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5. Effect of Thermal Heat Transfer in Machines

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ABSTRACT

The heat exchanger (HE) is a mechanical system for transferring thermal energy between dissimilar substances without requiring their physical contact. For this reason, it plays a crucial role in facilitating the exchange of energy and the completion of many processes involving the transformation of energy. In HE operations between energy systems, various factors—including length, material type, exchange fluid, surrounding environment, and many others—influence and play a big and important part in the efficiency of transformation and exchange in forms of energy. This study used computational fluid dynamics (CFD) simulations to examine the impact of HE length for both parallel and counter flow configurations. The quality and efficiency of the HE and the temperature distribution were significantly affected by the exchange parameters, particularly the length of the HEs in both the parallel and counter-flow HEs. The overall assessment demonstrates that, for both parallel and counter-flow HEs, increasing the length of the HE improves the efficiency of energy transfer by increasing the heat transfer and making heat dispersion more homogenous.

KEYWORDS:

Heat Exchanger; Heat Transfer; Energy; Thermal heat exchanger; Thermal Design.

Introduction:

Managing various energy systems is crucial for deriving the maximum benefit from energy sources [1-3], since energy is one of the most influential elements affecting system stability. Conventional and renewable energy sources both play a role in providing the necessary energy to meet the needs of the various engineering systems and are integral to the operation of some auxiliary systems that are necessary for the full use of all forms of energy [4-6]. Research on renewable energy sources have developed as a solution and a basic alternative to traditional energy sources [7-9], and we identified many studies around the world concerned with traditional energy sources, evaluating their whereabouts and the best ways to benefit from them. Researching energy sources in isolation is not enough, according to experts [10, 12]. The focus here is on assisting energy-using systems, such as turbines, boilers, coolers, pumps, and the like. Because it relies on the efficient transport of heat between system components without requiring physical mixing, he is regarded as one of the most essential systems contributing to the closing of the various energy cycles [13–18].

Heat Exchange Theory:

Internal structure, flow pattern, and pattern of arrangement are the typical criteria for categorising HEs. For example, in the parallel-flow HE, the hot and cold fluids flow in the same direction, and in the counter-flow HE, the fluids flow in the opposite way.

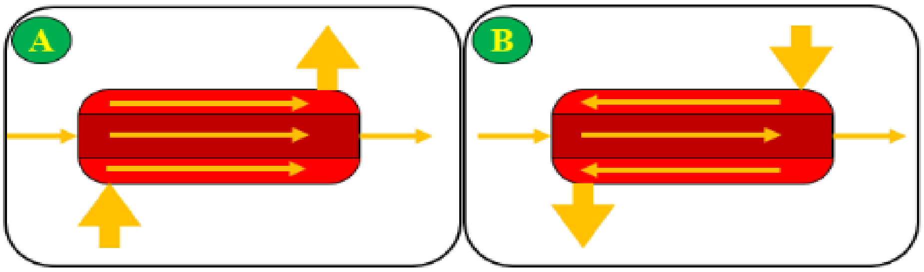

Figure 1: Parallel flow HE (A), Counter flow HE (B)

Figure. 1 shows the types of HEs used in this study, where the Figure 1A refers to the parallel flow HE, while the Figure 1B refers to the counter flow HE.

Objectives:

1. A wide range of applications can be performed in effect of thermal heat transfer.
2. To avoid the heat loss, it is necessary to know how heat is transferred.
3. To study of heat exchange in different machines.
4. Testing of effect of Heat Exchanger.

Review Of Literature:

Miniaturization of thermal devices is a goal of research and development in today's scientific and technological climate. To better meet specific requirements, several devices are scaled down to the micro and nano range. The promising future in biotechnology has brought increased interest in the Brownian motor, a common type of micro thermal device (Astumian, 1997; Hu et al.,2021). Heat (temperature differential) (Hnggi et al., 2020; Taye, 2021), chemical potential difference (Orlando et al., 2010), and external force (Feynman et al., 1963) are all examples of the types of drivers for Brownian motors. The most frequent form of Brownian motor is the thermal Brownian motor (TBM). Current TBM research focuses mostly on two subfields: (1) the study of Brownian particle motion (Li et al., 2016) and (2) the investigation of thermodynamic properties (Parrondo and de Cisneros, 2002). Analysis of its thermodynamic behaviour can shed light on the method by which it converts energy. In the past several decades, numerous researchers have studied this topic at length, yielding a wealth of useful information (Ding et al., 2021a). [19-20]

The origins of classical thermodynamic theory can be traced back to the study of the theoretical limitations of performance for thermal devices, with the Carnot engine (Carnot, 1824) serving as a prototypical example. The theoretical performance bound is unrealistically high since it does not account for the constraints of time and heat transfer area (HTA). Although time and irreversibility are considered in non-equilibrium thermodynamic theory (Andresen, 2008), the emphasis is on understanding the latter. It is difficult to determine the relevant performance metrics for a given process. Consequently, there are obvious confines to the idea. The development of the theory of finite temporal thermodynamics (FTT; Chen et al., 1999b; Chen and Sun, 2004; Feidt, 2012, 2013b,a; Vaudrey et al., 2014; Ge et al., 2016; Feidt, 2017a,b, 2018; Chen and Xia, 2019; Chen et al., 2019; Feidt and Costea, 2019; Berry and Salamon P. It investigates new performance bounds with varying degrees of irreversibility in the thermal process, as well as the limitations of finite heat transfer time and the HTA application scope of FTT theory, and provides guidance for the enhancement of real-world thermal devices. [21 - 24]

Experiments were performed by O'Brien et al. in a narrow rectangular duct equipped with an elliptical tube inside a fin tube heat exchanger, at Reynolds numbers between and. The turbulence was produced by a set of delta winglets. They calculated the pressure drop and calculated the local surface heat transfer coefficient. A single set of winglets was shown to improve heat transfer by 38%. Furthermore, they discovered that, within the examined Reynolds number range, the increase in friction factor owing to the addition of a winglet pair was less than. [25]

The increase in heat transfer due to the baffle's vertical orientation was studied quantitatively by Tsay et al. for a reverse step flow channel. For a wide range of Reynolds numbers, the impact of the baffle's height, thickness, and distance from the baffle to the rearward-facing step on the flow structure was analysed in great depth. The average Nusselt number was found to be increased by the addition of a baffle to the flow. Furthermore, they found that the flow conditions and heat transfer characteristics are highly dependent on the baffle position. [26]

There has been a lot of recent focus on studying heat transport in porous fins. To improve heat transfer, porous materials with high thermal conductivity have been employed. Recent studies have used numerical methods to examine the impact of porous fins on heat transmission from a heated horizontal surface, and these studies have been conducted by researchers like Kiwan and Al-Nimr. These types of enhancers work by increasing the amount of mixing or thermal dispersions between the ambient fluid and the solid phase of the porous fin, which in turn increases the convection heat transfer coefficient. The researchers discovered that if the porosity of the fin was just right, it could achieve the same results as a traditional fin while utilising only 1% of the material. In addition, Kiwan and Zeitoun discovered that, under natural convection conditions, the heat transfer coefficient of porous fins was significantly higher than that of traditional solid fins. [27-28]

Research Methodology:

We learned about the Effect of thermal heat transfer in machines from a variety of secondary sources, such as books, educational and development publications, government papers, and print and online reference resources.

Numerous studies have looked into the issues of HEs and ways to enhance the quality of heat transfer in HEs. There was a noticeable improvement in HE efficiency and a corresponding increase in heat exchange area. explored the HE channels' geometries and discovered that making internal changes to the HE design boosts the technology's performance. Our findings here also corroborate the validity of this notion and expand upon its scientific foundation.

The research strategy involves running the simulation code multiple times, once with each of the HEs' starting lengths (10, 15, 20, and 25 m), to examine and compare the effects of each length.

It is useful for determining which HE has the optimal length for a certain engineering application by first considering heat exchange and the temperature distribution, and then verifying the length that follows.

Result and Discussion:

This research examined the impact of HE length for a variety of configurations, including parallel and counter HE, using a hot substance flowrate of 0.2 k and a cold substance flowrate of 0.3 kg/s. Several lengths (10, 15, 20, and 25 m) of the aforementioned systems have been investigated to determine the impact of HE length. The heat transfer coefficient was observed to improve from 42.9 kW for a length of 10 m in a parallel HE with liquid water medium to 47.6 kW for a length of 15 m, 49.5 kW for a length of 20 m, and 50.2 kW for a length of 25 m. Since it is evident that the temperature difference gap reduces with increasing the HE length and the heat transfer rate, Figures 4A–4D and Figures 5A–5D depict the temperature distribution inside the parallel HE with liquid medium between the hot and cold substances.

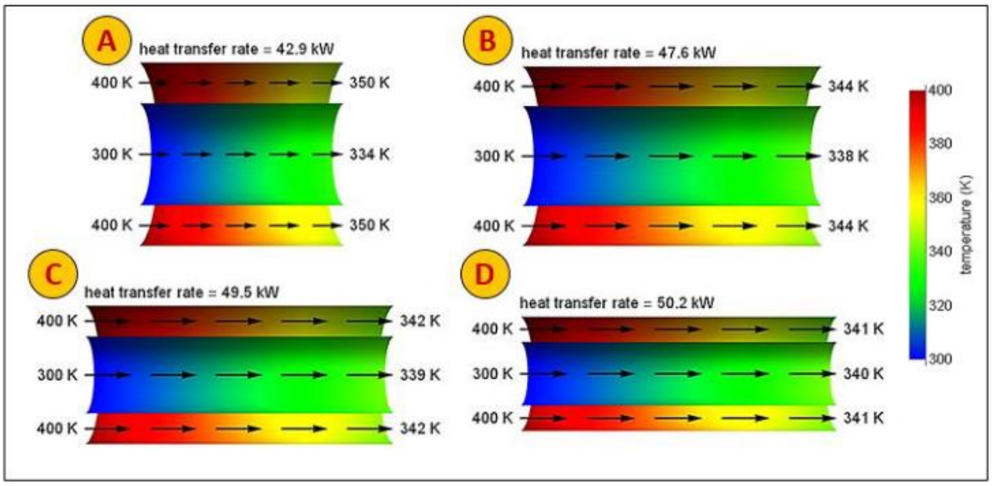

Figure 2: Parallel HE with length of (A), 10 m (B), 15 m (C), 20 m and (D) 25 m

Heat transfer increased from 48.7 kW inside the HE with a length of 10 m to 58.6 kW inside the HE with a length of 15 m to 65.1 kW inside the HE with a length of 20 m to 69.6 kW inside the HE with a length of 25 m (see Figures 2A–2D), demonstrating that the length of the HE has a direct effect on the amount of heat transferred. The values of the heat transfer rates are higher in the counter HE as compared to the parallel HE, suggesting that the counter HE is more efficient in the heat transfer.

Specifically, we showed that the length of the HE significantly affects the increase in heat exchange between the materials utilised in the HE, demonstrating the effect of the design parameters on the performance of the HEs (hot-cold).

Heat exchange performance improves in both the parallel-flow and counter-flow HEs that are employed. As the length of a heat exchange increases, its efficiency improves because more of its surface area and more time elapse between heat exchanges are exposed to the heat transfer materials. The results also suggest that the bigger temperature differential in the counter-flow HE compared to the parallel-flow exchanger contributes to its better efficiency. Researchers have spent a lot of time thinking about how to fix HEs and making them better at transferring heat. Here we find research from Wang et al. that supports the idea that enlarging the HE's heat exchange surface improves its efficiency. According to Zheng et alresearch .'s on HE efficiency, the form of the channels is a key factor. Our findings here also corroborate the validity of this notion and expand upon its scientific foundation. [29-30]

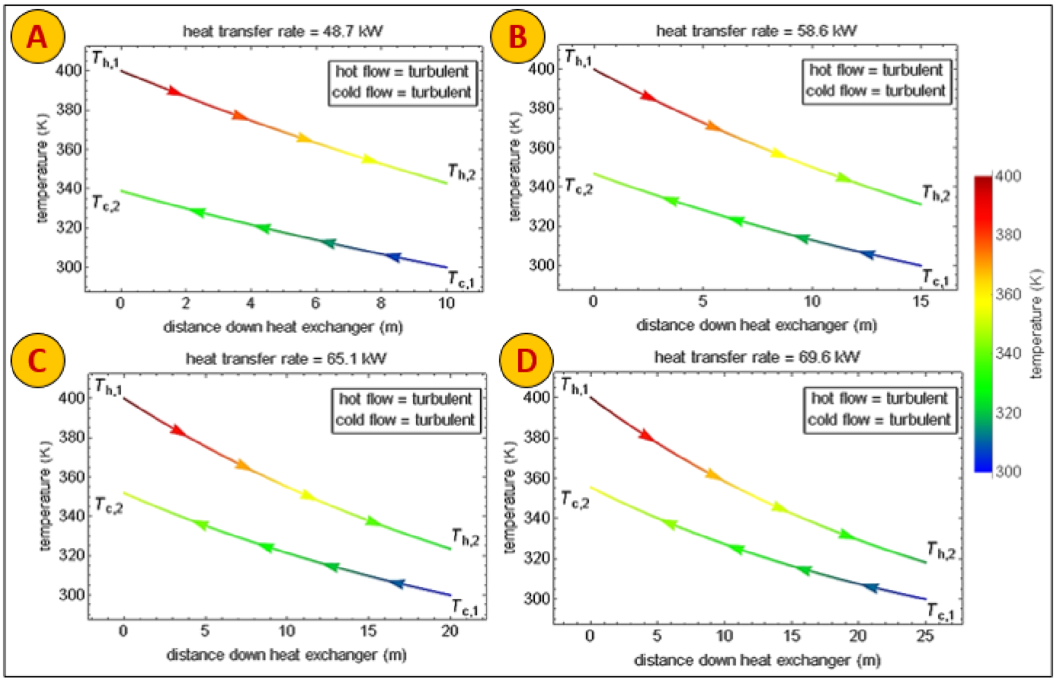

Figure 3: Counter HE temperature distribution at length of (A), 10 m (B), 15 m (C), 20 m, and (D) 25 m

The temperature distribution inside the counter HE is depicted in Figure 3A–3D. As the length of the HE and the heat transfer rate increase, it is evident that the temperature differential gap in the counter HE diminishes.

Conclusion:

Examining the impact of longer HEs on heat transfer performance, this research first verifies the design conditions of parallel and counter-flow HEs. These findings show that heat is distributed more uniformly within the HEs during both parallel and contra flow. Increasing the length of HEs improves their performance since doing so increases both the surface area available for heat exchange and the time available for internal heat exchange processes. Comparing the efficiency of parallel and counter-flow HEs revealed that the latter are more effective because of the greater temperature difference between their ends. In many cases, improving heat exchange efficiency can be achieved by modifying the design characteristics of various HEs. This is consistent with the findings of past studies, and it is argued here that it is vital to investigate the enhancement of new design conditions in order to boost the efficiency of HEs in the future.

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