

Review on Heat Exchanger Using Different Nano Fluids

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Abstract : Heat Exchanger is a very important device in every modern industry. In this paper the thermal performance of the heat exchanger is studied by using various nanofluids, which is the mixture of the thermal conducting material such as SiO₂, Al₂O₃, TiO₂, Cu, Zn, etc. with base fluid like water or glycol. The objective of these projects is to determine whether the use of nanofluid improves the heat exchanger's performance and at what percentage of nanoparticles-coolant mixture the performance of pipe in pipe heat exchanger obtains maximum heat exchange rate.

Keywords : Nanoparticles, Nanofluid, Overall heat transfer coefficient, Mass flow rate.

I. Introduction

Heat Exchanger is a mechanical device, which is used for the exchange of heat between two fluids at different temperatures. There are various types of heat exchanger available in industries, but pipe and pipe tube heat exchanger are widely used. It is mostly used in oil refineries, food industries, thermal power plants, chemical plants, etc. This is mostly used due to the large ratio of heat transfer area to volume weight, easy cleaning method, and replaceable part, etc. The first time the term nanofluid was defined was in 1995, when Choi coined it, while working in a research project at Argonne National Laboratory. Nanofluid consists of nanoparticles and base fluid. Nanoparticles have high thermal conductivity and when mixed with base fluid, that's why it will increase the thermal conductivity of the base fluid. So that nanofluid helps to efficiently exchange heat from high temperature fluid to low temperature fluid. Now a days nanofluid is mostly used in heat transfer devices.

Preparation of nanofluid: There are two methods for preparation of nano fluid

Two step method

One step method

- **Two step method**

According to recent studies regarding Nano fluids, used a two-step process in which nanoparticles are first produced as a dry powder either by physical or chemical method. Next step is to suspend nanoparticles into the base fluid by using magnetic force agitation, ball milling or by some other techniques. This method is more widely used to produce Nano fluids because Nano powders are commercially available nowadays. Nanoparticles can get agglomerate during the process. Hence to stabilize the nanoparticles surfactants are used. Though surfactants are used in this process it is quite difficult to produce stable nanofluid by using two step methods.

- **One step method**

Need of one step method

- Agglomeration of nanoparticles in two step method (mixing in bulk during drying storage and transportation process).
- Difficulties in dispersion stage in one step method.
- Stability and thermal conductivity of Nano fluid is not ideal.

Hence to overcome these effects one step method is developed. In one step method nanoparticles are made and dispersed at the same time which avoids agglomeration. This process includes drying, storage, transportation and dispersion in base fluid. Use of this method gives highly dispersed, uniformly stable nano-fluid. Though one step method has merits over two step method, it is not found successful in case of bulk production.

Experimental setup

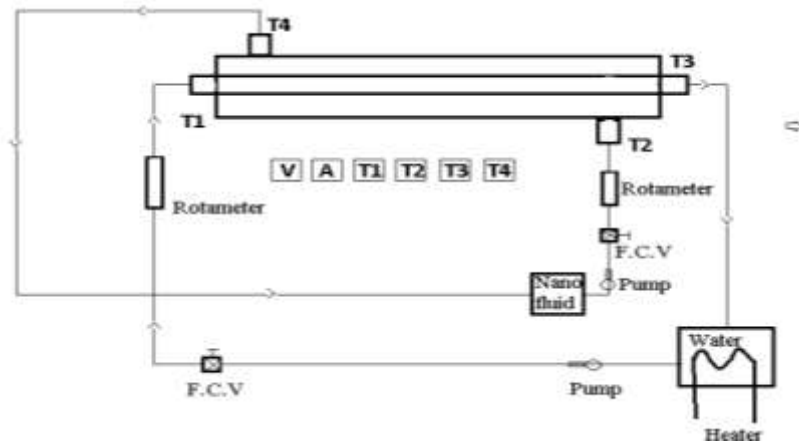


Fig.1

As per the line diagram four temperature indicators are used to measure the inlet and outlet temperature. Two pumps are used to pump the hot and cold fluid through rotameter to measure the flow. Also flow control valve is used to regulate the flow. Two tanks to store hot fluid and nano fluid and heating arrangement is used to heat the water.

Analysis of heat Exchanger:

According to first law of thermodynamics

Hot fluid Heat transfer rate $Q_h = m_h \cdot C_{ph} \cdot (T_{hi} - T_{ho})$

Cold fluid Heat transfer $Q_c = m_c \cdot C_{pc} \cdot (T_{co} - T_{ci})$

Where, m_h and m_c are the mass flow rate of hot and cold fluid respectively.

C_{ph} and C_{pc} are the specific heat of hot and cold fluid respectively. T_{hi} and T_{ci} are the inlet temperature of the hot and cold fluid and T_{ho} and T_{co} are the outlet temperature of the hot and cold fluid respectively.

$Q_{avg} = (Q_h + Q_c) / 2$

Logarithmic Mean Temperature Difference is given by,

$LMTD (\Delta T_{lm}) = (T_{hi} - T_{co}) - (T_{ho} - T_{ci}) / \ln (T_{hi} - T_{co}) - (T_{ho} - T_{ci})$

Table 1: Conductivity values for different solids and liquids (metallic and non-metallic)

II.

Solids / Liquids	Material	Thermal Conductivity (W/m-K)
Metallic solids	Silver	429
	Copper	401
	Aluminum	237
Non-metallic solids	Diamond	3300
	Carbon nanotubes	3000
	Silicon	1458
	Alumina (Al ₂ O ₃)	40
Metallic liquids	Sodium @644K	72.3
Non-metallic liquids	Water	0.613
	Ethylene glycol	0.253
	Engine oil	0.145

II. Literature Survey

S.Gh. Etemad^[1] An experimental system was designed and constructed to investigate heat transfer behavior of γ -Al₂O₃ nanofluid in a shell and tube heat exchanger. Heat transfer characteristics were measured under the turbulent flow condition. The experiments were done for wide ranges of Peclet numbers, and volume concentrations of suspended nanoparticles. The experiment done for the result obtained for Peclet number and nanoparticle concentration. They concluded that heat transfer characteristics enhance significantly with Peclet number.

Kallalu Harika Shell^[2] and tube heat exchanger is a class of heat exchanger. Heat exchanger is a device used to transfer heat between a solid and a fluid or between two or more fluids. This paper is concerned with the study of shell and tube heat exchanger. Also the main components of shell and tube type heat exchanger are shown in drawing and its detail discussion is given. Moreover the constructional details and design methods of shell and tube heat exchangers are given from which Kern's method for design is described in detail with step inside the paper. Also other research papers are studied and the review from those papers is also described in this paper with some of the review work in detail. After this study it is said that the shell and tube heat exchanger has given the respect among all the classes of heat exchanger due to their virtues like comparatively large ratios of heat transfer area to volume and weight and many more.

Amarjit Singh^[3] In this study, the experimental analysis was performed on the shell-and-tube type heat exchanger containing segmental baffles at different orientations. In the current work, three angular orientations (θ) $0^\circ, 30^\circ, 60^\circ$ of the baffle and analyzed for laminar flow having the Reynolds number range 303-1506. It was observed that, with increase of Reynolds number from 303 to 1516, there was a 94.8% increase in Nusselt number and 282.9% increase in pressure drop. Due to increase of Reynolds number from 303 to 1516, there is a decrease in nondimensional temperature factor for cold water (ω) by 57.7% and hot water (ξ) by 57.1%, respectively. Experimental study of shell-and-tube heat exchanger is conducted to calculate the heat transfer Coefficient, LMTD, Nusselt number, and pressure drop at different Reynolds numbers (303-1516). It is concluded that the increase in Reynolds number has a significant impact on different Parameters of shell-and-tube type heat exchange.

Dr. Hiregoudar Yerrennagoudaru^[4] Ultrahigh cooling performance is one of the major need in industries. But low thermal conductivity is the major limitation of the fluid to efficient heat transfer. Nanofluids are engineered by suspending nano particles with average sizes below 100 nm in heat transfer fluids such as water, oil, diesel, ethylene glycol, etc. Experiments have shown that nanofluids have substantial higher thermal conductivities compared to the base fluids. The aim of this project is to summarize recent developments in research on nanofluids, and to carry

out CFD analysis for four different nano fluids and the result is analysed, two fluids are selected for experimentation work and finally the experimented result is compared with the CFD results to draw out the conclusion. The different nanofluids used for CFD analysis are Magnesium oxide-water, copper oxide-water, Titanium oxide-water, and Iron oxide-water. For experimentation nanoparticle's sizes are varied in the range of 70 to 230 nm for preparing nanofluids, and to observe enhancement in the thermal conductivity.

A. Gopi Chand^[5] A simplified model for the study of thermal analysis of shell-and-tubes heat exchangers of water and oil type is proposed. Shell and Tube heat exchangers are having special importance in boilers, oil coolers, condensers, pre-heaters. They are also widely used in process applications as well as the refrigeration and air conditioning industry. In this paper we have shown how to do the thermal analysis by using theoretical formulae for this we have chosen a practical problem of counter flow shell and tube heat exchanger of water and oil type, by using the data that come from theoretical formulae we have design a model of shell and tube heat exchanger using Pro-e and done the thermal analysis by using Floefd software and comparing the result that obtained from Floefd software and theoretical formulae. For simplification of theoretical calculations we have also done a Mat lab code which is useful for calculating the thermal analysis of a counter flow of water-oil type shell and tube heat exchanger.

Bharat B. Bhosle^[6] Now days to achieve high heat transfer rate, different techniques have been used. One of the advanced techniques among them is suspension of nanoparticle in the base fluids as water, ethylene glycol, oil. In the present work Al₂O₃ nanoparticle of diameter size 50nm is suspended in water. The present work has been carried out on double pipe heat exchanger for water to water and Nano fluid to water heat transfer investigation with counter flow arrangement under turbulent flow condition. The computational fluid dynamic code is used to simulate different concentrations of Nano fluid (0.01% to 0.19%) in ANSYS FLUENT 14 software. The overall heat transfer coefficients for all concentrations are measured as a function of hot and cold streams mass flow rates. Considering friction factor, one appropriate concentration (0.1%) is taken into account experimentally. The thermal performance parameter overall heat transfer coefficient is compared for Nano fluids with water. The study is done at different mass flow rates and inlet fluid temperatures. It is observed that for high Reynolds number low concentration of Nano fluid is useful. The work concludes that there is promising enhancement in heat transfer rate using Nano fluid.

DawitBogale^[7]Here the redesign takes place because of temperature fluctuation at the 9th zone of the pasteurizer in the Harar Brewery Company. Thermal and mechanical design is run in order to optimize the output temperature of the cold fluid at the last heat exchanger in which it is sprayed on the beer ready for customer use. In thermal design part geometry optimization is done through trial and error. And for Mechanical design part the natural frequency & vortex shedding of different components of heat exchangers are investigated through governing equations of vibrations under dynamic fluid with in tubes. Using computational fluid dynamics (CFD) the heat transfer of the two fluid is investigated using FEM simulation software's Gambit1.3 and Fluent 6.1 and the performance of the STHEx determined in terms of variables such as pressure, temperature, flow rate, energy input/output, mass flow rate and mass transfer rate that are of particular interest in STHEx analysis. Vindhya Vasin Prasad Dubey^[8]This paper is concerned with the study of shell & tube type heat exchangers along with its applications and also refers to several scholars who have given the contribution in this regard. Moreover the constructional details, design methods and the reasons for the wide acceptance of shell and tube type heat exchangers has been described in details inside the paper. After the above discussion it is easy to say that the shell & tube type heat exchangers has been given a great respect among all the classes of heat exchangers due to their virtues like comparatively large ratios of heat transfer area to volume and weight and many more. Moreover well designed as well as described methods are available for its designing and analysis. The literature survey also shows the importance of this class of heat exchangers. It is also shown by the literature survey that the Computational Fluid Dynamics and other software's like ANSYS etc. have been successfully used and implemented to secure the economy of time, materials and efforts.

III. Conclusion

Experimental results indicate that heat transfer characteristics of nanofluid enhance significantly with increasing Peclet number. Heat transfer have comparatively large ratio of heat transfer area to volume and weight. Increase in Reynolds number has a significant impact on different parameters of shell-and-tube type heat exchanger. The value of pressure drop gradually increases with increase in Reynolds number. Analysis of different nanofluid with different concentration is studied. There is chances to study on pipe and pipe tube heat exchanger using SiO₂ nanofluid.

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