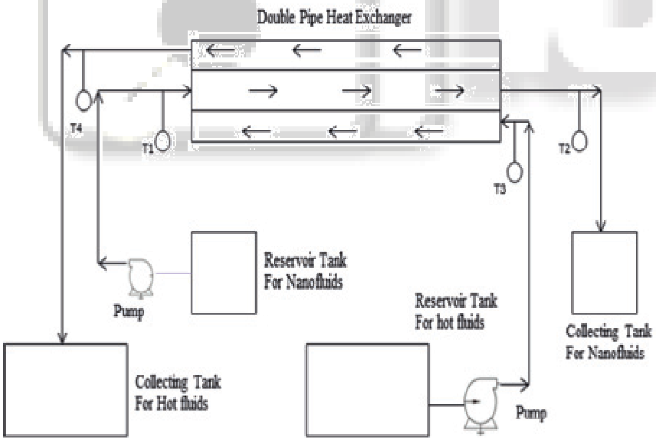

Fig. 1: Experimental setup of concentric tube heat exchanger [4]

It is concluded that from the results it is found that heat transfer co-efficient of Al_2O_3 nanofluid of 3% volume fraction is 16% greater than the water for same flow rate. And the greatest thermal conductivity of this nanofluid was found for 0.075% volume fraction with compare to water.

[5] The fourth paper we have reviewed is, "Analysis of heat exchanger with Nanofluids", International Journal of Core Engineering & Management (IJCEM) Volume 1, Issue 6, September 2014, ISSN: 2348 9510

An experiment is performed to analyze the performance of counter flow heat exchanger using nanoparticle with coolant. The iron nanoparticles are used with variation of 0-2.0% of volume fraction with base fluid. The main aim of this paper is to found out that whether the use of nanofluids improves the performance of heat exchangers and at what percentage of Nanoparticles-coolant mixture the performance of counter flow heat exchanger obtain maximum heat exchange rate and at what percentage the performance deteriorates. There are methods for analysis of heat exchanger mentioned here are the logarithmic temperature difference method and NTU (number of transfer units) method. Results are obtained from numerical analysis. And it is shown that heat transfer co-efficient is increased by 10%, 14% and 16% by iron nanofluids with volume fraction of 0.05%,1.0& and 1.5% respectively.

[6] The fifth paper we have reviewed is, "Experimental study on the effect of TiO_2 –water nanofluid on heat transfer and pressure drop", Experimental Thermal and Fluid Science 42 (2012) 107–115

In this article, it is studied that increasing the heat transfer at various equipments used in microelectronics, industry and transportation etc. becomes a problem for researchers and engineers. Conventional fluids say water and oil have poor thermal properties that restricted the heat transfer performance compared to the solids. Some conventional methods are available to increase heat transfer rates and reduce the size of the heat transfer thermal systems. Suspending small solid particles, size of millimeter and micrometer in the normal fluids is a method that is used many years ago. Some problems occurred by use of these types of fluid. For example, poor stability of the suspension of these particles, clogging, and high erosion and pressure drop in pipelines observed. About a period ago, with the rapid development of nanotechnology, particles of nanometer-sized (commonly between 1 nm and 100 nm) are used into the conventional fluid called Nanofluid, used to increase in heat transfer of thermal systems. This heat exchanger consists of two concentric tubes, inner copper tube of diameter 8.18 mm and outer diameter 9.48 mm with total length is 128.8 cm. The total heated length of tube is 98.8 cm. It is mentioned that for creating a fully developed turbulent flow at Reynolds number of 51,000, the required length of the tube is 22 cm.

In this experimental work, TiO_2 nanoparticles (30 nm) suspended into the water is used for examine the effect of heat transfer characteristics on heat exchanger with the use of a horizontal double tube counter flow heat exchanger and TiO_2 nanofluid of 0.002 and 0.02% of volume fraction with Reynold number between 8000 to 51000.Changes in Nusselt number is also investigate at lower Reynold number as well as at greater than 30,000.

It is concluded form the work that by increasing the Reynolds number or by increasing the nanoparticles volume fraction, the Nusselt number increases. All nanofluids have a higher Nusselt number compared to distilled water. By use the nanofluid at high Reynolds number greater than 30,000 more power is consumed in compare with low Reynolds number needed to compensate the pressure drop of nanofluid, while increases in the Nusselt number for all Reynolds numbers are approximately equal. Therefore, it is not beneficial of using nanofluids at high Reynolds numbers compared with low Reynolds numbers. From series of experiments it is shown that the maximum thermal performance factor of 1.8 is found with the simultaneous use of the TiO2–water nanofluid with 0.02% volume and at Reynolds number of 47,000.

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III. FUTURE SCOPE OF WORK

In Future, study can be done for better characteristics of nanofluids for advanced engineering designs based on various research works. Advancement of theoretical equations and co-relations for properties of nanofluids can be explored. The effect of different types of nanoparticles with same size on heat transfer and friction characteristics of nanofluids can be taken up for further study.

Comparison of effect of different nanoparticles with same size and shape, with fixed surface area, and at same temperature can be taken as a future study.

Comparison can be done of pure metal and their oxide form nanoparticles for enhancement of heat transfer, with the help of their properties, in the study of heat exchanger performance can be investigated.

IV. CONCLUSION

From the review of these papers it is shown that by using of nanofluids heat transfer enhancement can be done compare with conventional fluids say water or oil. The heat transfer co-efficient is increased by increasing of mass flow rates of various volume concentration of Nanofluids. By using the information about preparation of Nano fluid and results from experimental work using these nanofluids, experiments will be conducted on heat Exchanger by using nanofluids for enhancement of heat transfer. Comparison of effect of different nanoparticles with same size and shape with fixed surface area and at same temperature on heat exchangers can be studied. Comparison of effect pure metal and their oxide form nanoparticle on effect of heat transfer can be investigated by these gathered data.

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