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Heat Transfer Properties of Shell and Tube Heat Exchanger Using Copper Nanofluids

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Abstract: Energy is one of the most crucial challenges in every industry, and its use or potential transmission devices are critical parameters. The chemical industry relies on HE. Nano-fluids may now be utilized in combination with a heat exchanger to boost heat transmission rates. The STHE are a basic model that demonstrates fundamental HT concepts. It is made up of numerous parallel tubes held together by a cylindrical casing. Heat is transferred between the tube bundle and the cylinder shell that covers the tubes via two fluids that pass through the tube bundle. Nanofluids are extremely important in HT applications. Several industrial processes rely on heat transport. Preparation of a green synthetic nanofluid and evaluation of the total coefficient of HT in a STHE.
Keywords: HT, STHE, CuNPs, LMTD,XRD, SEM, AFM.

1. Introduction

STHE are devices that aid in the transfer of energy amid fluids of various temperatures. They're employed in industries including power generating, chemical processing, food production, electronics, manufacturing, air conditioning, and refrigeration. HE are used in automotive systems such as automobile radiators, domestic appliances like as coolers and freezers, as well as the oil and gas industries for fluid preheating and cooling. They are also used in power plants to cool the fluid used in exhaust turbines or warm the entering boiler fluid to save heating costs. Solar collectors, electronic industries, aeronautics, and other applications for HE include also of great interest.

The potential applications of nanomaterials in catalytic, electrical, optical, photonic, fluid, and antibacterial activities have led to a substantial body of research. Nanostructures can be formed by physical, chemical, or biological processes. Physical and chemical approaches are not favored due to the usage of toxic substances, expensive expenses, and high energy demands. Green synthesis approaches have focused much more than earlier methods on resolving the negative consequences of physical and chemical operations. Ecofriendly solutions to produce metal oxide nanoparticles, such as the use of plant extract, microbes, and algae, have piqued the interest of researchers. Plant extract was more selective than other green ways for the purpose to create metal nanoparticles due to its simplicity of use and accessibility, as well as its low cost and compliance with thermal applications.

HT by fluid movement is vital in numerous industries, including power plants, electronics, and so on. Technological developments in industries opened the way for different studies to be undertaken to identify new techniques for HT augmentation.

This study intends to contribute to the growing body of knowledge on advanced HT technologies by investigating the rate of HT of a STHE using Cu nanofluids, with potential benefits for various industrial processes, energy efficiency, and sustainable engineering practices.

2. Literature Survey

M. Stella Bharathy et al. (2021) have discussed fabrication of CuO nanoparticles utilizing Solanum trilobatum leaf extract, which has been shown to have considerable antibacterial effects.

Zahrah Alhalili et al. (2022) have explored nanoparticles of CuO are made from eucalyptus eloboulus leaf extract. the green CuO nanoparticles that were created are spherical, with a the average particle size is 88 nm. and 16.9 mV negative zeta potential, according to SEM and dynamic light scattering tests

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Saeed Aghakhanib et al. (2019) explored the use of nanofluid in different types of HE. In this paper, a review of nanofluids studies and an outline to nanofluids are presented first, followed by an examination of their modeling methodologies, and lastly, investigations on the employed tubes in HE are studied.

Eric C. Okonkwo et al. (2021) explored the synthesis and application of nanofluid in heat exchanging devices. This paper analyses the advancements in the field of heat exchanging devices utilising nanofluids, as well as the benefits and drawbacks of these applications.

Elcio Nogueira et al. (2020) explored the Analytical solution for determining hot and cold fluid exit temperatures in a STHE. The findings show that having a high efficiency, which implies a higher rate of heat exchange, is insufficient if the intended outcome temperature is as low as feasible.

Nilanjan Chakraborty et al. (2022) covered all in his review, he discusses possible green manufacturing methods for CuO nanoparticles. That research indicated that numerous metal NPs exhibit a range of biological and biochemical actions, but Cu NPs have lately received interest.

P.G. Bhavyasree et al. (2020) discussed at room temperature; CuO nanoparticles were prepared from Cuso4 pentahydrate solution using Malabar nut leaf extract. Under certain circumstances, the nanocomposites were created by combining a Cuso4 pentahydrate solution with a plant extract.

Sunday Adewale Akintelu et al. (2020) discussed the creation of CuO n anoparticles using several chemical methods. This study focuses on gathering complete data from current advances in synthesis, characterization, and applications.

Suresh Chand Mali et al. (2020) discussed the leaf extract of Celastrus paniculatus is used in the ecologically friendly green manufacture of Cu nanoparticles. CuNPs were created utilizing a simple and uncomplicated technique from Celastrus paniculatus leaf extract. The characterization research showed the morphological aspects and the influence of stabilizing agents during CuNPs manufacturing.

Mithun Kumar Ghosh et al. (2020) descussed the paper describes the green production of CuNPs utilizing a leaf extract from jatropha curcas . A simple green chemistry strategy was used to create Cu nanoparticles from a JC leaf extract. XRD, examples of spectrophotometry were used to analyze the JC-CuNPs.

Rajeshkumar et al. (2019) discussed Celastrus paniculatus leaf extract was used in the ecologically friendly green manufacture of Cu nanoparticles were produced from Celastrus paniculatus leaf extract using a simple and straightforward procedure in this papper investigation. The characterization investigations showed the morphological properties as well as the effect of stabilizing agents on the formation of CuNPs..

Murugesan Gowri et al. (2019) discussed the green method of synthesis of metal oxide nanoparticle production utilizing leaf extracts has sparked considerable interest due to its low cost, speed, simplicity, and environmental friendliness. UV-visible spectroscopy, FTIR, XRD, SEM, and XRD were used to analyze the produced CuO NPs, and Transmission electron microscope.

Shanmugam Rajeshkumar et al. (2020) reviewed the CuNPs are produced by Cissus vitiginea. Nano Cu's antioxidant and antibacterial properties were investigated. The absorbance at 370 nm of UV spectroscopy was applied to characterize the nanoparticles. Because Cu is a well-known antibacterial agent, our findings suggest that Cu nanoparticles could be used as a novel class of biocidal agents.

Syed Sameer et al. (2020) reviewed the total HT coefficient and efficacy in a counter-flow STHE with a 25% baffle removal. Before deploying nanofluids in industrial applications, the dangers associated with these problems must be studied and addressed.

Mohammad Fares et al. (2020) discussed the Multiple processes are required to improve the HT performance of a STHE operating with graphene nanofluids; graphene nanofluids are known for their exceptional thermal conductivity, making them appealing for improving HT in HE. According to the findings, using graphene/water nanofluids improves the thermal performance of STHE.

Boshra Mahmoudi et al. (2019) Explored the use of nanofluids in HE has been discussed. The nanofluids investigations and introduction of nanofluids are given, followed by an investigation of their simulation methodologies, and ultimately, investigations of the tubes were used in HE, including Plate HE, helical HE, STHE, and double-tube HE have all been studied.

S. V. Sridhar et al. (2020) reviewed the performance of a STHE using tin nanoparticles-water and AgNPs-water nanofluids was investigated through an experiment. The effects of nanoparticle Volume concentrations were studied for their effects on thermal conductivity, viscosity, HT coefficient, fiction factor, Nusselt number, and pressure drop.

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Amr M. Hassaan et al. (2022) described at various volume concentrations, The performance of a HT type shell and tube utilising multi wall carbon nanotubes based on distilled water was discussed. HT improvement techniques are one of the sources that are constantly being investigated due to their utility in energy-saving processes in a variety of fields.

Hyo-Jeoung Lee et al. (2011) focused the goal of Biological production of Cu nanoparticles using a plant extract is to create Cu nanoparticles in an environmentally friendly and sustainable way, mediated by bioactive substances found in the plant extract. As a result, foams coated with biologically synthesized Cu nanoparticles demonstrated greater antibacterial activity than untreated foams.

M. Naraki et al. (2013) explored the overall transfer of heat efficiency of Nanofluids made of CuO and water is investigated experimentally in a car radiator using a laminar flow. The findings show that the overall HT coefficient of a nanofluid is greater than that of the base fluid. The data is statistically analyzed using the Taguchi method and the Software from Qualitek-4.

N.A. THAMER et al. (2018) explained an aqueous extract of Cordia myxa L. leaves was successfully used as a reducing, stabilizing, and capping agent in the preparation of CuO nanoparticles. The biosynthesized nanoparticles were characterized using XRD, SEM, EDS, and AFM.

Suci Amaliyah et al. (2020) reviewed the use of Piper retrofractum Vahl medicinal fruit extract as an environmentally benign reagent used in the production of CuNPs from Cuso4. The results demonstrated that Piper retrofractum Vahl fruit extract could be used for a greener synthesis of CuNPs with high particle size uniformity.

S. Mohammad Sajadi et al. (2015) discussed the green synthesis of CuO NPs on Tamarix gallica leaf extract, as well as its catalytic activity for the N-arylation of nitrogen-containing heterocycles with aryl halides in the absence of a ligand. Tamarix gallica leaves are employed as a reducing agent for the first time as a biomaterial.

P.Naga Padma et al.(2018) discussed Several plant extracts were used along with lowering and stabilizing agents in The sustainable combination of Cu NPs. Agar well tests were used to estimate the antibiotic properties of the biosynthesized nanoparticles against Gram-positive Bacteria Staphylococcus aureus is a kind of bacteria.

3. Result and Discussion

Nanofluids are fluids that have been produced that incorporate nanoparticles that can increase thermal characteristics when compared to traditional HT fluids. Because of their excellent thermal conductivity, Cu nanoparticles are widely investigated for increasing HT rates. A variety of factors influence particular HT performance, including nanoparticle concentration, base fluid properties, and experimental circumstances. HT rates using Cu nanofluids were determined in a few investigations. Increasing the level of awareness of Cu NPs in the fluid may enhance thermal conductivity and, as a result, heat transmission. However, there may be an optimal concentration beyond which additional increases may not significantly enhance performance or may produce stability issues.

The thermal conductivity of the fluids involved is essential. For example, if you use a nanofluid containing Cu nanoparticles, the thermal conductivity may change with temperature. Cu, as a metal, has temperature-dependent conductivity. The logarithmic mean temperature difference is an important measure to consider when analyzing HE. It is determined by the temperature profiles of fluids that are both hot and cold. The LMTD fluctuates as the difference in temperatures between hot and cold fluids changes, influencing the overall HT rate.

4. Conclusion

When compared to standard transmission of heat fluids, the use of Cu nanofluids has resulted in a considerable improvement in thermal conductivity. This innovation improves heat exchange efficiency within the STHE. The introduction of Cu nanoparticles into the HT fluid improves HT coefficients, as illustrated in these case studies. This is especially important for applications requiring effective cooling or heating. Cu nanofluids' improved HT capabilities may lead to higher energy efficiency. This not only saves money on operations, but it also helps the environment by lowering energy use.

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