A Comparative Study forImproving of Heat Characteristics of Helical Coil Heat Exchanger

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ABSTRACT

Heat Exchanger has become an essential component of almost every modern industry; in the time when resources are limited and there is tough competition in the market heat exchanger marks special importance. In this paper the thermal performance investigating of a counter flow heat exchanger is performed with traditional coolant flow in heat exchanger. Now a day the new fluid is introduced in market i.e. nanofluids. The nanofluid contains some fine particle with base fluid like water, glycol etc. In this study will suggested to use of nanofluid, which is a mixture of aluminium oxide particles. Some researcher has been introduced the nanofluid for the used as coolant in heat exchanger or radiator. The nanofluid (aluminium oxide) having some good thermal properties as compared to other traditional fluid. The main objective of this work is too determined whether the use of Nanofluids improves the heat exchangers performances and at percentage of nanoparticles mixture the performance of counter flow helical coil heat exchanger to obtain maximum heat exchange rate.

Keywords: *Helical Coil Heat Exchanger (HCHE), Nanofluid, Aluminum oxide.*

I. INTRODUCTION

Heat exchanger is a process equipment designed for the effective transfer of heat energy between two fluids. For the heat transfer to occur two fluids must be at different temperatures and they must come thermal contact. Heat exchange involve convection in each fluid and conduction through the separating wall. Heat can flow only from hotter to cooler fluids, as per the second law of thermodynamics.

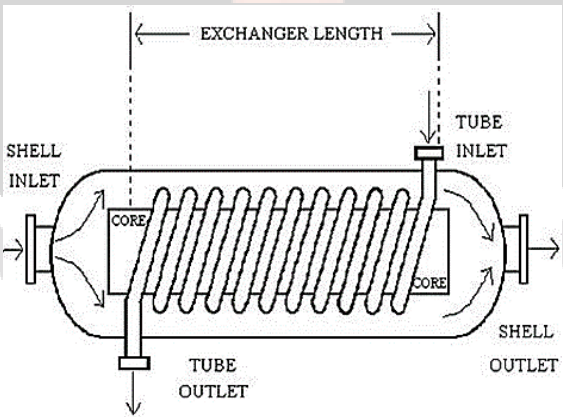

Fig 1.Helical coil heat exchanger (HCHE).

1.1 Nanofluids

Low thermal conductivity of process fluid hinders high compactness and effectiveness of heat exchangers, although a variety of techniques is applied to enhance heat transfer. Improvement of the thermal properties of energy transmission fluids may become a trick of augmenting heat transfer. An innovative way of improving the thermal conductivities of fluids is to suspend small solid particles in the fluids. The types of nanofluid are:

(a) Pure metals (Au, Ag, Cu, Al, and Fe),
(b) Metal oxides (Al_2O_3, CuO, Fe_3O_4, SiO_2, TiO_2, and ZnO),
(c) Carbides (SiC, TiC) and
(d) Variety of carbon materials (diamond, graphite, single/multi wall carbon nanotubes).

Table 1.Some thermal conductivity measurements from several nanofluid studies [4]

Nanoparticles		Particle Size (mm)	Working Fluid	Fraction (vol%)	Thermal Conductivity ($Wm^{-1}K^{-1}$)
Metals	Ag	<100	Water	0.3-0.9	315
	Ag	100-500	Ethylene Glycol	0.1-1.0	424
	Cu	50-100	Water	0.1	398
	Cu	<10	Ethylene Glycol	0.01-0.05	273
	Fe	10	Ethylene Glycol	0.01-0.55	80
Metal Oxide	Al_2O_3	9	Water	2-10	40
	Al_2O_3	28	Water/Ethylene Glycol	3-8	77
	Al_2O_3	650-1000	Transformer Oil	0.5-4	77
	CuO	100	Water	7.5	7
	TiO_2	15	Water	0.5-5	8.37
	SiO_2	12	Ethylene Glycol	1-4	29
Carbon	Carbon Black	190	Water	4.4-7.7	1.59
	Carbon/ graphene oxide	NS	Ethylene Glycol	0-0.06	1.59
	SWCNT	Dia.10-50 Len.0.3-10μm	Diesel Oil	0.25-1	13
	MWCNT	25nm×50μm Dia. 10	Oil	1	14
	MWCNT	Len. 5-15μm	Gum Arabic & Water	0.14-024	14

II. LITERATURE REVIEW

In recent many years, the improvements in work increased the interest of engineers and researchers to simulate their problems with computational and numerical methods. A lot of computational tools and methods have been developed in the last decades to analyses fluid dynamics, combustion, and different modes of heat transfer. Use of heat exchangers in wide range of applications attract the researchers and scientists to work in this field.

The helical coil-tube heat exchangers are used in industries and power sectors due to its compact structural design, larger heat transfer surface area and higher heat transfer capability. In recent past few years so much work has been done to improve the heat transfer rate of heat exchangers. Wide range of literature has been found to improve the heat transfer rate by using helical coil heat Exchanger. In spite of numerical and analytical studies that have been done in helical coil tube.

Sahu and Saikhedkar [1] (2016),concept of helical coils and their enhanced heat transfercharacteristics have better heat and mass transfer thanstraight tubes. In most of the literature, a CFD modeling isused to investigate the heat transfer through helical tubes.In this work, the optimization of helical coil heat exchangertakes place. We have taken only one variable or parameterto optimize the helical coil heat exchanger i.e. helical coilpitch. Entail setup cost may approximately 45 Lakh Indianrupees. Due to this reason, we cannot fabricate this setupbut instead of this, we simulate the experiment with CFDsoftware. In this experiment, the helical coil heat exchangerhas a constant coil pitch i.e. 30 mm coil pitch. Due to highcost, we can’t modify this experimental setup but instead ofthis, we use the CFD simulation and change only oneparameter i.e. coil pitch of 20 mm. We can easily simulatethe parameters of helical coil heat exchanger in CFDsoftware without any modification in experimental setup.Although the application of CFD in the thermal basedindustries and power plants will benefit the understandingof the dynamics and physics of a thermal analysis operationand thus aid in the optimization and design of existingequipment, constraints are the requirement for faster, easierand less expensive CFD techniques. In CFD softwaredevelopment will turn automatic design and optimization inrealitiesand the development of web based CFD will allowmore people to access the technology. All thesedevelopments will contribute CFD to becoming a maturediscipline and a powerful engineering tool. As a result,more widespread and rapid adoption of the use ofCFD inthe thermal engineering will take place in future.

Xuan and Li, [2] (2000), A preparation method of nanofluids has been developed. With this method, several sampled nanofluids have been prepared by directly mixing nanophase powders and base fluids, which reveals the possibility of practical application of the nanofluid. The nanofluid shows great potential in enhancing the heat transfer process. One reason is that the suspended ultra-®ne particles remarkably increase the thermal conductivity of the nanofluid. The volume fraction, shape, dimensions and properties of the nanoparticles affect the thermal conductivity of nanofluids. The hot-wire method has been used to measure the thermal conductivity of nanofluids. The measurement results illustrate that the thermal conductivity of nanofluids remarkably increases with the volume fraction of ultra-®ne particles. For the water-Cu nanoparticles suspension, for example, the ratio of the thermal conductivity of the nanofluid to that of the base liquid varies from 1.24 to 1.78 if the volume fraction of the ultra-®ne particles increases from 2.5% to 7.5%.

With respect to the complicated phenomena of Brownian diffusion, sedimentation, dispersion which may coexist in the main flow of a nanofluid, the dispersion model has been used to analyze the enhanced heat transfer mechanism of nanofluid. Some correlations for predicting Nu have been derived. However, experimental research is urgently needed to investigate the heat transfer process of nanofluids.

Sivashanmugam [3] (2012), A detailed description of the state-of-the-art nanofluids research for heat transfer application in several types of heat exchangers is presented in this chapter. It is important to note that preparation of nanofluids is an important step in experiments on nanofluids. Having successfully engineering the nanofluids, the estimation of thermophysical properties of nanofluids captures the attention. Great quanta of attempts have been made to exactly predict them but large amount of variations was found. Research works on convective heat transfer using nanofluids is found to increase exponentially in the last decade. Almost all the works showed that the inclusion of nanoparticles into the base fluids has produced a considerable augmentation of the heat transfer coefficient that clearly increases with an increase of the particle concentration. It was reported by many of the researchers that the increase in the effective thermal conductivity and huge chaotic movement of nanoparticles with increasing particle concentration is mainly responsible for heat transfer enhancement. However, there exists aplenty of controversy and inconsistency among the reported results. The outcome of all heat transfer works using nanofluids showed that our current understanding on nanofluids is still quite limited.

Chamsa-ard etal [4] (2017), 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 nanofluids available and the synthesis techniques used to manufacture them. In closing, a brief discussion of nanofluid property modelling is also presented.

Golakiya et al [5] (2015), It has been seen that nanofluids can be considered as a potential candidate for Automobile application. As heat transfer can be improved by nanofluids, in Automobile radiators can be made energy efficient and compact. Reduced or compact shape may result in reduced drag, increase the fuel economy, reduce the weight of vehicle. Exact mechanism of enhanced heat transfer for nanofluids is still unclear as reported by many researchers. There are different challenges of nanofluids which should be identified and overcome for Automobile radiators application.

Ajaykumar and Sudhakar [6] (2015), The objective of this project is to analyze net heat transfer rate in shell and tube heat exchanger using nanoparticle suspended in different base fluids such as Water and Ethylene glycol. The thermophysical properties of nanofluid mixture like density, thermal conductivity, specific heat, viscosity and density were predicted by analytical method. Then, the shell and tube heat exchanger using aluminium metal is created using CATIA and flow and thermal analysis is created using ANASYS.

Chouda [7] (2014), series of experiments were conducted on a counter flow heat exchanger which was performed by the variation of mass fraction of hot fluid (a mixture of coolant with iron Nanoparticles). The effect of these parameters on outlet temperature and overall heat transfer coefficient and the efficiency of heat exchanger were studied. It was found that when the mass flow rate of cold fluid was increased the outlet temperature of hot fluid was decreased. The heat transfer rate of the heat exchanger increases as the iron particle concentration in the hot fluid was increased, the effectiveness (E) of the heat exchanger also increased but when the concentration exceeds by 1.5% effectiveness decreases because high pumping was required and other circulatory problems. The use of Nanoparticles other than increasing the efficiency can also serve as clearing the inner unreached part of exchanger by performing as abrasive action, this can be tested on a long run of the heat exchanger. The result on counter flow heat exchanger were positive the same can be tested o other type, shape and size of heat exchangers.

Thirumarimurugan et al [8] (2011), they discussed about the effective use of spiral tube heat exchanger in oil extraction process. They carried out research on the performance analysis of spiral tube heat exchanger over the shell and tube type heat exchanger. They studied the Performance of spiral tube heat exchanger and shell and tube heat exchanger for sugandhmantri oil emulsion. They found that the relation between mass flow rate and effectiveness and found out that for the same mass flow rate effectiveness increases for the spiral tube heat exchanger. Also, it was observed that the heat transfer coefficient increased with increase in Reynolds number. Also, they investigated the relation between Reynolds numbers and Nusselt number and concluded that Nusselt number increases with increase in Reynolds number. They finally compared the spiral heat exchanger with the shell and tube heat exchanger and found out that effectiveness of shell and tube heat exchanger for lemon grass oil and sugandh mantra oil averages between 0.3 to 0.4 against for spiral 0.4 to 0.5 which shows increase in the effectiveness. They found out that heat transfer coefficient for shell and tube type heat exchanger was 350 – 600 W/m2K against for spiral tube heat exchanger is 450 to 650 W/m2K. It shows increase in the heat transfer rate with use of spiral tube heat exchanger. The research work was carried out by Thirumarimurugan et. al on experimental and simulation studies on spiral heat exchanger for miscible system using MATLAB.

Naphon and Wongwises [9] (2005), they have done an experimental investigation on comparative heat transfer study on a solvent and solution using spiral heat exchanger. They used steam as the hot fluid and water and acetic acid -water miscible solution as cold fluid. They carried out series of runs between steam and water, steam and acetic acid solution. The flow rate of the cold fluid was varied from 120 to 720 lph and the volume fraction of Acetic acid was varied from 10-50%. Experimental results such as exchanger effectiveness, overall heat transfer coefficients were calculated. Generalized regression model was used for artificial neural network simulation using matlab and the data obtained was compared with experimental findings and found to be valid. The research was carried out by on study of the heat transfer characteristics of a compact spiral coil heat exchanger under wet-surface conditions.

Hossain et al [10] (2005), the objective of their work was to find the heat transfer characteristics and the performance of a spiral coil heat exchanger under cooling and humidifying conditions. Air and water were used as working fluids. A mathematical model based on mass and energy conservation is developed and solved by using the Newton–Raphson iterative method to determine the heat transfer characteristics. They found that enthalpy, effectiveness and the humidity effectiveness decreased with increasing air mass flow rate for a given inlet-water temperature, inlet-air humidity ratio and water mass flow rate. The increase in the outlet enthalpy and outlet humidity ratio of air was larger than those of the enthalpy of saturated air and humidity ratio of saturated air. Therefore, the enthalpy effectiveness and humidity effectiveness tend to decrease with increasing air mass flow rate. They also observed that the effect of inlet-air temperature on the tube surface temperature. At a specific inlet-air temperature, the tube surface temperature generally increases with increasing air mass flow rate; however, the increase of the tube surface temperature at higher inlet-air temperatures was higher than at lower ones for the same range of air mass flow rates. They found that at a specific air mass flow rate, the tube surface temperature decreases as water mass flow increases. Finally, the results obtained from the developed model are validated by comparing with the measured data. The research was carried out by comprehensive study on heat transfer co-efficient and effectiveness for water using spiral coil heat exchanger.

III. CONCLUSION

From study the many literatures, it is clear that helical coil heat exchangers offer more effectiveness than conventional heat exchangers likestraight tube, shell and tube, etc. Due to secondary flow development inside the helical tube, it offers more heat transfer and alsoincreases the rate at which heat transfer takes place. It also increases the friction factor which eventually increases the effectivenessof helical coil heat exchanger per unit pressure drop. It is also seen that the impact of coil curvature is to suppress turbulentfluctuations arising within the flowing fluid and smoothing the appearance of turbulence. In study also concluded that the nanofluid for the used as coolant in heat exchanger or radiator. The nanofluid (aluminium oxide) having some good thermal properties as compared to other traditional fluid. The used of nanofluid increased the overall efficiency of heat exchanger.

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