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Review: CFD Analysis Comparison of Tapered Helical and Square Coil Heat Exchanger Bu Using Different Types of Nanofluid with Oil as Its Base Fluid in Aluminium and Copper Tube

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Abstract: The recovery of waste heat has been a topic of concern for large-scale industrial companies for several decades. This recovery not only makes an operation more environment friendly, but it also helps to cut costs. In addition to this, it can reduce the amount of resources needed to power a facility. Many industries have implemented different methods of waste heat recovery. One popular choice is using a heat exchanger. This paper presents the study of two different types of nano-fluids in two materials off heat exchangers ie.aluminium tapered helical coil heat exchanger and copper tapered helical coil heat exchanger. In this present paper the efforts are made to understand that how to compare the heat transfer rate in Copper and aluminium tapered helically coiled tube heat exchanger using different types of Nano fluid by studying research papers of various authors.
Keywords: Tapered Helical Coil, Tapered Square coil, Nano-fluid, Heat Exchanger, CFD, Pressure Drop, Temperature Distribution, Aluminium and copper.

I. INTRODUCTION

Helical coil heat exchangers are of great use in industrial applications such as power generation, nuclear industry, process plants, heat recovery systems, refrigeration, food industry, etc due to its compact structure and high heat transfer coefficient. Helical coils of circular cross section have been used in wide variety of applications due to simplicity in manufacturing. Flow in curved tube is different from the flow in straight tube because of the presence of the centrifugal forces. These centrifugal forces generate a secondary flow, normal to the primary direction of flow with circulatory effects that increases both the friction factor and rate of heat transfer. The intensity of secondary flow developed in the tube is the function of tube diameter (d) and coil diameter (D). Due to enhanced heat transfer in helical coiled configuration the study of flow and heat transfer characteristics in the curved tube is of prime importance. Developing fluid-to-fluid helical heat exchangers (fluid is present on both sides of the tube wall) requires a firm understanding of the heat transfer mechanism on both sides of the tube wall. Though much investigation has been performed on heat transfer coefficients inside coiled tubes, little work has been reported on the outside heat transfer coefficients

Heat transfer fluid is one of the serious factors as it disturbs the size and cost of heat exchanger systems. Conventional fluids like oil and water have partial heat transfer potentialities. For reduce cost and meet the increasing demand of industry and commerce we have to develop different types of fluids it is our top priority. By chance, the growths in nanotechnology make it possible to get higher efficiency and cost saving in heat transfer methods. Nanoparticles are occupied as the fresh group of materials which having potential applications in the heat transfer area.

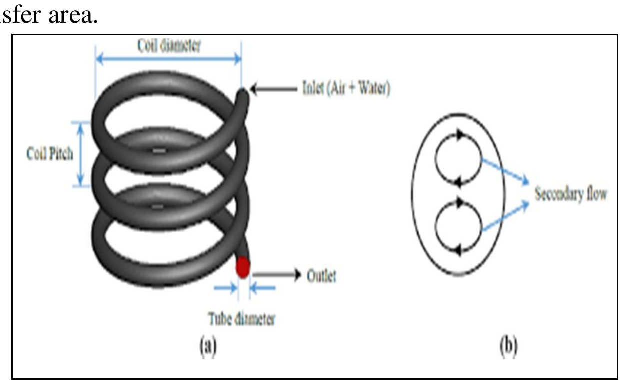

Figure 1 [12]

A. *Nano Fluid*

Nano fluid is nothing but it is a fluid particles which have less than even a micron (9-10 times) smaller in diameter and highly reactive and proficient material which can be used to increase feature like rate of reaction, thermal conductivity of any metal or material and they are that much reactive and strong.

The following benefits are expected when the nano fluid circulates the nano particles: [3]

1) Heat conduction is higher
2) Stability
3) Choking not occurs in Micro passage cooling
4) Probabilities of erosion reduced
5) Pumping power is reducing

II. LITERATURE REVIEW

Helical coil is very compact in structure and it possess high heat transfer coefficient that why helical coils heat exchangers are widely used. In literature it has been informed that heat transfer rate of helical coil is larger than straight tube.

GA Sheikhzadeh et.al. [1] has done work on Effect of Al_2O_3-water nanofluid on heat transfer and pressure drop in a three-dimensional micro-channel after analysis of his work he found that Addition of nanoparticles increased average Nusselt number, which indicated higher heat transfer into the fluids. Thus nano-fluids could be a promising replacement for pure water in micro-channel where there is need to more efficient heat transfer

K. Abdul Hamid et. al. [2] has done work on pressure drop for Ethylene Glycol (EG) based Nano fluid. The Nano fluid is prepared by dilution technique of TiO_2 in based fluid of mixture water and EG in volume ratio of 60:40, at three volume concentrations of 0.5 %, 1.0 % and 1.5 %. The experiment was conducted under a flow loop with a horizontal tube test section at various values of flow rate for the range of Reynolds number less than 30,000. The experimental result of TiO_2 Nano fluid pressure drop is compared with the Blasius equation for based fluid. It was observed that pressure drop increase with increasing of Nano fluid volume concentration and decrease with increasing of Nano fluid temperature insignificantly. He found that TiO_2 is not significantly increased compare to EG fluid. The working temperature of Nano fluid will reduce the pressure drop due to the decreasing in Nano fluid viscosity.

Hemasunder Banka et. al. [3] have done an analytical investigation on the shell and tube heat exchanger using forced convective heat transfer to determine flow characteristics of nano fluids by varying volume fractions and mixed with water, the nano fluids are titanium carbide (TiC), titanium nitride (TiN) and ZnO Nano fluid and different volume concentrations (0.02, 0.04, 0.07 & 0.15%) flowing under turbulent flow conditions. CFD analysis is done on heat exchanger by applying the properties of nano fluid with different volume fractions to obtain temperature distribution, heat transfer coefficient and heat transfer rate. He found that heat transfer coefficient and heat transfer rates are increasing by increasing the volume fractions.

M. Balchandaran et. al [4] have done experimental study and CFD simulation of helical coil heat exchanger using Solid works Flow Simulation using water as fluid. The fluid used for both coil and tube side is water. The flow rate of both fluids is maintained below as laminar and the flow rate of cold fluid is kept constant while that of hot fluid is changed. The readings during experimental study are taken once steady state has reached. The performance parameters pertaining to heat exchanger such as effectiveness, overall heat transfer coefficient, velocity contours, temperature contours etc. have been reported. Based on the results, it is inferred that the heat transfer rates and other thermal properties of the helical coil heat exchanger are comparatively higher than that of a straight tube heat exchanger.

Ashkan Alimoradi et.al [5] has done his Investigation of exergy efficiency in shell and helically coiled tube heat exchangers. He presents exergy analysis for forced convection heat transfer in shell and helically coiled tube heat exchangers. The effect of operational and geometrical parameters on the exergy efficiency was investigated. Water is selected as the working fluid of both sides. Results show that, the efficiency decreases linearly with the increase of the fluids dimensionless inlet temperature difference. Based on the results, a correlation was developed to predict the efficiency for wide range of mass flow rates ratio ($0.1 < Rm < 4$), fluids dimensionless inlet temperature difference ($0 < RT < 0.8$), product of Reynolds numbers (3.31E+8 < (Rec. Resh) < 1.32E+9) and dimensionless geometrical parameters. According to this equation it was found that, the coil which has the maximum number of turns and minimum diameter is more efficient than other coils which have the same length and pitch.

Arvind Kumar Pathak et. al. [6] has done his study on the comparison of CFD analysis of Natural Fluid and Nano fluid in a helical coil heat exchanger. He has used water as a natural fluid and Titanium Oxide (TiO_2) and Zinc Oxide (ZnO) is used as a Nano fluid with base as water. He has fabricated a helical coil of aluminium and copper by bending 1000 mm of tube with 8 mm tube diameter, pitch 15 mm and coil diameter is 35 mm. He found that aluminium coil gives more pressure drop on Zinc oxide Nano fluid as compared to other tubes and fluids.

B. Sidda Reddy et al. [7] studied helical tube heat exchanger as compared to straight tubular heat exchanger in both counter flow and parallel flow by variable parameters like pitch, mass flow rate , temperature and pitch coil diameter. He use outside diameter of stainless steel cylinder of 63.5 mm and inside diameter of stainless steel cylinder 1.058D mm, thickness of tube vary from 6 mm to 9 mm, flow rate of cold and hot water is taken 0.0625 kg/s and 0.166 kg/s. The initial temperature of cold and hot water is 300C and 1000C is taken. Result show that heat transfer increase in counter flow configuration when hot fluid mass flow rate is increased. Increase in pitch coil diameter decreases the rate of heat transfer at same configuration and at same mass flow rate. Also if the coil pitch increases there is decrease in heat transfer at same mass flow rate. Helical coils ensuring larger surface area which allows the fluid to be interacting with the walls for greater period of time. So that there is enhancement in heat transfer as compare to that of straight pipe.

Karishma Jawalkar et. al. [8] has done CFD analysis of Manganese oxide, Silicon Dioxide and Zinc oxide nano-fluid on copper helical coil by using oil as a base fluid, She fabricated a copper coil helical coil of 1000 mm length, 50mm PCD, pitch of 15 mm, and the diameter of tube is 8 mm made in Solid works, she observed after doing CFD analysis that the nano-fluid which has high thermal conductivity and specific heat that fluid will give high pressure drop. As compare to water the oil is used as base fluid oil and creates more pressure. The pressure drop is more when Zinc oxide nano-fluid flow is used.

K Palanisamy [9] investigates the heat transfer and the pressure drop of cone helically coiled tube heat exchanger using (Multi wall carbon nano tube) MWCNT/water nanofluids. The MWCNT/water nanofluids at 0.1%, 0.3%, and 0.5% particle volume concentrations were prepared with the addition of surfactant by using the two-step method. The tests were conducted under the turbulent flow in the Dean number range of $2200 < De < 4200$. The experiments were conducted with experimental Nusselt number is 28%, 52% and 68% higher than water for the nanofluids volume concentration of 0.1%, 0.3% and 0.5% respectively. It is found that the pressure drop of 0.1%, 0.3% and 0.5% nanofluids are found to be 16%, 30% and 42% respectively higher than water.

Shiva Kumar et. al [10] have worked on both straight tube and helical tube heat exchanger. He has compared CFD results with the results obtained by the simulation of straight tubular heat exchanger of the same length under identical operating conditions. Results indicated that helical heat exchangers showed 11% increase in the heat transfer rate over the straight tube. Simulation results also showed 10% increase in nusselt number for the helical coils whereas pressure drop in case of helical coils is higher when compared to the straight tube.

T. Srinivas et. al. [11] have done experimental study on heat transfer Enhancement using Copper Oxide (CuO)/Water Nano fluid in a Shell and Helical coil heat exchanger. Experiments have been carried out in a shell and helical coil heat exchanger at various concentrations of CuO nanoparticles in water (0.3, 0.6, 1, 1.5 & 2%), speed (500, 1000 and 1500rpm) and shell side fluid (heating medium) temperatures (40, 45 & 50^0C). Water has been used as coil side fluid. He found that the heat transfer rate increases with increase in concentration of CuO/water Nano fluid. This can be attributed to increased thermal conductivity of base fluid due to the addition of nano particles.

Vinita Sisodiya et. al. [12] study on the use of Helical coil heat exchangers (HCHEs) with (Aluminium Oxide) Al_2O_3 -Water phase change material to understand if HCHEs can yield greater rates of heat transfer. An analytical study was conducted using a counter flow HCHE consisting of 8 helical coils. Two analysis was conducted, one where water was used as heat transfer fluid (HTF) on the coil and sell sides, respectively; while the second one made use of different Volume fractions of Al_2O_3 and water on the coil and shell sides, respectively. The NTU effectiveness relationship of the HCHE when Al_2O_3 fluid is used approaches that of a heat exchanger with a heat capacity ratio of zero. The heat transfer results have shown that when using an Al_2O_3, an increase in heat transfer rate can be obtained when compared to heat transfer results obtained using straight heat transfer sections. It has been concluded that the increased specific heat of the Al_2O_3 as well as the fluid dynamics in helical coil pipes are the main contributors to the increased heat transfer.

III. PROBLEM FORMULATION

There is less work has been done on heat transfer rate of tapered helical coil heat exchanger and square coil heat exchanger so In my work I am trying to showing the CFD analysis of Al_2O_3 and MgO Nanofluid with oil as its base fluid in square and helical coil heat exchanger by keeping in mind that Nano fluid should produce maximum heat transfer rate with minimum power consummation. Because some times in the process of improving the heat transfer coefficient we consume more power without knowing the economic cost. Consider the helical coil heat exchanger of PCD 50 mm, length 500 mm the pitch of the coil is 25 mm, the coil diameter is 10 mm and tapered angle is 2^0 & the material of coil is Copper and aluminium. And square coil heat exchanger of PCD 50, length 500 mm, pitch of the coil is 25 mm the side of the square is 10 mm and tapered angle is 2^0. In my research I am using Al_2O_3 and MgO as a Nano fluid with oil as its base fluid.

IV. CONCLUSION

The different boundary conditions are taken for tapered helical coil and tapered square coil heat exchanger in aluminium and copper for the numerical simulations. The numerical study considers the effect of Nano fluid Al_2O_3, MgO and oil as its base fluid on the flow and heat transfer characteristics of tube. The thermal properties of fluid are lesser as compared to Nano fluid. We made a tapered helical coil of 50 mm PCD and 10 mm tube diameter of length 500 mm, tapered angle is 2^0, and the square tapered coil of 50 mm PCD, 10 mm square side, tube length 500 mm, tapered angle is 2^0 and the Nano fluid with oil as its base fluid is flow inside the tube.

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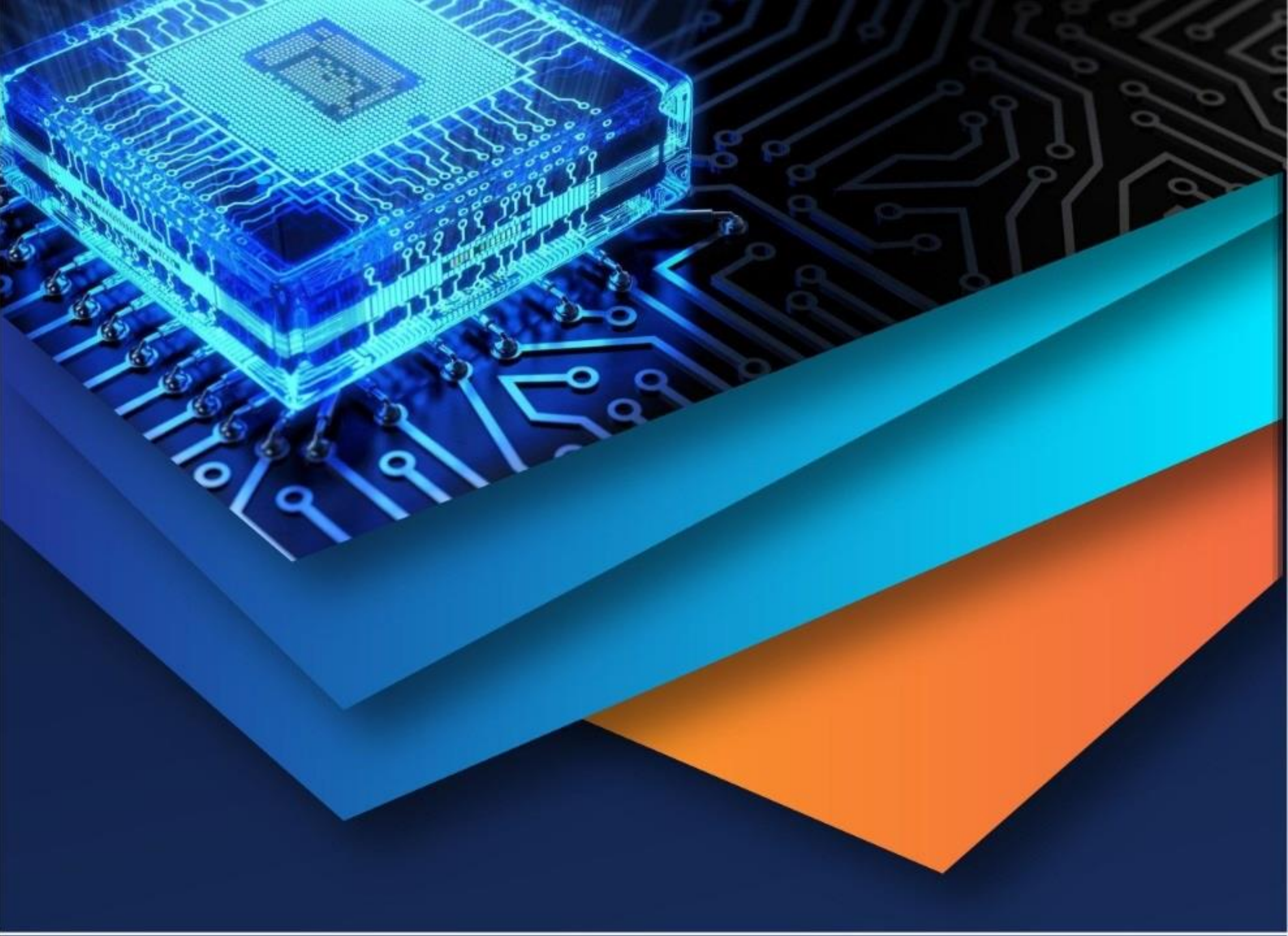

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