International Journal of Research and Development in Engineering Science
ISSN: 2582 - 4201(Online) , http://www.ijrdes.com/
Regular Issue, Vol. 5, Issue.4 (July – August) , 2023 , Pages: 11 - 13
Received: 19 November 2022 ; *Accepted*: 18 July 2023 ; *Published*: 28 July 2023
https://doi.org/10.63328/IJRDES-V5RI4P3
Brief Review: Laboratory Research – Analytical Research Paper

Heat Transfer Properties of Silver Nanofluids on Shell and Tube Heat Exchanger

Adarsh Benny [1]*, P. Sridharan [2] , S. Christopher Ezhil Singh [3]

Professor, Department of Mechanical Engineering, Vimal Jyothi Engineering College, Champeri, India – 670632

** Corresponding Author: Adarsh Benny ; adharshbenny@gmail.com*

Abstract: Nanofluids colloidal suspensions of nanoparticles in base fluids have attracted increasing research interest due to their improved heat transfer characteristics. This study investigates the use of silver nanofluids as a medium to enhance heat transfer in a shell-and-tube heat exchanger. Silver nanoparticles, known for their high thermal conductivity and stability, were dispersed in a base fluid (water/ethylene glycol) at different concentrations. Experimental tests were conducted by circulating nanofluids through the tube side, while hot fluid passed through the shell side. Results demonstrate a significant increase in heat transfer rate compared to the base fluid alone, attributed to the superior thermal conductivity of silver nanoparticles. Effects of concentration, flow rate, and temperature differential were analyzed. Challenges such as nanoparticle stability and aggregation were also discussed, along with potential mitigation strategies.

Keywords: Nanofluids, Silver Nanoparticles, Heat Transfer, Shell and Tube Heat Exchanger, Thermal Conductivity

1. Introduction

Efficient heat transfer plays a crucial role in power generation, HVAC systems, chemical processing, and electronics cooling. Conventional fluids often exhibit limitations in thermal performance, motivating the exploration of advanced alternatives. Nanofluids, suspensions of nanoparticles in a base fluid, have shown significant potential to enhance thermal conductivity and convective heat transfer. Silver nanoparticles, in particular, offer exceptional thermal properties and stability, making them suitable candidates for heat exchanger applications.
This paper examines the heat transfer performance of silver nanofluids in a shell-and-tube heat exchanger. Nanofluids are specially designed colloidal suspensions made up of nanoparticles scattered throughout a base fluid, usually smaller than 100 nm in diameter. Metals, oxides, and materials based on carbon can all be used to create these nanoparticles. Compared to conventional heat transfer fluids, nanofluids have shown the potential to greatly improve heat transfer qualities when correctly designed and used. Because of their special set of qualities, silver nanoparticles in particular have garnered a lot of interest in the subject of heat transfer.

The extraordinary heat conductivity of silver is well known, as it is far higher than that of many other materials. Silver nanoparticles are also less likely to settle or agglomerate and have outstanding stability, which makes them attractive options for improving heat transmission in a variety of applications. In this work, a shell and tube heat exchanger a popular heat transfer equipment in industrial processes, power plants, and HVAC systems—is utilized to examine the heat transfer characteristics of silver nanofluids. A bigger shell encloses a number of tubes that make up the shell and tube heat exchanger.

1.1. Objectives

(a). To characterize silver nanofluids in terms of physical and chemical properties.
(b). To evaluate thermal conductivity variation with nanoparticle concentration, flow rate, and temperature difference.
(c). To determine conditions under which silver nanofluids maximize heat transfer in a shell-and-tube heat exchanger.
(d). To assess nanoparticle aggregation and propose stabilization measures.

1.2. Methodology

Silver nanofluids were prepared at varying concentrations. A controlled shell-and-tube heat exchanger system was set up with pumps, sensors, and

ISSN: 2582 - 4201(Online) , http://www.ijrdes.com/ , IJRDES, Vol. 5, Issue 4, 2023 , https://doi.org/10.63328/IJRDES-V5RI4P3

thermal conductivity measurement equipment. Experiments measured heat transfer rates under different operating conditions, and results were compared against the base fluid. Data analysis focused on the effect of nanoparticle concentration, flow rate, and thermal gradients on performance.

2. Literature Review

L. Godson et al . (2014) discussed about silver/water nano fluids in a shell and tube heat exchanger discovered that increasing particle volume concentration improved convective heat transfer and efficacy. Because to better thermophysical characteristics and delayed boundary layer establishment, the convective heat transfer coefficient rose by up to 12.4%. When 0.04% nanofluid was used at Re=25,000, the pressure drop rose by 16.22% when compared to pure water.

Sujata Kalsi et al. (2023) investigates into the advancements in nanofluids, exploring their synthesis techniques, thermophysical properties, and applications, including their use in MRI contrast agents and desalination systems. It highlights the enhanced thermal conductivity and heat transfer capabilities of nanofluids, especially when using a high nanoparticle concentration. Hybrid nanofluids are found to outperform conventional fluids in heat exchangers. However, the stability of nanofluids remains a significant challenge affecting their long-term performance in various applications.

S. Anitha et al. (2019) examined nanoparticle volume concentration and proportion in an Al2O3-Cu/water hybrid nanofluid on heat transfer performance in a single pass shell and tube heat exchanger is investigated. With optimized nanoparticle concentrations, results reveal considerable improvements in heat transfer coefficient, Nusselt number, and overall heat exchanger performance. The heat transfer rate improves as the Reynolds number increases, making hybrid nanofluid systems extremely effective. This study contributes to the possible use of nanofluids in heat exchangers on an industrial scale.

Chaiyanan Kamsuwan et al. (2023) simulated polymer-based microchannel heat exchangers with nanofluids, this study blends artificial neural network predictive models and computational fluid dynamics. When compared to water, the results demonstrate a 12% improvement in heat transfer with TiO2/Water, and a 1.03 performance index with CuO/Water nanofluid.

The study reveals the possibility of efficient, ecologically friendly, and low-cost heat exchange equipment, while emphasizing the significance of material selection for performance Muhammad Awais et al. (2021) investigates the application of nanofluids in a variety of engineering thermal devices, including heat exchangers and solar thermal systems. It goes into how nanoparticle size, concentration, shape, and other aspects affect thermal performance.

The study also emphasizes the environmental benefits of employing nanofluids as well as the obstacles they represent, such as sedimentation and nanoparticle agglomeration. Furthermore, it emphasizes the significance of future study addressing both enhanced heat transmission and increased pressure drop.

S.H. Pourhoseini et al. (2018) addressed that in a plate heat exchanger, a cost-effective approach for synthesising silver-water nanofluid was designed and tested. The results suggest that both nanofluid concentration and flow rate promote heat transmission, with flow rate having a greater impact.

Heat transfer is maximized at roughly 2.5 mg/L concentration, whereas higher concentrations result in lower thermal conductivity due to aggregation. Temperature rise and Brownian motion both increase with concentration, emphasizing the importance of a threshold concentration for optimal nanofluid performance.

3. Result and Discussion

The accuracy of the experimental design was confirmed by a slight 9.2% departure from expected results using the Dittus-Boelter correlation. Silver nanoparticles improved the effectiveness of the solar collector, resulting in higher nanofluids temperatures, with the rise being directly proportional to nanoparticle concentration.

Higher mass flow rates resulted in higher hot fluid exit temperatures, whereas increasing particle concentration in nanofluids resulted in lower exit temperatures due to better thermal conductivity and delayed boundary layer growth. The findings highlight the ability of silver/water nanofluids to improve heat transfer efficiency, which is important in applications such as solar energy systems and industrial heat exchangers

3.1. Applications

Solar Thermal Systems – enhanced efficiency in collectors.
Electronics Cooling – improved reliability in compact devices.
Automotive Radiators – better fuel economy via improved cooling.
Industrial Processing – efficient thermal management in chemical and food industries.
Medical Devices – temperature control in MRI and laser systems.

ISSN: 2582 - 4201(Online) , http://www.ijrdes.com/ , IJRDES, Vol. 5, Issue 4, 2023 , https://doi.org/10.63328/IJRDES-V5RI4P3

4. Conclusion

4.1. Conclusion

The incorporation of silver nanoparticles into the fluid has consistently demonstrated enhanced heat transfer capabilities when compared to traditional heat transfer fluids. The optimized concentration of silver nanoparticles within the nanofluids has been identified as a critical factor, with an ideal range offering the highest heat transfer efficiency. Additionally, the temperature differential between the hot and cold fluid streams has a direct impact on the heat transfer enhancement, showcasing the importance of selecting the appropriate operating conditions. The stability and long-term performance of the silver nanofluids in the heat exchanger have been evaluated, and the results suggest that, with proper stability measures and regular maintenance, the nanofluids can maintain its effectiveness over extended periods of operation.

Variations in flow rate have shown to affect the efficiency of the nanofluid in the heat exchanger. While the pressure drop across the system is generally increased with the use of silver nanofluids, the trade-off between enhanced heat transfer and increased pressure drop must be carefully considered for practical applications Comparative analysis with conventional heat transfer fluids, such as water or oil, has consistently favoured the use of silver nanofluids, highlighting their superior heat transfer capabilities.

Potential applications of silver nanofluids in various industries, including electronics cooling, power generation, and HVAC systems, are substantial, promising more efficient and effective heat exchange processes. Looking ahead, this study points to future research opportunities and optimization possibilities. Researchers may explore different nanomaterial, alternative nanoparticle shapes, and innovative heat exchanger designs to further enhance heat transfer efficiency. The use of silver nanofluids in a shell and tube heat exchanger holds great potential for improving heat transfer processes across various industries, and with ongoing research and development, their application is likely to expand.

4.2. Scope For Future Work

Future research should explore that are different nanoparticle shapes and surface modifications. Multi-objective optimization to balance thermal enhancement and pressure drop. Large-scale industrial implementation and cost-effective synthesis methods. Environmental and sustainability impacts of nanofluid use.

Reference

[1]. L. Godson, K. Deepak, C. Enoch, B. Jefferson, B. Raja, (2014) Heat transfer characteristics of silver/water nanofluids in a shell and tube heat exchanger, Archives of Civil and Mechanical Engineering, Vol.14(3),pp.489-49, https://doi.org/10.1016/j.acme.2013.08.002

[2]. Sujata Kalsi, Sunil Kumar, Anil Kumar, Tabish Alam, Dan Dobrotă, (2023) Thermophysical properties of nanofluids and their potential applications in heat transfer enhancement: A review, Arabian Journal of Chemistry,Vol.16(11),pp.105272,https://doi.org/10.1016/j.arabjc.2023.105272

[3]. S. Anitha, Tiju Thomas, V. Parthiban, M. Pichumani, (2019) What dominates heat transfer performance of hybrid nanofluids in single pass shell and tube heat exchanger? Advanced Powder Technology, Volume 30, Issue 12, Pages 3107-3117. https://doi.org/10.1016/j.apt.2019.09.018

[4]. Chaiyanan Kamsuwan, Xiaolin Wang, Lee Poh Seng, (2023) Enhancing performance of polymer-based micro channel heat exchanger with nanofluids: A computational fluid dynamics-artificial neural network approach, South African Journal of Chemical Engineering https://doi.org/10.1016/j.sajce.2023.09.001

[5]. H. Ravi Kulkarni, C. Dhanasekaran, P. Rathnakumar, S. Sivaganesan, (2021),Experimental study on thermal analysis of helical coil heat exchanger using green synthesis silver nanofluids, https://doi.org/10.1016/j.matpr.2020.12.087

[6]. L. Syam Sundar, B. Deepanraj, Hiren K. Mewada, (2023), ANFIS based effectiveness and number of transfer unit's predictions of MWCNT/water nanofluids flow in a double pipe U-bend heat exchanger, Case Studies in Thermal Engineering, Volume 43, https://doi.org/10.1016/j.csite.2022.102645

[7]. K. Somasekhar, K.N.D. Malleswara Rao, V. Sankararao, Raffi Mohammed, M. Veerendra, T. Venkateshwara, (2018), A CFD Investigation of Heat Transfer Enhancement of Shell and Tube Heat Exchanger Using Al2o3-Water Nanofluid, Materials Today: Proceedings, Volume 5, https://doi.org/10.1016/j.matpr.2017.11.182.