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A review on the Enhancing Heat Exchanger Efficiency with CuO/Water Nanofluid in a Shell and Helical Coil System

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Abstract

Over the years, there has been a lot of focus on improving heat transmission by utilizing various approaches in an effort to make heat exchangers smaller and less expensive. The following methods have been found to be the most successful in increasing heat transfer rate in heat exchangers: Nano-Fluids, first (3) Rubbing heat exchanger surfaces rough. (2) Inserting fluid tabulators. However, a combination of all three approaches or any two of them might be employed for greater heat transfers. “A device that transmits heat utilizing Nano-Fluid is called a heat exchanger. This uses a Nano-Fluid as the working fluid. One can make Nano-Fluid by suspending nanoparticles in fluids such as ethylene glycols, waters, oils, and hydrocarbons that are fluorocarbons.

Keywords: Nano-fluid, Heat Exchanger, Helical Coil, Pressure Drop, CFD, Temperature Distribution.

INTRODUCTION

The concept of a two-phase fluid, or a liquid including nanoparticles, is innovative, and it is anticipated that this fluid combination would have excellent thermal conductivity. When compared to the thermal conductivities of pure liquids, nanoscale metal, and metal oxide particles scattered in any traditional heat transfer fluid exhibit greater thermal conductivities. Numerous theoretical and experimental research on the characteristics of liquid suspensions containing millimeter- or micrometre-sized particles has been conducted during the past century.

LITERATURE REVIEW

In this publication, Ahmad K. Sleiti [1]discusses the first study combining hexagonal boron nitride (HBN) with poly alpha-olefin (PAO) oil to create a new class of nanofluids for lubrication and heat transfer applications. Experimental research is done on the heat transfer capabilities of nanofluids as well as their specific heat, thermal conductivity thermal diffusivity, and viscosity. Temperature and nanoparticle concentration are used to develop relationships between thermophysical characteristics. As a function of the Reynolds number, heat transfer tests are carried out for both the poly alpha-olefin based on the nanofluid and fluid. It is discovered that the behavior of poly alpha-olefin / hexagonal boron nitride nanofluid depends on temperature (between 20 and 70 °C) and volume concentration (0.25 and 1%). For both base fluid and poly alpha-olefin / hexagonal boron nitride nanofluids, the viscosity falls with temperature and rises with concentration. For pure poly alpha-olefin and for nanofluid with a 1% concentration, the specific heat increases with temperatures by 44.0% from 45.0 °C to 95.0 °C and by 48.0% from 45.0 °C to 95.0 °C. As the concentration of hexagonal boron nitride rises, the thermal conductivity of nanofluids becomes noticeably greater than that of pure PAO. Unlike other nanofluids, pure poly alpha-olefin and nanofluids experience a temperature-dependent drop in thermal conductivity. The average and highest Nusselt Number values for the heat transfer augmentation for hexagonal boron nitride concentrations of 0.25, 0.6, and 1%, respectively, were 10%–13%, 17%–20%, and 26%–29%. When viscosity falls and thermal conductivity rises, respectively, the resistance to the thermal diffusion sublayer increases, affecting the efficiency of heat transmission. The improvement in heat transfer was brought about by the increase in thermal conductivity for the poly alpha-olefin / hexagonal boron nitride nanofluids. [1].

H M Shankara Murthy et al. The combined impacts of water-based Al2O3 and GO nanofluids, as well as the Propeller Turbulator (PT) inserts, on improving the thermal performances of counter-flow double tube heat exchangers are the subject of experimental investigation. The experiments used a hot water flowrate of Re in the inner tube with a propeller insert and varied flow rates of water-based Al2O3 and GO nanofluid flowing in the annulus at 500.0 B Re B 5000 (vol.%: 0.050, 0.10, 0.150). According to experimental data, when a tube is equipped with a 10.0 propeller and 0.150vol% of Al2O3 nanofluid, the Nusselt number increases by 29.430%, and the TPF increases by 1.320 times. With a little rise in friction factor, a severe increase in the conducted combinations was seen for the greater ratio of propellers to Al2O3 nanofluid. The correlations between the Nusselt number and the friction factor were constructed and projected to be accurate to within 14.0% to 10.0% and 10.0% to 5.0%, respectively [2].

Mohamed Omri et al.[3] Experimental analysis has been done on the thermal performance's improvement of a verticals spiral coil heat exchanger employing distilled water-based metal nanofluid. As a result, the synthesis for hybrid nanoparticle-based suspensions with different mass fractions is the main emphasis of this study. To maintain the system of laminar flow the volume per second is varied between. An ultrasound so nicator is utilized to ensure dispersion and prevent agglomeration, and thermal conductivity is assessed using the KD2 Pro Infrared Properties Analyzer. It has been discovered that increasing the mass fraction of nanoparticle significantly improves thermal conductivity and thermal energy.

Pandya, Naimish S. [4]Since the last two decades, there has been a significant increase in the use of nanofluids. Nowadays, nanofluids have successfully captured the interest of researchers. There are currently many publications being reported that deal with this fascinating field and its amazing applications. However, the current captivity of nanofluids illustrates the urgent necessity to provide a thorough analysis of nanofluid applications in several fields. The use of nanofluids in various Plate Heating Exchanger (PHE) geometries is examined in this research. All of the research that have been published fall into one of two broad categories: experimental or numerical. Additionally, each section includes an extensive table with pertinent data on the size of the nanoparticles, techniques. In the end, it was discovered provided required and notable thermal stability when compared with conventional fluids. The findings of the statistical analysis the author provided for previously published works demonstrate the growing significance of the use of nanofluids in plate heat exchangers. In comparison to the basic fluids, the majority of investigations revealed favored thermal behavior, improved heat transmission, decreased entropy formation, and decreased exergy destruction. A higher Reynolds number might result in faster heat transfer. The efficiency of heat exchange systems and heat transfer improvement is significantly influenced by the operational temperature of nanofluids. Nearly all investigations have shown that, when compared to the base fluid, nanofluids exhibit preferable thermal behavior in plate heat exchangers, but Chevron.

Y. Vermahmoudi and others.[5] This study reports the experimental measurement of the Fe2O3/water nanofluid's general coefficient of heat transfer using the LMTD method in a small air-cooled heat exchanger. Various nanofluid inlet temperatures, nanoparticle volume concentrations, and Reynolds numbers for air and nanofluid flow were used in the studies. From this research, the following findings can be drawn: (a) The determined overall heat transfers the coefficient for nanofluid and water show very good agreements with the associations of. via average errors of 7.0% as well as 17.0% for filtered water, respectively, together with the relationships with an average variance of 3% for nanofluids; (b) raising the nanofluids concentration increases the overall heat transfer coefficients. In contrast, it is discovered that increasing its inlet temperature results in an increase in heat transfers rates of about 116.0%, which is only possible at much greater flow of nanofluid rates; (c) experiment results show that increasing an nanofluid or air flow Reynolds numbers improved the total coefficient of heat transfer and the rate of the nanofluid [5].

D. Sarath Chandra and colleagues[6]. It is calculated how the is affected by the total coefficient of heat transfer and the pressure drop. Nickel as well as copper nanoparticle are added to a base fluid mixture in volume concentrations of 0.02, 0.04, and 0.06 to measure the rate of heat transfer. The ultrasonication method is utilized first, followed by the magnetic stirrer approach, to regulate the deposition of nanoparticle in the foundation fluid. In this study, studies are carried out that enhances the efficiency of heat transfers instead of decreasing nanoparticle stability. Under a laminar flow regime, experiment is Carrie out with various coil turns and concentrations. According to the findings, 0.04% vol of Cu-Ni/H2O containing 12 turns is more commonly employed for food processing application.

Gogan Dhar and others.[7] This investigation looked at the enhancement of heat transmission in a tube employing a 0.10% volumes fraction of MgO-water nanofluids. The experiment was conducted in a 900mm long copper tubes with an outer diameter of 30.0mm and an interior diameters of 26.60mm. For measuring the fluid's and the tube's exterior temperature, two thermometers and four k-type thermocouples, respectively, were used. The flow rate was determined using a rotameter. The difference in pressure head between the tube's intake and exit sections was measure use a U-tube manometers. A nichrome wire that was encircling the tube was heated continuously by a voltage regulator. the heats transfer coefficients, the Nusselt number, the friction factors, the needed pumping powers, and the percentage increase of.

Sulaiman Musediq A and others[8]. This study looked at how heat transmission in a DPHE was affected by a mixture of cold fluids and cold fluids and different volume fraction of CuO nanoparticle. This was accomplished by modeling the running computerized fluid dynamics analysis on it the volume percentage of nanoparticles made of copper oxide in the nanofluid increased from 0% to 0.10%. Consequently, adding CuO nanoparticles improved heat transmission, supporting earlier findings.

M.A. Khairul and others[9]. For effective heat transmission from one medium to another, heat exchangers have been extensively employed. Potential coolants that offer high thermal performance in heat exchanger are nanofluids. This study looked at how water and CuO/water nanofluid affected the When the volume concentration of nanoparticles was increased from 0.50 to 1.50% in comparison to water, the rose by roughly 18.50 to 27.20%. Furthermore, for nanofluids, an increase in heat transfer rate was noted. However, by using nanofluids as a heat transfer medium instead of a traditional fluid, energy loss was decreased by 24%. Additionally, 34% greater energetic.

Ankit Kumar Gupta[10] and others. It was discovered via research into the use of tiny fluids in turbulent and laminar flows that the addition of nanoparticle to the base fluids increase the thermals conductivity of nanofluids. In comparison to the impacts of the thermos-physical property of the nanoparticle in the flow, the effects of nanotechnology on the coefficient of heat transfer of homogenous nanofluids are generally negligible. Both single-phase and a two-phase model are used in numerical investigations of small particles within heat exchangers. Without considering any slide between nanoparticle and fluid, a single-phase model is taken into account. However, the particle's slip and molecule Brown's laws of motion are taken into account in the two-phase model. Since research has proven that using small fluids in heat exchangers improves their performance characteristics, using nanofluid.

A nanofluid, according to N. K. Chavda,[11] is a suspension of small particle made out of metals, oxide, or carbide atoms with sizes up to 100 nm in water, ethylene glycol, or oil as the base fluid. Numerous tests have recently been conducted to determine how nanofluids can improve the rate of the transfers of heat in different heat exchanger. The type, size, shape, type of base fluids, and number of nanoscales in the base fluid are the primary factors influencing the improvement of heat transfer utilizing nanofluid. The effects of various concentrations of nanoparticles of CuO mixed in waters on the heat transmission properties of double pipe have been experimentally evaluated in the current research. CuO nanofluid made in two steps has volume concentrations of 0.002%, 0.003%, and 0.004%. The study's result, which has also been supported by theoretical prediction [11], is that the overall coefficient of heat transfer rises as CuO nanoparticle volume concentration is increased relative to water.

"Syed Sameer[12] et al." Nanofluids are capable of improving heat transmission in a variety of applications. Nanoparticle (1 to 100 nm) spread consistently and uniformly in an underpinning fluid make up nanofluids. The thermal conductivity and turbulence coefficients of the nanofluids are greatly enhanced by these distributed nanoparticles, which enhances heat transfer. This study examines the efficiency and total coefficient of heat transfers of counter-flows STHEs (tube and shell heat exchangers), which have a 25% baffle cut.

Particles of CuO in DW base fluid were used to create the CuO-DW nanofluid utilizing a two-step procedure at volume fractions of 0.050%, 0.10%, and 0.20%. The stability of dispersed nanoparticles is improved by the use of as a surfactant. As a boost in CuO nanoparticle concentration in DW base fluid, the thermophysical parameters of CuO-DW nanofluid as such as volume, the dynamic viscosity and thermal conduction, increase, but the amount of specific heat drops. At a mass flow rate of 0.6 lpm, the maximum exchanger efficacy was, respectively, 2.92%, 3.85%, and 5.66% greater than water for CuO-DW nanofluid volumes fractions of 0.05%, 0.10%, and 0.2%. In comparison to water, the counter flow STHE has higher actual heat exchange, degree of general heat transfer, as well as efficacy values.

P. Sivashanmugam[13] et al. conducted an experimentally investigations of the heat transmit and friction factors features of a circular tube fitted with a completes helical screws element of various twist ratios, and they also looked at the decrease and increase sequence of twist ratio sets while studying a uniform heat flux in turbulent flow conditions. Between 2700 and 13 500 was the range for the Reynolds number. The results of the experiments are compared to published results from plain tubes. The twist produced a maximum Nusselt number of 1.95. When the helical twist insert's performance was compared to the twisted tape effectiveness described in the literature, it was discovered that the helical twist inserts performed better. Also given was the heat transfer enhancement for helical twists of rising and falling order twist. To determine the viability of applying the helical twist insert, a performance evaluation research has been presented [13].

Ravi Kulkarni[14] and others. The goal of this review is to provide an overview of current advances in the drop of pressure in shell and helix coil heat exchangers, convective heat transfer, and these technologies when using Nano-Fluids as the working liquid. The Nano-Fluid is a blend of traditional base liquids like ethylene glycol and DI water with nanoscale materials, such as metal oxide. The focus of the study has been in turbulent and laminar flow conditions. In this essay, we will examine. By introducing a modest proportion of nanoparticle concentration in the foundation fluid for both flow conditions, we can see a significant variation in the Nusselt number [14].

Rohit Soni [15] and others. A heat exchanger that utilizes Nano-Fluid is an appliance that transfers heat used to study forced convection heat transfer utilizing distill water as the base fluid and a Nano-Fluid. For the purpose of determining heat, tests on both plain and tube with inserts have been done. The experimental results indicate that the friction factor, heat transfer, and thermal performance factor achieved with the combined use of CuO/water nanofluids and helical coiled inserts are superior to those obtained using each method individually under similar operating conditions. Evidently, as CuO/water nanoparticle fluid volume percentage and pitch ratio increase, so does the rate of heat transmission. Additionally, the parallel arrangement of a copper tube with a Nano-Fluid made of copper oxide and a helical coiled insert offers better heat transfer performance than a plain tube. In this experiments work, the usage of CuO/water

Nano-Fluids at volumes concentrations ranging from 0.02% under copper tube linked via helical coiled plugs.

Malik Parveez [16] and others. With a general rise in parameters, including overall heats transfers coefficients, Nusselt number for the wrap and coils alongside each other heat transfer rate, creation of entropy rate and effectiveness with an upsurge of Nano-particle volume fraction, the current experimentally work use Nano-Fluid instead of normal base fluid for heats transfer utilization has shown promise effect. Density and heat conductivity are the most crucial factors when considering efficiency improvements. In comprising to waters, the rate of the transfer of heat for nanofluid increases noticeably for the same flow rate. The spiral coil heat exchanger's efficiency rose by 38.80% [16].

SENTHILRAJA [17] and others, S. The effects of a CuO/water-based coolant on a particular diesel engine's combustibility and exhaust emissions are discussed in this article. The nanofluid-based coolant for engines was made with 27 nm CuO nanoparticles. CuO/water nanofluid at three distinct volume concentration (0.050%, 0.10%, and 0.20%) were made utilizing a two-step procedure. This study uses a CuO/water nanofluid to analyze the nitrogen oxides, exhaust gas temperatures, and particular fuels consumptions under various load circumstances. Following a number of tests, it was found that exhaust emissions are significantly impacted by CuO/water tiny liquids, even at small volume concentrations. According to the experimental findings, the particular fuel consumption decreased by during full load conditions.

Gregory J. Zdaniuk [18] and others. Using fluid water at Reynolds amounts that vary from 12,000 to 60,000, the heat transfer efficiencies and friction factors for nine helically-finned cylinders and one smoothness tube were experimentally calculated. The helix angles of the helically-finned tubes evaluated in this study range from 25° to 48°. Following completion of an uncertainty analysis, acceptable agreement was found when comparing plain-tube findings. Using least-squares regression, power-law correlations for the have been established. With typical prediction errors ranging between 30% and 40%, the accuracy of the associations was assessed using data from other studies. Elsevier Inc. published [18].

S.P. Kulkarni [19] et al. To determine the impact of each parameter, numerous factors impacting the heat transmission characteristics were examined. To create the nanofluid for the experiment, 40 nm-sized Copper Oxide nanoparticles with a volumetric percentage of 0.25% are utilized. To improve the temperature transfer efficiency for heat exchangers, the study's findings demonstrated that CuO nanoparticle dispersion. The findings also showed that a coil with a lower pitch ratio, 1.29, could increase heat transfer when compared to coils with P/D values of 1.47 and 1.85. Comparisons are made between the Nusselt quantity, convective heat transfer coefficients, total heat transfer value, and nanofluid for various designs with and without helically wires coils insertions [19].

E. Gokulnathan [20] and others. The possibility of the swirl coils heat transfer at a low flowrate (laminar) is improved by the examination of additive passive manner by using the various fluids to base fluids. Here, adding nanoparticles and nanofluids to the base fluid results in a greater heat carrier coefficient. Some alternative non-Newtonian theories are capable of increasing the amount of a heat carrier.

S.P. Kulkarni [21] et al. The improvement determines the impact of each parameter, many parameters impacting the heat transfer properties were examined. To create the nanofluid for the experiment, 40 nm-sized Copper Oxide nanoparticles with a volumetric percentage of 0.25% are utilized. The heat exchangers, the study's findings demonstrated that CuO nanoparticle.

Prabhakar Zainith [22] and others. The improve heat transfer is described. In the current study, three distinct CuO levels (0.010%, 0.0150%, and 0.020% by capacity) or three distinct p/d ratios of helical coiled inserts are employed. The working fluid in this is a Nano-Fluid. By suspending nanoparticles in fluids one can create nanofluid. Nanofluid with helical coiled inserts was used to investigate forced convection heat transfer in a circumferential tube heat exchanger. For the purpose of determining heat, tests on copper tubes with nanofluid and on tubes with helical coil inserts have been done. When utilizing the base fluid, the results obtained coil inserts are contrasted with those obtained using a simple tube, both with and without inserts. T. Evidently, as pitch by diameter (p/d) ratio decreases and CuO/water Nano volume concentration increases, heat transfer rate also increases. Additionally, the parallel arrangement of a copper tube with a Nano-Fluid made of copper oxide and a helical coiled insert offers better heat transfer performance than a plain tube. The highest thermal performance factor in this experiment.

G. J. Zdaniuk [18] and others. For the flow of fluid water in helically-finned tubes, experimentally measured Colburn j-factors with Fanning friction factors were correlated using a linear regression technique. Eight improved tubes with helix inclinations between 25 and 48, fin counts around 10 and 45, fin height-to-diameter proportions around 0.0199 and 0.0327, plus Reynolds coefficients that range from 12,000 to 60,000 were used to collect experimental data. The results of the current study showed that for helically-finned tubes, linear combinations involving the same five basic groupings of parameters and a constant can be used to correlate the logarithms of friction and Colburn j-factors. Excellent findings were obtained when the postulated functional link was validated using data from independent experiments [22].

S. Senthilraja and others. This paper reports on experimental studies of the heat transfer value of the CuO/Water nanofluid. A double-tube heat exchanger was used to determine the coefficient of heat transfer of CuO/water. A CuO-nano particle was dispersed in deionized water to create the nanofluid. For this experiment, a CuO/water nanofluid with a theoretical diameter of 27 nm was employed at two distinct volume concentrations (0.1 & 0.3 vol.%) at room temperature. This experimental finding demonstrated that the Nusselt numbers increases with rising liquid flow rate and the convective transfer of temperature coefficient increases with increasing time [17].

Shriram Pathak and others. A heat exchanger that uses nanofluids is a device that transfers heat using nanofluids. Nanofluid a working fluid in this. Using CuO/water as a the nanofluid and reduces water as the base fluid, heated by forced convection has been investigated studied in a heat exchanger made up of concentric tubes fitted with helical coiled inserts. To determine the heat transfer, friction factor, and thermal performance coefficient within a Reynolds number range of 3000 to 11000 and volume concentrations of 0.01%, 0.015%, and 0.02% of nanofluid at room temperature, tests were conducted on both plain tubes and tubes with inserts. The results obtained using CuO/water nanofluid and helical coiled inserts were compared with those from plain tubes without inserts. The findings of the experiment show that under similar operational circumstances, friction factor, thermal performance factor related Additionally, heat transfer, the parallel arrangement of a copper tube with a Nano-Fluid made of copper oxide and a helical coiled insert offers better [23].

An exact explanation of the best nanofluid research for use in the transfer of heat in heat exchangers with helical coils has been discussed. The majority of the research mentioned in the literature review demonstrates that distributing nanoparticles into the base fluid improves the heat transfer coefficient. Increased particle size also results in an increase in heat transfer coefficient. The findings of employing tiny fluid in thermal transfer experiments show how little is currently known about nanofluid. Nanofluids with regulated particle size and shape pose the biggest threat to heat transfer applications among the problems facing the nanofluid community, which range from generation to system knowledge[24]. Future research should take into account additional qualities, particularly viscosity and wet ability, and carefully explore how these affect flow and heat transmission in addition to the impact of heat conductivity.

CONCLUSION

Chemical reactions in cooling and heating systems, understanding micro-sized applications are three areas where understanding and improving heat transfer velocity is a big challenge. There are numerous ways to lower operating costs. The heat transmission coefficient, tension drop, and resistance to flow are the three most essential factors in the heat transfer device's dimensions and price reduction. Designing equipment with a focus on improving heat transfer coefficients while lowering flow resistance is the major goal. So, it's crucial to create methods to improve heat exchanger performance. It is well knowledge that a variety of augmentation techniques can increase heat exchanger efficiency. The use of Nano-Fluid and active augmentation techniques, like incorporating turbulence promoters, are regarded to be the most successful among them.

To the best of our knowledge, despite the fact that compounding thermal transfer improvements have been the subject of countless studies, the amalgamation of two ways still stands. The focus of the current project is on the use of CuO nanofluids in copper tubes with helical coiled inserts. Three distinct Nano-Fluid concentration ranges of 0.010, 0.0150, and 0.020% by quantity, three coiled insert proportions (plane, p/d=2, and 4) and Reynolds number values between 3000 and 11,000 are among the areas of interest.

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