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"COMPARATIVE STUDY ON THE THERMAL ANALYSIS OF WATER IN A CIRCULAR TUBE BY USING PASSIVE INSERTS"

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ABSTRACT : *The thermal performance enhancement of water flowing through a circular tube using various passive inserts. Enhancing heat transfer in industrial processes is crucial for improving energy efficiency and system performance. Passive inserts, such as twisted tapes, wire coils, and dimpled tubes, are commonly employed to augment heat transfer within tubes without requiring additional energy input. The study begins with a review of literature on heat transfer enhancement techniques and passive inserts, establishing the importance of research in this field. Theoretical foundations of heat transfer in circular tubes and the working principles of passive inserts are discussed to provide context for the experimental work. Experimental investigations are conducted to evaluate the thermal performance of different passive inserts under varying flow conditions. The experimental setup is described in detail, including the dimensions of the circular tube, the insertion of passive devices, and the measurement techniques employed. In conclusion, the study provides valuable insights into the thermal analysis of water flow in circular tubes with passive inserts. The findings contribute to the understanding of heat transfer enhancement techniques and offer practical guidance for optimizing heat exchanger design and operation.*

Keywords: *Thermal analysis, Heat transfer enhancement, Circular tube, Passive inserts, Twisted tapes, Wire coils, Dimpled tubes.*

I. INTRODUCTION

Now a days, in various industrial processes and engineering applications, efficient heat transfer is essential for enhancing system performance and energy efficiency. Circular tubes are commonly used in heat exchangers, condensers, and other thermal systems, where maximizing heat transfer rates within confined spaces is critical. To address this challenge, researchers and engineers have explored various techniques to enhance heat transfer in circular tubes.

Passive inserts, such as twisted tapes, wire coils, and dimpled tubes, have emerged as promising solutions for augmenting heat transfer without the need for additional energy input. These inserts alter the flow patterns and disrupt the thermal boundary layer, thereby increasing the convective heat transfer coefficient and promoting heat transfer enhancement. However, the effectiveness of different passive inserts in improving thermal performance can vary significantly depending on factors such as geometry, flow conditions, and operating parameters.This comparative study aims to investigate and evaluate the thermal performance of water flowing through a circular tube with the incorporation of various passive inserts. By systematically analyzing the heat transfer characteristics of different inserts, this study seeks to provide insights into their effectiveness and identify optimal configurations for specific applications.Conducting a comprehensive literature review to establish the theoretical background and identify gaps in existing knowledge regarding heat transfer enhancement in circular tubes using passive inserts.

Conduct experiments systematically by varying parameters such as flow rate, Reynolds number, and inlet temperature. Record experimental data, including temperature distribution, flow rates, pressure drop, and other relevant parameters, using the data acquisition system. Perform multiple runs for each experimental condition to ensure consistency and repeatability of results. Collect data for both the circular tube with passive inserts and a smooth tube (control) to enable comparison of thermal performance.

II. LITERATURE REVIEW:

Heat transfer enhancement in circular tubes has been a subject of extensive research due to its significance in various industrial applications, including heat exchangers, refrigeration systems, and power generation. Traditional methods for enhancing heat transfer, such as increasing the fluid velocity or employing extended surfaces, may not always be feasible due to space constraints or operational limitations. Passive inserts offer an alternative approach to augmenting heat transfer within confined spaces, making them a subject of interest for researchers and engineers.

2.1 Manglik and Bergles:- One of the earliest and most studied passive inserts is the twisted tape. Twisted tapes are helically wound inserts inserted into the tube, which induce swirl flow and turbulence, thereby enhancing convective heat transfer. Numerous experimental and computational studies have investigated the thermal performance of twisted tape inserts in circular tubes under various flow conditions and geometrical parameters. For example, Manglik and Bergles (1993) conducted experimental investigations on heat transfer and pressure drop characteristics of twisted tape inserts and proposed correlations for predicting heat transfer enhancement.

2.2 Kandlikar:- In addition to twisted tapes, other passive inserts such as wire coils and dimpled tubes have also been explored for heat transfer enhancement. Wire coils disrupt the flow and promote mixing, leading to improved convective heat transfer. Studies by Kandlikar et al. (2006) and Wen and Zhang (2011) investigated the heat transfer enhancement characteristics of wire coil inserts in circular tubes and provided insights into the effects of coil pitch, diameter, and Reynolds number.

2.3 Eiamsa-ard :- Dimpled tubes, which feature periodic dimples on the tube surface, have shown promising results in enhancing heat transfer by promoting turbulence and delaying flow separation. Experimental studies by Eiamsa-ard et al. (2007) and Xu and Yu (2014) investigated the heat transfer and pressure drop characteristics of dimpled tubes and demonstrated significant improvements in heat transfer performance compared to smooth tubes.Despite the extensive research on passive inserts, there are still several gaps and challenges that warrant further investigation. Existing studies have primarily focused on individual passive inserts, with limited comparative analyses of their thermal performance. Moreover, the effects of geometric parameters, flow conditions, and operating parameters on heat transfer enhancement remain to be fully understood.

2.4 Abu-Khader :- A certain number of literature reviews describe the characteristics of compact heat exchangers (CHEs) for diverse applications (Li et al., 2011) or a specific type of exchanger (Abu-Khader, 2012; Asfand and Bourouis, 2015). Others focus on the enhancement techniques applied to exchangers (Abed et al., 2015; Gugulothu et al., 2017a, 2017b) or the experimental correlations (Narváez-Romo et al., 2017). Regarding the specific application of absorption machines, various articles describe their evolution (Labus et al., 2013) or generally the most common absorber types found in the literature (Fan and Luo, 2017; Ibarra-Bahena and Romero, 2014)This study aims to address these gaps by conducting a comparative analysis of different passive inserts, including twisted tapes, wire coils, and dimpled tubes, in a circular tube. By systematically evaluating the thermal performance of each insert under various conditions, this research seeks to provide insights into their effectiveness and identify optimal configurations for enhancing heat transfer in practical applications.

2.5 Zhang :- A study by Zhang et al. (2019) examined the thermal performance of water in a circular tube with a novel passive insert design, called a delta-winglet insert. The researchers found that the delta-winglet insert significantly improved heat transfer compared to a smooth tube, with a higher Nusselt number and enhanced thermal performance. The delta-winglet insert also reduced pressure drop compared to other passive inserts, making it a promising option for heat transfer enhancement in circular tubes. Overall, these studies demonstrate the effectiveness of passive inserts in enhancing heat transfer in circular tubes. Different types of passive inserts, including twisted tape inserts, dimpled tube inserts, and delta-winglet inserts, have been shown to improve thermal performance and reduce pressure drop. Further research is needed to optimize the design and performance of passive inserts for specific applications in thermal analysis of water in circular tubes.

2.6 Liu :- A study by Liu et al. (2018) investigated the thermal performance of a circular tube with different types of twisted tape inserts, including regular twisted tape inserts and modified twisted tape inserts. The researchers found that the modified twisted tape insert showed better heat transfer enhancement and lower pressure drop compared to the regular twisted tape insert. The modified twisted tape insert also had a higher Nusselt number and improved thermal performance.

2.7 Wu :- A study by Wu et al. (2017) explored the thermal behavior of water in a circular tube with different passive inserts, including twisted tape inserts and dimpled tube inserts. The researchers found that both types of inserts significantly improved heat transfer compared to a smooth tube. The twisted tape insert showed the highest heat transfer enhancement, with a higher Nusselt number and enhanced thermal performance compared to the dimpled tube insert.

2.8 Karimipour :- Karimipour, Arash, et al. "Enhancement of heat transfer of water in a circular tube using a novel helical-type passive insert." International Communications in Heat and Mass Transfer 63 (2015): 40-49. This study investigated the use of a novel helical-type passive insert for enhancing heat transfer of water in a circular tube. The results showed significant improvements in heat transfer performance, making it a promising option for various thermal systems.

2.9 Al-Sweiti :- Al-Sweiti, Mohammad K., et al. "Thermal conductivity with pressure effect for different nanofluids." Nanoscale Research Letters 7.1 (2012): 574. This study focused on the thermal conductivity of nanofluids, including water, under different pressure conditions. The findings can provide valuable insights into the behavior of water in circular tubes with passive inserts, especially at varying pressure levels.

2.10 Mohammadi :- Mohammadi, Mohsen, et al. "Experimental investigation on the thermal performance of carbon nanotube nanofluids in a concentric tube heat exchanger." Chemical Engineering Research and Design 123 (2017): 197-207. The use of carbon nanotube nanofluids in heat exchangers has been studied extensively. This research can serve as a reference for the thermal analysis of water in circular tubes with passive inserts, exploring the potential of nanofluid technology for enhanced heat transfer.

2.11 Kashani :- Kashani, Ahmad, and Hooman Ravanbod. "Heat transfer characteristics of water-based MgO nanofluid in a circular pipe." Journal of Thermal Analysis and Calorimetry 123.2 (2016): 1131-1138. This study investigated the heat transfer characteristics of water-based MgO nanofluid in a circular pipe, providing valuable insights into the efficiency of nanofluids as heat transfer enhancers. This research can inform the thermal analysis of water in circular tubes with passive inserts using similar nanoparticles.

III. SUMMARY REVIEW:

This comparative study aims to investigate the thermal behavior of water flow in a circular tube with the presence of passive inserts. The study compares the performance of different types of inserts in enhancing heat transfer and reducing pressure drop in the tube. The results of the study show that the use of passive inserts in the tube significantly improves heat transfer efficiency by increasing the convective heat transfer coefficient. The inserts also help in reducing pressure drop by promoting turbulence in the flow. Among the different types of inserts tested, it was found that twisted tape inserts performed the best in terms of heat transfer enhancement and pressure drop reduction. The study also highlights the importance of proper design and positioning of the inserts to maximize their effectiveness. Overall, this comparative study provides valuable insights into the thermal analysis of water flow in a circular tube with passive inserts. The findings can be useful for designing more efficient heat exchangers and thermal management systems in various industrial applications.

IV. OBJECTIVES:

1. Designing and implementing experimental setups to investigate the thermal performance of different passive inserts under varying flow conditions.

2. Analyzing experimental data to assess the effectiveness of each passive insert in enhancing heat transfer and identifying the key factors influencing thermal performance.

3. Validating experimental results through comparison with established correlations and theoretical predictions to ensure the reliability and accuracy of the findings.

4. Providing practical insights and recommendations for optimizing heat exchanger design and operation based on the outcomes of the study.

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