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A Review on Heat Exchanger Using Nano Fluid

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Abstract
Recently, many researchers have focused on their studies on the analysis of nanofluid flows due to their participation in the enhancement of heat transfer rates in industrial processes. The ordinary fluids, such as water, mineral oils, and so on, are known for their low thermal conductivity in heat transfer processes. The significant applications in the engineering field explain why so many investigators have studied heat transfer with augmentation by a nanofluid in the heat exchanger. This article presents a review of the heat transfer applications of nanofluids to develop directions for future work.
Keyword: Nanofluids, Heat transfer enhancement, Heat exchanger

I. Introduction

A heat exchanger is a device used to transfer heat between two or more fluids. Heat exchangers are used in both cooling and heating processes. The fluids may be separated by a solid wall to prevent mixing or they may be in direct contact. They are widely used in space heating, refrigeration, air conditioning, power stations, chemical plants, petrochemical plants, petroleum refineries, natural-gas processing, and sewage treatment. There are three primary classifications of heat exchangers according to their flow arrangement. In parallel- flow heat exchangers, the two fluids enter the exchanger at the same end, and travel in parallel to one another to the other side. In counter-flow heat exchangers the fluids enter the exchanger from opposite ends. The counter current design is the most efficient, in that it can transfer the most heat from the heat (transfer) medium per unit mass due to the fact that the average temperature difference along any unit length is higher. See counter current exchange. In a cross- flow heat exchanger, the fluids travel roughly perpendicular to one another through the exchanger.

Heat transfer is one of the most important industrial processes. In any industrial facilities heat must be efficiently managed by adding, removing or moving in the relevant sectors. Conventional heat transfer fluids such as water, ethylene glycol (EG), pumping oil, etc., have not shown sufficient capability for cooling applications due to their poor thermal performance. It has been already demonstrated that adding solid particle to these traditional fluids could enhance their thermal performance. However, still these suspensions with micrometre or larger size particles are not efficient choice for the high-tech applications such as microelectronics, data centers and micro-channels. Therefore, development of highly efficient heat transfer fluids for solving the drawback of conventional fluids has become one of the most important priorities in the cooling industries. In last decade, Nano science and nanotechnology (NFs) has offered new solution by introducing Nano fluids (NFs) which may assist to enhance heat transfer fluids' performance especially in the high-tech applications.

For instance there are numerous applications that involve magnetic NFs such as hyperthermia, magnetic cell separations and contrast improvement in magnetic resonance imaging. About application of NFs in non-renewable energy fields such as petroleum industry, some reports can be found in the literature. For example recent experiments have exposed that some NFs have successfully been formulated and applied in enhanced oil recovery (EOR) process, anticorrosive coatings, wettability alteration and drilling technology are other applications of NFs concerning oil and petroleum industry. Recently, NFs systems prepared by dispersing NPs (such as MoS_2, TiO_2 and copper oxide) in the conventional lubricating oil have successfully enhanced as anti-wear properties and friction-reduced. These features exhibit the potential of NFs' applications as effective lubricants. Several reports in the literature also show the remarkable potential of NFs for use in surface coating, environmental remediation (for example soil remediation), inkjet printing and as fuel additives. By suspending Nano phase particles in heating or cooling fluids, the heat transfer performance of the fluid can be significantly improved. The main reasons may be listed as follows:

- The immersed nanoparticles increase the surface area and the heat capacity of the fluid.
- The suspended nanoparticles increase the thermal conductivity of the fluid.
- The mixing fluctuation and turbulence of the fluid are intensified.
- The dispersion of nanoparticles flattens the transverse temperature gradient of the fluid.

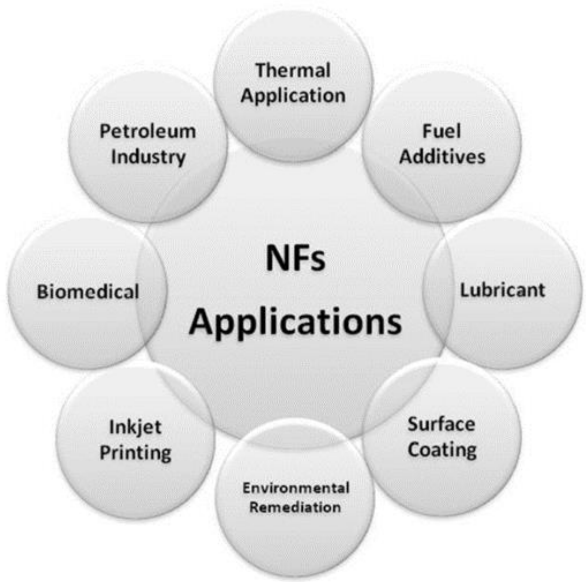

Figure 1 Application of Nano fluids

A. Types of Heat exchanger

There are three main types of flows in a spiral heat exchanger:

- **Counter-current Flow:** Fluids flow in opposite directions. These are used for liquid- liquid, condensing and gas cooling applications. Units are usually mounted vertically when condensing vapour and mounted horizontally when handling high concentrations of solids.
- **Spiral Flow/Cross Flow:** One fluid is in spiral flow and the other in a cross flow. Spiral flow passages are welded at each side for this type of spiral heat exchanger. This type of flow is suitable for handling low density gas, which passes through the cross flow, avoiding pressure loss. It can be used for liquid-liquid applications if one liquid has a considerably greater flow rate than the other.
- **Distributed Vapour/Spiral flow:** This design is that of a condenser, and is usually mounted vertically. It is designed to cater for the sub-cooling of both condensate and non- condensable. The coolant moves in a spiral and leaves via the top. Hot gases that enter leave as condensate via the bottom outlet

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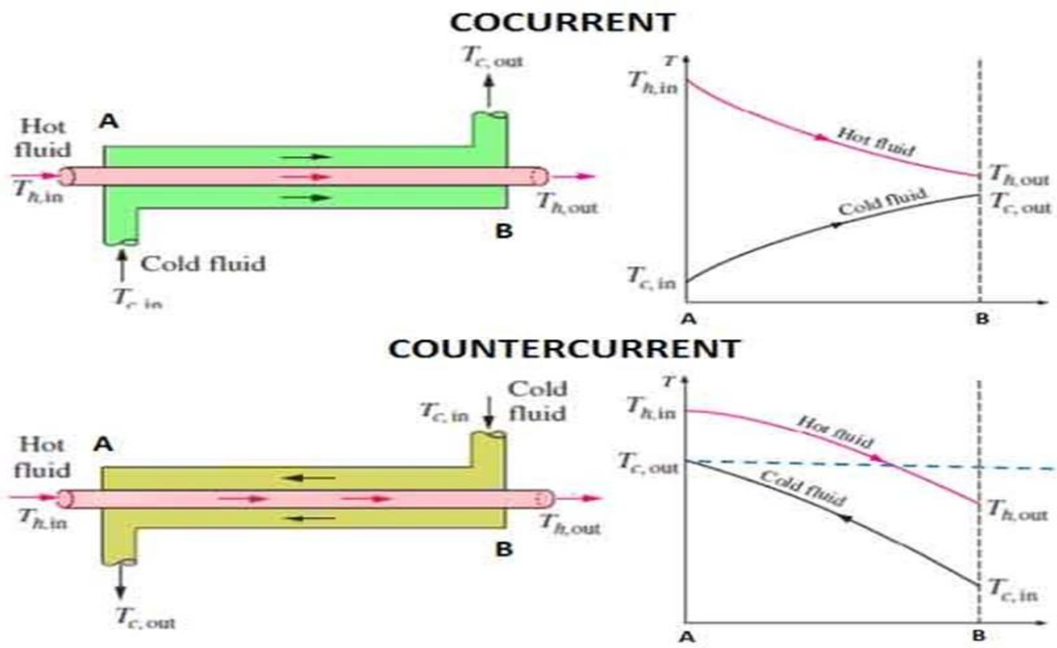

Flow Arrangement

II. Literature Review

Kim et al [1] experimentally studied the effect of nano fluid on heat transfer flowing through a circular horizontal tube under both laminar and turbulent flow regimes. In this research, alumina oxide nano particles were used because this was very environment friendly. It was observed that adding Al2O3 nano particles in the base fluids had helped to enhance the heat transfer rate. The maximum enhancement was observed to be 15% and 20% respectively at 3% under both the laminar and turbulent flow conditions.

G.Murali et al [2] studied the heat transfer and friction factor characteristics of a circular tube fitted with full length twisted tape trapezoidal cut for the Reynolds number range of 2000– 12,000. They used twisted tape with water as the working fluid and compared with Fe3O4 Nanofluid as working fluid at a volume concentration of 0.06%. The secured experimental data from plain tube were validated with standard correlations to make sure the authorization of experimental results. They found that the thermal performance of trapezoidal cut twisted tape increase significantly than the plain tube. Performance ratio is more than unity is reasonable for trapezoidal cut twisted tape.

M.Awais et al [3] investigate the thermo-hydraulic performance of serpentine tube heat exchanger (STHX) by using CFD analysis. The prominent focus was given to the momentous factors which impart noteworthy role in acquiring desired heat transfer and pressure drop performance of heat exchanger. The impact of various volumetric flow rates (1L/min to 5L/min) and various cross-section lengths of serpentine tubes such as uniform, high-to-low-to- high (H-L-H), low-to-high-to-low (L-H-L) and low-to –high (L-H) were considered to acknowledge their effect on heat transfer and pressure drop characteristics. Furthermore, the influence of Al2O3/water-based Nano-fluid on thermo-hydraulic performance was broadly studied with the inclusion of different nanoparticles concentration (1%, 3% and 5%) under different volumetric flow rates (1-5 L/min).

P.C. Mukesh Kumar et al [4] investigate the heat transfer and pressure drop of the double helically coiled heat exchanger handling MWCNT/water Nano fluids. The properties are analysed by the computational software ANSYS 14.5 version. The computational analysis was carried out under the laminar flow condition. The design of new shell and double helically coiled tube heat exchanger was done by using standard designing procedure and 3D modelling. Finite Element Analysis software ANSYS Workbench 14.5 was used to perform CFD analysis under the standard working condition. The MWCNT/water Nano fluids at 0.2%, 0.4%, and 0.6% volume concentrations have been taken for this investigation. The major factors like volume concentrations of Nano fluids and Dean Number are considered for predicting the heat transfer rate and pressure drop. The simulation data was compared with the experimental data. they found that the heat transfer rate and pressure drop increase with increasing volume concentrations of MWCNT/water Nano fluids. It is found that the Nusselt number of 0.6% MWCNT/water Nano fluids is 30% higher than water at the Dean number value of 1400 and Pressure drop is 11% higher than water at the Dean number value of 2200. It is found that the simulation data hold good agreement with the experimental data.

T. Hussein,et al [5] An overview of systematic studies that address the complexity of nanofluid systems and advance the understanding of nanoscale contributions to viscosity, thermal conductivity, and cooling efficiency of nanofluids is presented. A nanoparticle suspension is considered as a three-phase system including the solid phase (nanoparticles), the liquid phase (fluid media), and the interfacial phase, which contributes significantly to the system properties because of its extremely high surface-to-volume ratio in nanofluids. The systems engineering approach was applied to nanofluid design resulting in a detailed assessment of various parameters in the multivariable nanofluid systems. The relative importance of nanofluid parameters for heat transfer evaluated in this article allows engineering nanofluids with desired set of properties.

H. Togun et al [6] the continuum formulation is applied to the developing boundary layer problem, which approximates the entrance region of Nano fluid flow in micro channels or tubes. The thermo physical properties are expressed as “equations of state” as functions of the local Nano fluid volume fraction. Based on experimental utilization of Nano fluid prevalently at small volume fraction of nanoparticles, a simple perturbation procedure is used to expand dependent variables in ascending powers of the volume fraction. The zeroth order problems are the Blasius velocity boundary layer and the Pohlhausen thermal boundary layer. Two property cases are calculated as comparisons: one is the use of mixture properties for the nanofluid density and heat capacity and the transport properties prevalently used in the literature attributed to Einstein and to Maxwell. Results for alumina are compared to experiments. The theory underestimates the experimental results. This leads to the second comparison, between “conventional” properties and those obtained from molecular dynamics computations available for gold-water Nano fluids. The latter properties considerably increased the heat transfer enhancement relative to “conventional” properties and heat transfer enhancement is comparable to the enhanced skin friction rise.

M.R. Safaei et al [7] the global demand for energy is increasing and the detrimental consequences of rising greenhouse gas emissions, global warming and environmental degradation present major challenges. Solar energy offers a clean and viable renewable energy source with the potential to alleviate the detrimental consequences normally associated with fossil fuel-based energy generation. However, there are two inherent problems associated with conventional solar thermal energy conversion systems. The first involves low thermal conductivity values of heat transfer fluids, and the second involves the poor optical properties of many absorbers and their coating. Hence, there is an imperative need to improve both thermal and optical properties of current solar conversion systems. Direct solar thermal absorption collectors incorporating a nanofluid offers the opportunity to achieve significant improvements in both optical and thermal performance. Since nanofluids offer much greater heat absorbing and heat transfer properties compared to traditional working fluids. The review summarizes current research in this innovative field. It discusses direct solar absorber collectors and methods for improving their performance. This is followed by a discussion of the various types of Nano fluids available and the synthesis techniques used to manufacture them.

T. Hussein et al [8] Heat transfer augmentation techniques are used to increase rate of heat transfer without affecting much the overall performance of the system. Heat transfer augmentation techniques are commonly used in areas such as heating and cooling in evaporators, air-conditioning equipment, thermal power plants, space vehicle, automobile etc. This paper contains literature survey of enhancement techniques in heat transfer using inserts with and without using nanofluid.

III. Conclusion

This review shows that nanofluids have great potential for heat transfer enhancement and are highly suited to application in heat transfer processes. Based on this study, it was reported that the thermal conductivity of nanofluids is one of the driving factors for improving performance in different applications. Increase in Reynolds number and volume concentration the average Nusselt number was increased. Diameter of nanoparticles has a small effect on the Nusselt number. Heat transfer rate in heat exchanger has been enhanced using nanofluids by compromising pumping power.

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