**International Journal of Computational Science and Engineering Research**
ISSN: 3107 -8605 (Online) , http://www.ijcser.com/
Regular Issue , Vol. 2, Issue. 1 ( January – February ), 2025 , Pages: 43 - 46
*Received:* 28 September 2025 ; *Accepted:* 12 March 2025 ; *Published:* 28 March 2025
https://doi.org/10.63328/IJCSER-V2RI1P9
Original Paper : Action Research – Compare and Contrast Research Paper

# A Study on the Green Synthesis of Silver Nanoparticles and Their Applications

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**Abstract:** STHE play a crucial role in facilitating efficient heat transfer between fluids in diverse industrial applications. To optimize performance, these heat exchangers often incorporate inclined baffles in their design. This research delves into the impact of inclined baffles on fluid flow properties and heat transmission within a STHE Strategically positioned within the shell side, the inclined baffles aim to enhance turbulence and disrupt laminar flow, thereby improving heat transfer rates. Through a combination of experimental studies and computational simulations, the performance of the heat exchanger with inclined baffles is compared to that without. The findings reveal a substantial increase in heat transfer efficiency with the incorporation of inclined baffles. This outcome suggests that the addition of inclined baffles presents a viable strategy for boosting thermal performance in various industrial processes. The deliberate placement of these baffles proves to be an effective means of augmenting heat transfer in STHE making them a valuable enhancement in the realm of industrial heat exchange systems.

**Keywords** STHE, inclined baffles, turbulence enhancement, heat transfer efficiency, industrial heat exchangers.

## 1. Introduction

In numerous industrial applications, the utilization of STHE is prevalent for efficiently transferring heat between two fluids while ensuring their physical separation. These devices find application in diverse industries such as HVAC systems, petrochemical processing, and power generation. The efficiency of heat exchange in these devices is crucial for optimizing system performance and energy usage. This article explores the significance of inclined baffles in STHE and elucidates how they enhance heat transfer efficiency. STHE Fundamentals: Before delving into the specifics of inclined baffles, it is essential to comprehend the basics STHE These exchangers comprise several tubes enclosed within a cylindrical shell. Baffles' Role in Heat Exchangers: Baffles within the shell play a vital role in directing the flow of fluid, preventing it from traversing the entire length of the exchanger in a straight line. This redirection induces turbulence, thereby enhancing heat transfer. Traditionally, baffles have been constructed as flat plates perpendicular to the tube axis to create a more direct flow channel.

## 2. Literature Review

In a study conducted by Joemer, C.S. et al. (2018), a heat exchanger, a device facilitating the transfer of heat between two mediums, was subjected to optimization through Computational Fluid Dynamics (CFD) analysis. Specifically, the baffle cut and baffle angle of a designated STHE were fine-tuned to achieve maximum heat transfer efficiency. The investigation, performed using Fluent CFD software, delved into adjusting parameters to enhance the heat exchanger's performance. Experimental validation of the CFD algorithm was carried out on an existing single-pass counter-flow STHE, with the optimal results indicating a baffle angle of 5° and a baffle cut of 25%. The study highlighted the thermal impact as the most significant factor in improving heat exchanger performance across various configurations.

S.A. Marzouk et al. (2022) conducted a numerical modeling analysis on six different baffle configurations for a STHE to optimize hydraulic and thermal parameters. Baffle configurations included circular ring (CR), flower segmental (FS), hybrid segmental (HS), staggered single segmental (SSS), and circular ring with holes (CRH) baffles. The investigation varied the number of loads from 10500 to 38500, examining water flow characteristics, pressure loss, and heat transfer performance. Results indicated that the efficiency and heat transfer coefficient increased with rising Reynolds numbers. Notably, HS and CR configurations demonstrated a more

ISSN: 3107 - 8605 (Online) , http://www.ijcser.com/ , Vol. 2, Issue 1, 2025, https://doi.org/10.63328/IJCSER-V2RI1P9

significant thermal influence on heat exchanger performance enhancement compared to other configurations.

Élcio Nogueira et al. (2020) covered an analytical method for determining hot and cold fluid outlet temperatures in a STHE Their analysis involved assessing efficiency, effectiveness (ε-NTU), and irreversibility in a system where the shell contained a cold nanofluid and the tube contained hot water. The nanofluid, comprising copper oxide (CuO) nanoparticles, with 50% ethylene glycol and water as the base fluid, exhibited varying volume fractions from 0.1 to 0.5. Parameters included two mass flow rates for the hot fluid (0.5 and 0.0568 kg/s) and a nanofluid flow rate ranging from 0.0331 to 0.0568 kg/s. Graphical results were obtained for efficacy, efficiency, irreversibility, heat transfer rate, and outlet temperatures of both hot and cold fluids.

Mića V. Vukić et al. (2018) conducted a study on a shell-and-tube heat exchanger with two cold water passes in the tube bundle and one warm water pass on the shell side. The heat exchanger had a triangular shape and featured 24 x 2 (U-tube) tubes. The research focused on the impact of the number of segmental baffles on the effectiveness of the heat exchanger. Hasan Kücük et al. (2023) explored compactness and overall heat transfer coefficient (OHTC) improvement in STHE by utilizing channels with small hydraulic diameters. Their study revealed significantly higher OHTC values for minichannel shell-and-tube heat exchangers compared to traditional ones.

Ali Akbar Abbasian Arani et al. (2018) investigated fluid flow and heat transfer in a laboratory-sized shell-and-tube heat exchanger using computational fluid dynamics (CFD) software. Different baffle orientations were analyzed, showing variations in pressure drop, with the 90° orientation exhibiting the highest reduction. Ahmed Youcef et al. (2021) used ANSYS Fluent for numerical analysis and found that increasing baffle inclination angle improved thermal performance, although there was a slight decrease in heat transfer coefficient and pressure drop.

J. Mahendran et al. (2019) redesigned baffle plates in a traditional STHE using SolidWorks flow simulation, showing that the segmental baffle plate heat exchanger was less efficient than the conventional model overall. Enass A. Sattar et al. (2022) examined the impact of different baffle shapes on STHE with varying flow rates, showing variations in water flow, pressure loss, and heat transfer performance.

Thundil Karuppa Raj et al. investigated the effects of different baffle inclination angles on fluid flow and heat transfer properties, finding that a 40° inclination angle had small dead zones and improved thermal performance. Seema Singh et al. (2022) aimed to reduce pressure drop and increase heat transfer in STHE utilizing computer programming for heat transfer calculations and comparing helical baffle heat exchangers with segmental ones.

Gudipudi Bhargav Sai et al. (2023) examined the design and analysis of STHE various fluids, using ANSYS Fluent CFD analysis for structural analysis. They concluded that coil heat exchangers with helical baffles had enhanced heat transfer properties. Vineet Kumar Pandey et al. (2022) modeled a STHE with a helical baffle using ANSYS 18.0 CFD package, highlighting its compact design and improved heat transfer properties.

Manish Kuvadiya et al. (2022) used CFD ANSYS to model and mesh a STHE studying the effects of different helix angles on pressure drop and flow rate. ESHWAR BIRADAR et al. (2020) compared helical and segmental baffles in a STHE using CFD calculation and numerical methods, finding that helical baffles outperformed segmental ones in terms of heat transfer rate and pressure drop.

Mehdi Bahiraei et al. (2021) studied the effects of nanoparticle shape on the Entropy Generation Rate (EGR) in a STHE revealing that platelet-shaped nanoparticles produced the highest frictional and thermal EGR in the heated fluid. Ahmed Rahmah Al-darraji et al. (2023) explored air bubble injection with disc and ring baffles in vertical STHE examining different baffle configurations and air bubble injection rates.

Awatef Abidi et al. (2023) numerically examined the thermo-hydraulic performance of shell-and-tube heat exchangers using Fe3O4/MWCNT/water hybrid nanofluid, finding increased average Nusselt numbers for varying Reynolds numbers and nanoparticle volume fractions.

## 3. Result and Discussion

Robotic The outcomes of numerous research on shell-and-tube heat exchangers highlight the need of optimizing design parameters for improved performance. CFD analyses were extensively used to explore the influence of parameters such as baffle designs, angles, and nanoparticle shapes. The findings demonstrated the significance of these factors in impacting heat transfer efficiency, pressure loss, and overall efficacy.

Baffle configuration studies found that some designs, such as hybrid segmental (HS) and circular ring (CR), demonstrated superior thermal effects, resulting in improved heat exchanger performance. Furthermore, research into baffle angles revealed that differences in inclination angles might affect fluid flow,

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pressure drop, and thermal performance. Notably, the usage of helical baffles developed as a design component consistently related with enhanced heat transmission properties. Furthermore, the introduction of nanofluids and the examination of various forms of nanoparticles within the setting of a heat exchanger adds a layer of complexity to the research. The findings highlighted the importance of nanoparticle properties in influencing entropy formation rates and overall thermal behavior.

In conclusion, the investigations provide useful insights into the delicate interaction of design factors in shell-and-tube heat exchangers, opening the way for breakthroughs in maximizing efficiency, compactness, and total heat transfer performance.

## 4. Conclusion

In summary, the wide spectrum of research that has been given demonstrates how robotically assisted and Effective heat transfer is crucial in various industries, and STHE with inclined baffles are versatile and efficient devices for achieving this. The inclined baffles in these heat exchangers enhance heat transfer by promoting turbulence and reducing the risk of fouling, making them suitable for a wide range of applications. However, it's essential to be aware of their drawbacks, such as increased pressure drops, complex design and analysis requirements, and potential challenges in cleaning and maintenance. When selecting a heat exchanger type, it's vital to weigh these limitations against the specific needs and constraints of each application. The design and operation of STHE with inclined baffles require careful consideration of factors like fluid properties, temperature ranges, and flow rates, as well as considerations for cost, construction materials, and safety requirements.

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