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# EFFECT OF PITCH ON THERMAL PERFORMANCE SERPENTINE HEAT EXCHANGER

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## Abstract:

Energy is one of the most important factors affecting the stability of any system and therefore, dealing with different energy systems is very important to get the most out of energy resources. Energy sources are divided into conventional and renewable sources, and both are involved in securing the energy needed to meet the requirements of different engineering systems, and they also participate to a large extent in a number of supporting systems to complement the use of different types of energy. Heat exchangers are used to transfer heat between two process streams. Heat exchangers can be used for cooling, heating, condensing, boiling or evaporating purposes. Efficiency and efficiency can be measured by the amount of heat transfer using the least heat transfer area and pressure drop. The objective of this work was to manufacture two coil-in-tube heat exchangers with step1" and 2" and to analyze the thermal efficiency of the two heat exchangers.

***Keywords**:* Serpentine Heat Exchanger, Pitch, Renewable Energy, Parallel flow and Counter flow.

## 1. Introduction

Heat exchangers are used to transfer heat between two process streams. Heat exchanger can be used for cooling, heating, condensation, boiling or evaporation purpose. A heat exchanger is a device used to exchange heat between two liquids, without mixing them. The heat transfer is of great interest to the development of heat exchangers in order to obtain high thermal effectiveness and low manufacturing cost. The integral finned tube heat exchangers have been widely applied. To improve the effectiveness of the exchangers, the passive techniques used to increase the heat transfer rate.

Pramod S. Purandare et al. [1] carried out to study the heat transfer phenomenon in conical coil heat exchanger with cone angle $90^0$. M. Ghazikhani et al. [2] investigated the effect of wedge-shaped tetrahedral VGs (vortex generator) on a gas liquid finned tube heat exchanger was studied using irreversibility analysis. Dillip Kumar Mohanty et al. [3] focused the statistical analysis is used as an invaluable tool for investigation of performance of a shell and tube heat exchanger under fouling condition. A. I. Zinkevich et al. [4] studied non uniform distribution of liquid flow among the tubes ofa shell and tube apparatus has to be taken into accountin determining the efficiency of heat transfer and analyzing its effect on the intensity of heat transfer.LIU Wei et al. [5] concentrated on enhancement of heat transfer in the core flow, and with the analysis of the disturbance

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mechanism of longitudinal flow. Seong Yeon Yoo et al. [6] studied the heat transfer rate of the external tube surface of the heat exchanger for a closed wet cooling tower can be divided into sensible and latent heat transfer rates. Kozeki et al. [7] studied the helically-coiled HE with stainless steel tubes. Desai et al. [8] investigated the fluid vibrations inside the HE provided by fins. He found that the fine arrays are stable, which aids in the stability of the HE body. Deng et al. [9] presented a study about the thermal storage with the HE provided by fins, and he found that the fins play a major role in storing the thermal energy. Guo et al. [10] provided a design module for the HEs aimed at reducing the volume of the exchanger, with the aim of reducing the cost of the fabrication. Wang et al. [11] present work regarding the pattern and optimization of the multi-layer exchangers. Figley et al. [12] studied the structure of the HE using numerical simulation and found a major effect of the structure on the HE work. Zheng et al. [13] developed a new channel with a new shape of the HE to investigate the efficiency. A transient flow is detected by the new design. Ma et al. [14] study the inclination of a new design numerically of the HE and the drop in the pressure. Andre´ L.H. Costa a et al [15] presented a study about the design optimization of shell-and-tube heat exchangers. O. García-Valladares [16] developed detailed one-dimensional steady-state and transient numerical simulations of the thermal and hydrodynamic behavior of triple concentric tube heat exchangers. Abdalla Gomaa et al. [17] studied experimental and numerical studies on triple concentric tube heat exchangers, paying particular attention to double tube heat exchangers. Hinge [18] investigated the design and performance of a single-segment shell-and-tube heat exchanger considering vertical and parallel baffle plates. Girish et al [19] used Fluent software to study the pressure drop inside a shell and tube heat exchanger considering various baffles. Haran, etc. [20] studied thermal analysis in case of shell and tube heat exchangers considering both water and oil type which is most used in refrigeration and air conditioning industries. Pranita et al. [21] studied shell and tube exchangers by considering the effect of types of baffles considering thermal performance and pressure drop. Petinin et al [22] studied the shell and tube heat exchangers considering different tube patterns variation like triangular, rotated triangular and the combined shell and tube heat exchangers. Kaushik [23] have studied the optimal design in shell and tube heat exchangers considering various parameters such as outer diameter, pitch, length, baffle spacing and cut etc. Yang et al [24] studied the properties of the heat exchanger by changing the fluid flow in the shell in the case of a shell and tube heat exchanger by considering a spiral baffle plate. Kahya et al. [25] studied a shell-and-tube heat exchanger comparing simulation results with analytical calculations using heat transfer studies. Amirtaraj et al [26] investigated a shell-and-tube heat exchanger with an inclined baffle to achieve higher heat transfer efficiency and lower pressure drop. Oguz et al. [27] studied the thermal design of a shell and tube heat exchanger using an intelligent coordination harmony algorithm. Yanzhong [28] investigated the improvement of heat transfer by installing a seal on an annulus. They closed the gap between the baffle and the hull with sealant. Tsjuwang et al. [29] investigated a coupled multi-pass shell-and-tube heat exchanger with spiral baffles to improve heat transfer properties and simplify the manufacturing process. An extensive review of the recent progress in heat transfer enhancement using longitudinal vortex generation has been done by Jacobi and Shah [3]. Fiebig [4] noted that longitudinal vortices show less flow losses and better heat transfer characteristics than transverse vortices. The first report on longitudinal vortices in boundary layer control was presented by Schubauer et al [5]. Jonhnson et al [6] early reported the impact of vortex generators on the heat transfer performance. For the current study of effect of pitch on serpentine heat exchanger by reviewing several thermal performance analysis for various heat spreader devices [34, 35, 37] Patel Anand et al. for Heat Exchanger [36] Anand Patel et al. for Cooling Tower [38-50] Patel Anand et al. for Solar Water/Air Heater.G. E. Kondhalkar et al [51] gives the performance analysis of spiral tube heat exchanger over the shell and tube type heat exchanger. P. Naphon [52] proposed that the heat exchanger consists of a shell and helically coiled tube unit with two different coil diameters. Ashish Agarwal et

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al [53] experimentally investigated the role of phase change material in case of shell and tube heat storage in case of solar dryer. Lavinia Gabriela et al [54] discussed about various thermal energy storage system and their significance in the thermal system. Syukri Himran et al [55] studied thermal energy storage in paraffin-wax using tube array on a shell and tube heat exchanger. Thirugnanam.C et al [56] studied about waste heat recovery using phase change material. In the present work concentric tube heat exchanger with phase change material has been used. Ganesh Patil et al [57] developed the phase change material-based heat exchanger using organic and inorganic material. Heat exchanger has many applications like desalination [58], helical flow [59], worked as microplate heat exchanger [60] and many more.

## 2. Experimental Set up

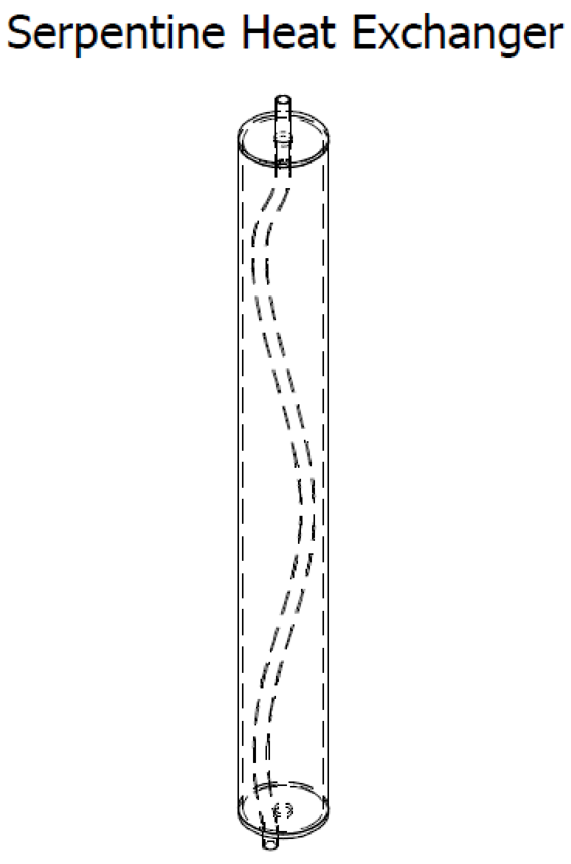


**Fig 1 CAD Model of Serpentine Heat Exchanger**

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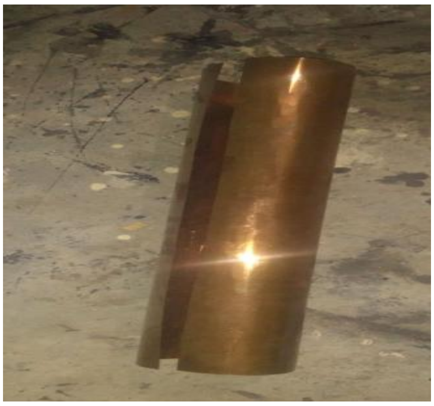

**Fig 2 4" Cylindrical pipe**

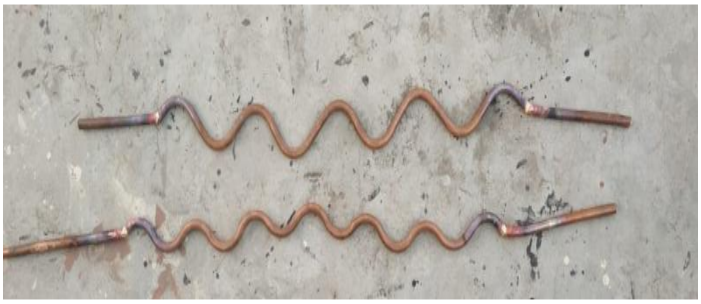

**Fig 3 1" and 2" serpentine pipes**


**Fig 4 1" and 2" Serpentine Heat exchanger**

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**Fig 5 Asbestos Insulator**

**Fig 6 Measuring Flasks and Thermocouples**

In the present work in the first phase from copper sheet of 20 gauges the 4" cylindrical pipe of 0.8 m and 0.85 m length are fabricated using brazing process. Inside the cylindrical pipe the ½" diameter and above mention lengths are inserted in serpentine shapes with pitch 1" and 2 "respectively. The outer cylinder is closed from both ends and inlets and outlets are provided on cylinder and serpentine pipes also. The K type thermocouples are used for temperature measurement purpose and 20 liter tank with tape is used to supply cold and hot water in the heat exchanger. The asbestos tape is wrapped around 4" cylinder to avoid heat transfer. Total four thermocouples and two measuring flasks are used to measure water flow and temperature at various locations of both heat exchangers, respectively.

## 3. Result and Discussion

**Table1 Observation Table**

| 2" Serpentine Counter Flow | | | |
|---|---|---|---|
| Hot | | Cold | |
| Tin | Tout | Tin | Tout |
| 65 | 53.9 | 33 | 43.5 |
| 55 | 45.8 | 33 | 40.4 |
| 2" Serpentine Parallel Flow | | | |
| Tin | Tout | Tin | Tout |

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| | | | |
|---|---|---|---|
| 65 | 54.9 | 33 | 45.6 |
| 55 | 46.6 | 33 | 43.1 |
| 1” Serpentine Counter Flow | | | |
| Tin | Tout | Tin | Tout |
| 65 | 53 | 33 | 41 |
| 55 | 46 | 33 | 38 |
| 1” Serpentine Parallel Flow | | | |
| Tin | Tout | Tin | Tout |
| 65 | 53.8 | 33 | 41.8 |
| 55 | 47.8 | 33 | 39 |

**Table 2 Result Table**

| |
|---|
| $\varepsilon_{\text{counter flow 2” pitch}}$ |
| 0.35 |
| 0.42 |
| $\varepsilon_{\text{parallel flow 2” pitch}}$ |
| 0.32 |
| 0.38 |
| $\varepsilon_{\text{counter flow1” pitch}}$ |
| 0.38 |
| 0.41 |
| $\varepsilon_{\text{parallel flow 1” pitch}}$ |
| 0.35 |
| 0.33 |

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Here Table 1 and Table 2 indicate observations and result values of experimentation process. From Table 2 it is quite clear that in case of serpentine heat exchanger with 2" pitch gives better results in case of parallel and counter flow both cases which might be because of more turbulence in the flow and more retention period is available for heat transfer between hot fluid and cold fluid. The length of heat exchanger length is small in case of 2" pitch and so heat exchanger is more compact too.

## 4. Conclusion

The compact heat exchanger with better thermal performance is possible with this kind of serpentine heat exchanger.

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