ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 13, Issue, 08, pp.18396-18399, August, 2021

DOI: https://doi.org/10.24941/ijcr.42025.08.2021

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

REVIEW ARTICLE

REVIEW: COMPARISON ON CFD ANALYSIS OF TiO2 NANO-FLUID WITH WATER AND ETHYLENE GLYCOL AS A BASE FLUID IN TAPERED HELICAL COIL HEAT EXCHANGER

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ARTICLE INFO

Article History:
Received 17th May, 2021
Received in revised form
29th June, 2021
Accepted 15th July, 2021
Published online 30th August, 2021

Key Words:
Helical Coil, Tapered, Nano-fluid, Heat Exchanger, CFD, Pressure Drop, Temperature Distribution.

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ABSTRACT

Helically coiled heat exchangers are globally used in various industrial applications for their high heat transfer performance and compact size. Nanofluids can provide the superb thermal performance in helical coil heat exchangers. Research studies on heat transfer enhancement have gained solemnmotion during recent years and have been proposed many techniques by different research groups (1). A fluid with higher thermal conductivity has been developed to increase the proficiency of heat exchangers. The dispersion of 1-100nm sized solid nanoparticles in the traditional heat transfer fluids, termed as nanofluids, exhibit substantial higher convective heat transfer than that of traditional heat transfer fluids. Nanofluid is a heat transfer fluid which is the combination of nanoparticles and base fluid that can improve the performance of heat exchanger systems. In this present paper the efforts are made to understand that how to compare the heat transfer rate in Tapered Helical Coil by using TiO_2 nanofluid as water and ethylene glycol as a base fluid by studying research papers of various authors.

Citation: ***Ram Bahadur and Vijaykant Pandey.*** **2021.** "Review: comparison on cfd analysis of tio2 nano-fluid with water and ethylene glycol as a base fluid in tapered helical coil heat exchanger.", *International Journal of Current Research*, 13, (08), 18396-18399.

INTRODUCTION

In most of the Industries, the designing and thermal evaluation of heat exchangers is generally carried out in order to reduce cost, material and energy and to gain maximum heat transfer. The key challenge in heat exchanger design is to make it compact and to get maximum heat transfer in least space. The passive augmentation technique using coiled tube has substantial ability in enhancing heat transfer by evolving secondary flow in the coil. Due to improved heat transfer the study of flow and heat transfer in helical coil tube is of vital importance. Through the growth of thermal engineering and industrial strengthening, the need of efficient and compact heat transfer systems has been increased. In wide-ranging, the heat transfer enhancement methods are classified into two groups. Active method is the method which requires external power, whereas passive method does not require any direct external power. Helically coiled tube heat exchangers (HCTHE) as well as nano-fluids are considered as passive heat transfer augmentation methods. The HCTHEs are generally used in many uses, such as electricity generation and nuclear industries, HVAC, piping systems, chemical reactors and refrigeration systems due to its high thermal proficiency and compactness (low volume to surface ratio). The curvature of helical coil which persuades secondary flow, in joining with more heat transfer area, adds to the heat transfer enhancements of HCTHEs. Numerous studies have specified that helically coiled tubes are higher to straight tubes when working in heat transfer uses.

The centrifugal force persuaded due to the curvature of the tube outcomes in the secondary flow development which augments the heat transfer rate. This phenomenon can be valuable, especially in the laminar flow system. Heat transfer liquid is one of the serious factors as it disturbs the size and cost of heat exchanger systems. Conventional fluids like oil, ethylene glycol 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 developments in nanotechnology create it possible to get higher proficiency 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.

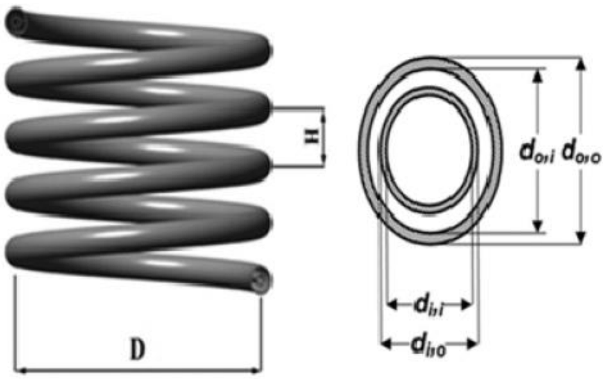

Figure 1 [http://thermalscienceapplication.asmedigitalcollection. asme.org/data/journals/jtsebv/930692/tsea_006_03_031001_f001.png]

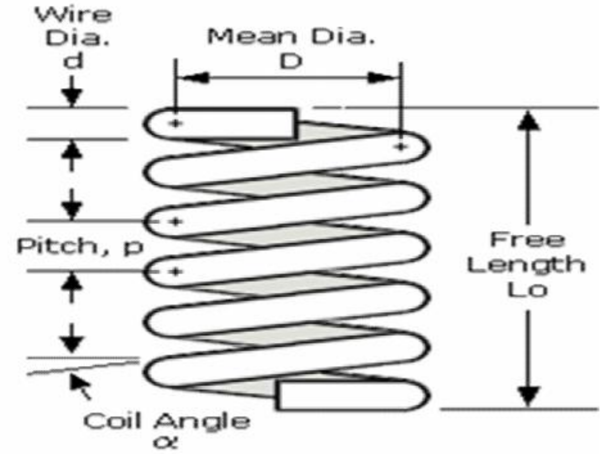

Figure 2 [http://engglearning.blogspot.in/2011/03/helical-spring. html]

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: (2)

Heat conduction is higher: The thermal interface is directly available if the particles are better than 20 nm & if they carry 20% of their atoms on their surface. The nanoparticle is of µ size so there will be the advantage in the movement of particles and it increased the heat transfer because of micro convection of fluid. When the nano particles having large heat surface area then the large heat transfer is allowable. Dispersion of heat is increasing in the fluid at a faster rate because of large heat transfer. When there will be a rise in temperature then the thermal conductivity of Nano fluid increases significantly.

Stability: Nano fluids have nanoparticle of which is smaller in size (9-10 times smaller) or in µ size, so they are light in weight, that's why the chances of sedimentation are reduced.When sedimentation is reducing it will deliver the stability in Nano fluid by settle down the nano-particles.

Choking not arises in Micro passage cooling: For transferring of heat in heat exchanger the Nano fluid is a best option in general and they can be perfect for micro passage uses where high heat loads are faced.

A big area of heat transfer andguiding fluids will occur by the mixture of micro path and Nano fluid and it cannot be managed with meso or micro-particles because they clog micro passages. Nano particles are smaller in size it is in µ which is very small to micro passage.

Probabilities of corrosion reduced: The thrust which is conveyed by a solid wall is minor because nanoparticles areminor. The probability of erosion of components is reducing when the momentum decreases and it occurs in pipelines, pumps and heat exchangers.

Pumping power is reducing: Pumping power is increasing by a feature of ten. When the heat transfer of conventional fluid is increased by a feature of two. If there is a simple increase in fluid viscosity then the pumping power will be increased satisfactory. Thus, a large reserves in pumping power can be achieved. Thermal conductivity can also be increased by small volume fraction of particles.

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.

Karishma Jawalkar *et al*. (2018) has done CFD analysis of Manganese oxide, Silicon Dioxide and Zinc oxide nano-fluid on copper helical coilby using oil as a base fluid, She fabricated a copper coilhelical 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.

Sunil Kumar *et al*. (2017) has done an analysis on Optimizing Design and Analysis on the Helically Coiled Tube Heat Exchanger Carrying Nanofluids by Providing Fins. He has used hot and cold water are used to check the simulation and logged the pressure and temperature of MWCNT/water of nanofluids at 0.2%, 0.4% and 0.6% volume concentrations with the Dean number range of 1300–2000. The final outcome of the study increase the total heat transfer rate inside the domain. And increase the pressure drop inside the domain. The water outlet temperature decrease up to 315k and cold outlet temperature increase up to 320 k. and total pressure drop rise with the temperature increases. Finally the CFD data were compared with previous data the total pressure drop increase up to 0.65 bar for case-2.the total efficiency of the system incites up to 5% to 6%.

Arvind Kumar Pathak *et al*. (2017) has done his study on the comparison of CFD examination 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.

Vijaykant Pandey *et al*. (2015) have done study on the influence of geometrical parameters on heat transfer in helical coil heat exchanger at three dissimilar mass flow rate 0.005, 0.02 and 0.05 kg/s. Helical coil was made-up by bending 1000 mm length of aluminium tube taking 6,8,10 mm tube diameter and each time coil diameter would be 40 mm and at same pitch 15 mm and at same length. The relation between pressure drop and mass flow rate has been obtained for three different curvature ratio 0.15, 0.2, 0.25 at three different mass flow rates. The result shows that by increasing the tube diameter 10 mm and at curvature ratio 0.25 at mass flow rate of 0.05 kg/s there is growth in pressure drop of about 12100 Pa (262.275 %) and Nusselt number also increases about 2.25% in evaluation to tube diameter 6 and 8 mm and at mass flow rate 0.005 and 0.02 kg/s. This can growth heat transfer in helical coil heat exchangers. The growth in heat transfer are a consequence of curvature of the coil which induces centrifugal force to act on moving fluid resulting in development of secondary flow.

Abdul Hamid *et al*. (2015) has done effort 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 investigational result of TiO_2 Nano fluid pressure drop is equated 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.

Palanisamy (2019) examines 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 calculation of surfactant by using the two-step method. The investigations were conducted under the turbulent flow in the Dean number range of 2200 $<$De $<$4200. The experiments were accompanied 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 greater than water.

Hemasunder Banka *et al*. (2016) have done an systematic investigation on the shell and tube heat exchanger using forced convective heat transfer to govern flow characteristics of nano fluids by fluctuating 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 study 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.

Shiva Kumar *et al*. (2013) have worked on both straight tube and helical tube heat exchanger. He has equated CFD results with the results obtained by the recreation of straight tubular heat exchanger of the similar length under identical operating conditions. Results specified that helical heat exchangers indicated 11% increase in the heat transfer rate over the straight tube. Simulation results also showed 10% growth in nusselt number for the helical coils whereas pressure drop in case of helical coils is greater when compared to the straight tube. Srinivas *et al*. (2015) have done experimental study on heat transfer augmentation 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 recognized to increased thermal conductivity of base fluid due to the addition of nano particles.

Balchandaran *et al* (2016) 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 conserved below as laminar and the flow rate of cold fluid is kept constant while that of hot fluid is changed. The analyses during experimental study are taken once steady state has reached. The performance parameters concerning to heat exchanger such as effectiveness, overall heat transfer coefficient, velocity contours, temperature contours etc. have been described. Based on the results, it is concluded 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.

Vinita Sisodiya *et al*. (11) study on the use of Helical coil heat exchangers (HCHEs) with (Aluminium Oxide) Al_2O_3 -Water phase change material to know if HCHEs can yield greater rates of heat transfer. Amethodical study was conducted using a counter flow HCHE containing of 8 helical coils. Two analysis was accompanied, one where water was used as heat transfer fluid (HTF) on the coil and sell sides, respectively; while the second one made use of diverse 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, agrowth in heat transfer rate can be found when compared to heat transfer results obtained using straight heat transfer segments. It has been determined 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.

PROBLEM FORMULATION

In the literature survey we found that so much work had been done to increase the heat transfer rate in heat exchanger. But there is less work has been done on heat transfer rate of comparing the copper taperedhelical coil on water and ethylene glycol nano-fuid as its base fluid. In my work I am trying to showing the comparison ofTitanium Oxide nano-fluid by changing its base fluid as water and ethylene glycol for the heat exchanger keeping in mind that Nano fluid should produce maximum heat transfer rate with minimum power consummation. Because some times in the method of improving the heat transfer coefficient we consume more power without perceptive the economic cost. Consider the Tapered helical coil of 500 mm length, 50 mm PCD, pitch of 20 mm, Tapered angle of $2^0$and the diameter of tube is 10 mm & the material of coil is Copper and Alloy. In my study I am using Titanium Oxide (TiO_2)as a Nano fluid with water and ethylene glycolas its base.

CONCLUSION

The different boundary conditions are taken for tapered helical coil heat exchanger for the numerical simulations. The numerical study considers the effect of Nano fluidTitanium Oxide, water and ethylene glycolas 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 will make aTapered helical coil of 500 mm length, 50 mm PCD, pitch of 20 mm, Tapered angle of $2^0$and the diameter of tube is 10 mm made in Solid works.

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