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A Review on "Heat transfer characteristics in ionic liquid-based Nano-fluids flowing in a double-pipe heat exchanger"

Nitesh Kumar Singh[1], Associate Prof. R.C. Gupta[2],

1 Research Scholar, Department of Mechanical Engineering, JEC Jabalpur (M.P.)

2 Associate Professor, Department of Mechanical Engineering, JEC Jabalpur (M.P.)

***Abstract*- One of the simplest and applicable heat exchangers is double pipe heat exchanger (DPHE). This kind of heat exchanger is widely used in chemical, food, oil and gas industries. Upon having a relatively small diameter, many precise researches have also hold firmly the belief that this type of heat exchanger is used in high-pressure applications. They are also of great importance where a wide range of temperature is needed. It is also well documented that this kind of heat exchanger makes a significant contribution to pasteurizing, reheating, preheating, digester heating and effluent heating processes. Many of small industries also use DPHEs due to their low cost of design and maintenance.**

The aim of present paper is to review "The various Nano fluids which affect the heat transfer rate with structural modification of double pipe heat exchanger." on the basis of previous study.

Keywords; Heat exchanger, nano fluids, DPHE, heat transfer rate etc.

I. INTRODUCTION

The process of heat exchange between two fluids that are at different temperatures and separated by a solid wall occurs in many engineering applications. The device used to implement this exchange is termed a heat exchanger, and specific applications may be found in space heating and air-conditioning, power production, waste heat recovery, and chemical processing.

Heat exchangers are generally devices or systems in which heat is transferred from one flowing fluid to another. The fluids may be liquids or gases, and in some heat exchangers more than two fluids might flow. These devices may have a tubular structure, of which the double-pipe and shell-and-tube exchangers are perhaps the most prevalent, or a stacked-plate structure, which includes the plate-fin and plate-and-frame exchangers, among some other configurations.

Nomenclature	Subscripts
D = Outer tube diameter d = Inner tube diameter p = pitch of the helix l = length of the tubes n = number of turns	i = inner circle o = outer circle

Basic Types of Heat Exchangers

A heat exchanger is a device in which heat is transferred between a warmer and a colder substance, usually fluids. There are three basic types of heat exchangers:

Recuperators

In this type of heat exchanger the hot and cold fluids are separated by a wall and heat is transferred by a combination of convection to and from the wall and conduction through the wall. The wall can include extended surfaces, such as fins, or other heat transfer enhancement devices.

Regenerators

In a regenerator the hot and cold fluids alternately occupy the same space in the exchanger core. The exchanger core or “matrix” serves as a heat storage device that is periodically heated by the warmer of the two fluids and then transfers heat to the colder fluid. In a fixed matrix configuration, the hot and cold fluids pass alternately through a stationary exchanger, and for continuous operation two or more matrices are necessary. Another approach is the rotary regenerator in which a circular matrix rotates and alternately exposes a portion of its surface to the hot and then to the cold fluid.

Direct Contact Heat Exchangers.

In this type of heat Exchanger the hot and cold fluids contact each other directly. An example of such a device is a cooling tower in which a spray of water falling from the top of the tower is directly contacted and cooled by a stream of air flowing upward. Other direct contact systems use immiscible liquids or solid-to-gas exchange. An example of a direct contact heat exchanger used to transfer heat between molten salt and air is described in Bohn and Swanson. The direct contact approach is still in the research and development stage, and the reader is referred to Kreith and Boehm, For further information. arrangement can be operated either in counter-flow or in parallel flow, with either the hot or the cold fluid passing through the annular space and the other fluid passing through the inside of the inner pipe.

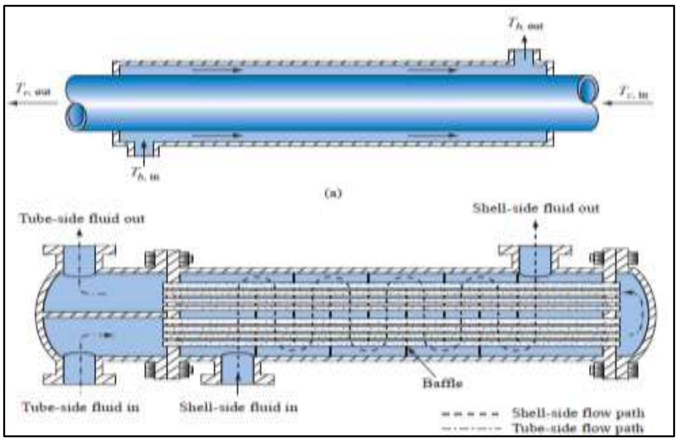

Figure 1.1 (a) Simple tube-within-a-tube counter-flow heat exchanger.

(b) Shell-and-tube heat exchanger with segmental baffles: two-tube passes, one-shell pass.

(Fig 1.1 Courtesy of Research of Keith and Boehm)

Classification of Heat Exchangers

In general, industrial heat exchangers have been classified according to Construction,

- Transfer processes,
- Degrees of surface compactness,
- Flow arrangements,
- Pass arrangements,
- Phase of the process fluids, and
- Heat transfer mechanisms.

Classification According to Construction

According to constructional details, heat exchangers are classified as follows:

- Tubular heat exchangers—double pipe, shell and tube, coiled tube
- Plate heat exchangers (PHEs)- Gasketed, brazed, welded, and spiral, panel coil, and lamella
- Extended surface heat exchangers—tube-fin, plate-fin
- Regenerators—fixed matrix, rotary matrix

Tubular Heat Exchanger- Double-Pipe Exchangers

A double-pipe heat exchanger has two concentric pipes, usually in the form of a U-bend design. Double pipe heat changers with U-bend design are known as hairpin heat exchangers. The flow arrangement is pure counter-current. A number of double-pipe heat exchangers can be connected in series or parallel as necessary. Their usual application is for small duties requiring, typically, less than 300 ft^2 and they are suitable for high pressures and temperatures and thermally long duties. Figures 1.2 shows double-pipe heat exchangers. To enhance the heat transfer rate geometrical modification is also made, fig 1.3 shows Schematic of a double helical coiled tube heat Exchanger.

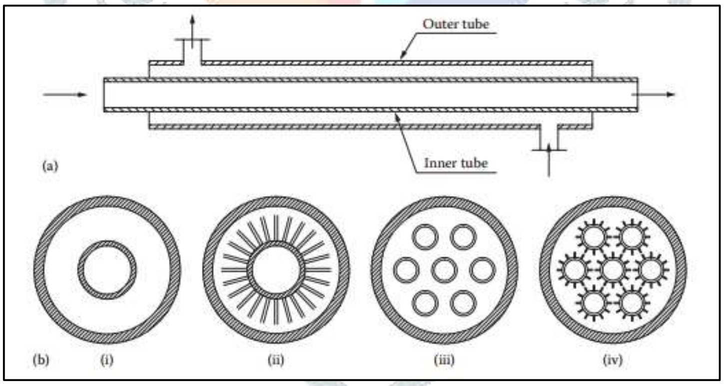

Figure 1.2 Double pipe/twin pipe hairpin heat exchanger. (a) Schematic of the unit, (b): (i) double pipe with bare internal tube, (ii) double pipe with finned internal tube, (iii) double pipe with multibare internal tubes, and
(iv) double pipe with multi-finned internal tubes. (Fig 1.2 Courtesy of Peerless Mfg. Co., Dallas, TX, Makers of Alco and Bos-Hatten brands of heat exchangers)

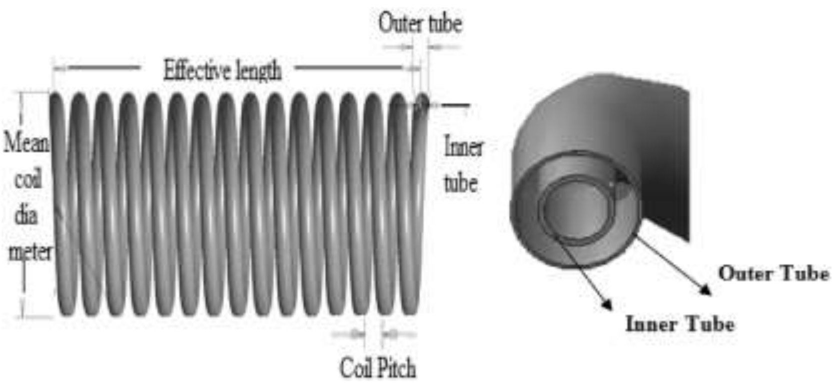

Figure 1.3 Schematic of a double helical coiled tube heat Exchanger. (Fig 1.3 courtesy P.C. Mukesh kumar et.al.research paper)

II- LITERATURE REVIEW

I. *P.C. Mukesh Kumar et. al. (2019) [1]*

This paper investigates the heat and flow characteristics of double helically coiled heat exchanger in which multi walled carbon Nano tubes (MWCNT)/water Nano-fluids is used. In this investigation, the heat transfer and pressure drop of the double helically coiled heat exchanger handling MWCNT/water Nano-fluids have been Analyzed by the computational software ANSYS 14.5 version, The MWCNT/water Nano-fluids at 0.2%, 0.4%, and 0.6% volume concentrations have been taken for this study. It is observed that the heat transfer rate and pressure drop increases with increasing volume concentrations of MWCNT/water Nano-fluids.

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II. *Iman Bashtani et. al. (2019) [2]*

This study numerically investigates a double pipe heat exchanger with a simple and corrugated tube taking three different wave amplitudes. The simulation is performed using ANSYS package, considering turbulent flow and k-ω SST turbulence model. the heat exchanger type is considered to be water-to water and the corresponding flow is parallel so that the hot and cold fluids pass through the inner tube and the shell, respectively. The results show that, in the similar Reynolds number, corrugating increases Nusselt number so that at the maximum state the average Nusselt number of the corrugated heat exchanger is about 1.75 times as compared to the simple heat exchanger.

III. *E.J. Onyiriuka et.al. (2019) [3]*

In the study given by the heat transfer characteristics of a new class of Nano-fluids made from mango bark was numerically simulated and studied during turbulent flow through a double pipe heat exchanger. A two-phase flow was considered using the mixture model. The mixture model governing equations of continuity, momentum, and energy and volume fraction were solved using the finite volume method. The results showed an increase of the Nusselt number by 68% for a Reynolds number of 5,000 and 45% for a Reynolds number of 13 000, and the heat transfer coefficient of the Nanofluid was about twice that of the base fluid.

III. *V. Nageswara Rao et. al. (2018) [4]*

Experimental investigation was conducted by*)* for the estimation of convective heat transfer and friction factor of CuO Nano-fluids flow in a double pipe U-bend heat exchanger under turbulent flow conditions. The hot water was flow through the annulus tube at a fixed mass flow rate of 8 Litre Per Minute. The results indicate that, the Nusselt number of Nano-fluids increases with increase of Reynolds number and particle volume concentrations.

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V. *Naseema et. al. (2017) [5]*

This study investigates the heat transfer enhancement in the heat exchanger with different concentrations in a water-basedAluminium oxide & Copper oxide Nano-fluids. They also examine the rate of heat dissipation by changing Reynolds number. They experimentally found that the rate of heat transfer is more in case of aluminium oxide compare to copper oxide up to volume concentration of 3%.

VIA. *Hussain et. al. (2016) [6]*

Both experimental and numerical study of the heat transfer coefficients of double pipe helically coiled heat exchanger is performed in this paper. test is done for both parallel and counter flow arrangements. Water is used as working fluid in both inner tube side and annulus tubes side. The mass flow rate is varied between (0.032 - 0.0721) kg/s for cold water while hot water is kept constants at (0.0724 kg/s). All experiments performed at the Dean Number for annulus tubes side range of (1250 - 1700). The study. All experimental data is performed at the steady-state conditions. The results show that the mass flow rate ratio ($\dot{m}_r$) effects the axial temperature distribution of heat exchanger also, the effectiveness and efficiency decreased by increasing mass flow rate ratio. Likewise, comparisons between numerical and experimental results have also been made.

VII. *Y.M. Ferng et al. (2011) [7]*

A computational fluiddynamics (CFD) methodology is proposed in this paper to investigate effects of different Dean (De)number and pitch size on the thermal hydraulic characteristics in a helically coil-tube heat exchanger.Depending on the De number, the secondary flow pattern within a coiled tube strongly enhance its heat transfer rate, Dean number (De) portrays the magnitude of the secondary flow. The results reveals that increase in Dean number enhances the magnitude of secondary flow, also the results have been validated experimentally.

VIII *Rahul Kharat et. al. (2009) [8]*

This paper shows the Correlation for heat transfer coefficient for flow between concentric helical coils. In the present study experimental data and CFD simulations using Fluent 6.3.26 are used to enhance the heat transfer coefficient correlation for the flue gas side of heat exchanger. Mathematical modelling is developed to analyze the data obtained from CFD and experimental results to account for the effects of different functional dependent variables such as gap between the concentric coil, tube diameter and coil diameter which affects the heat transfer. Optimization is done using Numerical Technique and it is found that the new correlation for heat transfer coefficient developed in this investigation provides an accurate fit to the experimental results within an error band of 3–4%.

IX. *J.S. Jayakumar et. al. (2008) [9]*

Experiment was done to study the constant thermal and transport properties of the heat transfer medium and their effect on the prediction of heat transfer coefficients. An experimental setup was made for studying the heat transfer and also CFD was used for the simulation of the heat transfer. Based on both the experimental and simulation results a correlation was established for the inner heat transfer coefficient.The results reveals enhancement in the heat transfer rate due to the helical geometry of the heat exchanger.

X. *Vimal Kumar et al. (2006) [10]*

This paper presents the pressure drop and heat transfer characteristics in a tube in tube helical heat exchanger using CFD analysis with counter current mode operation, the work has also been experimentally performed Water is used as working fluid in inner tubes side and annulus tube side, Four turns of coil is considered for the study, 30% increase in the overall heat transfer coefficient was observed with increase in Dean number.Nusselt number and friction factor for both outer and inner tubes were compared with the experimental data collected in this study.

Table 1: The existing research work and different process parameters.

S.No	Title, Authors Name and Year	Dimensions	Type/Geometry of Heat exchanger	Results
1.	CFD analysis on heat and flow characteristics of double helically coiled tube heat exchanger handling MWCNT/water Nano-fluids / P.C. Mukesh Kumar (2019)	Di=12.7mm Do=12mm di=6.35mm do=5.85mm n=15 p=20mm	Helically Coiled Counter flow.	The Nusselt number of 0.6% MWCNT/water nano-fluids is 30% higher than water at the Dean number value of 1400 &Pressure drop is 11% higher than water at the Dean number value of 2200.
2.	ε-NTU analysis of turbulent flow in a corrugated double pipe heat exchanger: A numerical investigation/Iman Bashtani (2019)	_	Shell and tube Heat exchanger with parallel flow	The results show that, in the similar Reynolds number, corrugating increases Nusselt number so that at the maximum state the average Nusselt number of the corrugated heat exchanger is about 1.75 times as compared to the simple heat exchanger.
3.	A numerical investigation of the heat transfer characteristics of water-based mango bark nano-fluid flowing in a double-pipe heat exchanger/E.J. Onyiriuka(2019)	Di=27.8mm Do=29.2mm di=8.13mm do=9.53mm l=1500mm	Counter-flow horizontal double tube heat exchanger.	Nusselt number is increased by 68% for a Reynolds number of 5,000 and 45% for a Reynolds number of 13 000, In addition, the Nusselt number decreased by an average value of 0.76 with an increase of volume fraction by 1%.

4.	Heat transfer and friction factor investigations of CuONano-fluid flow in a double pipe U-bend heat exchanger/V. Nageswara Rao (2018)	Di=50mm Do=56mm di=19mm do=25mm l=2200mm	Counter flow U-bend heat exchanger.	The Nusselt number of Nano-fluids increases with increase of Reynolds number and particle volume concentrations. Nusselt number is enhanced about 18.6% at 0.06% volumeconcentration when compared to base fluid.
5.	Heat Enhancement of Heat Exchanger Using AluminiumOxide(Al2O3), Copper Oxide(CuO)Nano Fluids With Different Concentrations/Naseema (2017)	–	Simple Double pipe heat exchanger	Dispersion of the Nano particles into the base fluid(water) increases the average heat transfer coefficient with the increase in the flow rate of fluid. At a particle volume concentration of 0.1%,0.25%, 0.4% the use of Al2O3/water (and 0.1% of CuO /water) Nano fluid gives significantly higher heat transfer characteristics.
6.	Experimental and numerical study of the heat transfer coefficients of double pipe helically coiled heat exchanger/A Hussain (2016)	Di=38mm Do=40mm di=18mm do=20mm n=15 p=30mm	Helically Coiled Counter flow and parallel flow.	The results show that the mass flow rate ratio effects the axial temperature distribution of heat exchanger also, the effectiveness and efficiency decreased by increasing mass flow rate ratio.
7.	Numerically investigated effects of different Dean number and pitch sizeon flow and heat transfer characteristics in a helically coil-tube heat exchanger/Y.M ferng (2011)	Coil dia=18mm Helical dia=224mm n=7,10,15,20	Shell and tube heat exchanger having helical tube geometry.	The results reveals that increase in number of turns increases Dean number and increase in Dean number enhances the magnitude of secondary flow.

8.	Development of heat transfer coefficient correlation for concentrichelical coil heat exchanger/Rahul kharat (2009)	–	Concentric helical coil heat exchanger	The heat transfer coefficient decreases with the increase in coil gap. With increase in tube diameter the heat transfer coefficient increases.
9.	Experimental and CFD estimation of heat transfer in helically coiled heat exchangers/J.S. Jayakumar (2008)	D=12.7mm d=10mm p=30mm pitch circle dia=300mm	helically coiled heat exchanger.	Enhancement in the heat transfer rate has been observed due to the helical geometry of the heat exchanger.
10.	Pressure drop and heat transfer study in tube-in-tube helical heat exchanger/Vimal Kumar (2006)	D=50.8mm d=25.4mm p=100mm coil dia.=762mm n=4	Tube in tube helical heat exchanger	30% increase in the overall heat transfer coefficient was observed with increase in Dean number.

Thermo-physical properties of Io-nanofluids

Nano-fluids are systems consisting of base fluids (i.e. water, ethylene glycol or oils) and nanoparticles (i.e. carbon nanotubes, oxides or metals) dispersed, therein. The effort undertaken in preparing such materials, is usually driven by the fact that these solutions exhibit specific properties, which are unusual when compared to other individual components, for example the loading of nanoparticles causes thermal conductivity to increase, as well as the specific heat capacity. This group of systems is particularly of interest due to a large range of possible combinations, driven by the selection of the types of base fluids, through a wide variety of nanoparticles, to be dispersed and ending on more sophisticated eutectic mixtures. In particular, the thermal conductivity and the heat capacity of nanofluids have attained an extraordinary scientific attention because of the unusual enhancement of these properties when a given nanoparticle is dispersed in a specific base fluid.

III. CONCLUSION

Due to the wide application of heat exchangers in various industries, improving the heat transfer and increasing the efficiency are very important. Accordingly, a lot of researches have been performed to increase heat transfer. There are various active and passive techniques to enhance the heat transfer Active techniques includes Mechanical aids,Surface vibration, Fluid vibration, Electrostatic fields etc. and Passive techniques includes Extended surfaces, Displaced enhancement devices Swirl-flow devices, Coiled tubes etc. Also compound techniques are also used i.e combination of different techniques mentioned above, As per the review done it is found that there is a research gap to carry out the investigate the heat transfer rate with structural modification of double pipe helical shaped heat exchanger. And the heat transfer phenomena can be effectively enhanced by using the various nano fluids. The further research can be gone in this direction.

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