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Performance Analysis on Solar Flat Plate Collector with Reducing Energy Wastage Using Optimal Geometry Application

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Abstract
Energy crises are the biggest problem in front of the world nowadays. There are many ways of energy wastage in the form of heat in heat transfer in Solar Flat Plate collectors. The main objective is to utilize solar energy more efficiently. An experimental investigation of heat transfers in solar flat plate riser's tubes was done by changing various parameters like Flow rate, geometry, the pattern of fluid flow as well as the tilt angle of flat plate collectors. For the Experimental simulation purpose PRO-E, AUTOCAD, and Fluent tools are used. The experimental theoretical and simulation result is compared with the Existing Flat Plate collector of the solar water heater. After the comparison found that the Zigzag flow pattern is better performance than the Solar conventional water heater. The density of flat plate collector is less as compared to conventional hence it's cost-effective also.

Keywords: Solar flat plate collector; Heat transfer; Riser Tube; Water Heating.

1. Introduction

After a study of research papers and literature work on solar flat plate collectors. It is found a research gap in solar flat plate collector analysis and the experimental role of energy of solar with various shapes of solar flat plate collectors.

The losses in a flat plate collector determines during a ambient temperature. The amount absorptivity of a solar collector is determining on amount of an incident radiation amount. The performance of solar collectors is better in sunny conditions than in cloudy conditions.
The factor that plays a key role in the performance of solar water heaters with respect to temperature is as shown in the Equation 1[21]

$$v = \frac{gK\beta(T-Ta)}{y} \quad (1)$$

Sanjay Kumar Sharma et.al [1] studied a V-flat plat collector in Rajasthan on a 30-lit. capacity tank with a five-liter flow rate per hour. The material used is aluminum. Thermal physical properties are obese as an optimum and its will work on 100-liter capacity also.
BAA Yousef et. al [2] In this paper the flat plate collector is comparatively studied on the basis of

1.1. Factors affecting solar water heating (SWH) performance

The factor that plays a key role in the performance of solar water heaters with respect to temperature is shown in Fig 1

1.2. Boundary Condition

material i.e. porous with a different mass flow rate, flow channel depth, and length of flat plate collector. The experiment was performed on single and double-flow modes. The efficiency increases by 12-15 % in a double flow and 11% in a single flow. The author states that performance efficiency relates inversely to flow rate. The porosity of a material increases the performance of a flat plate collector and increases in pressure drop which was help to create Syphon effect. Aliasghar Owla Iveli et. al. [3] The Author worked on the geometry of the Solar Energy tank for increasing the efficiency of the system. The tool used for the simulation is ANSYS and TRANSYS. Worked on the aspect ratio of the tank. Found that an aspect ratio of optimum condition significantly impacts the thermal performance the of system. The annual solar energy portion is increased from 75% to 95%. if optimized R-value is implemented in the design.B. N. Mankar et. al.[4] The Flat plate collector studied the basis of metal blocks and flow pulsation. The material used for the metal block is Aluminum. Found that pulsation of inside flow is helped in the mixing of the fluid and increased the heat transfer rate. 17% efficiency increases than conventional flat plate collectors. R. Herrero Martín et. al. [5] Wire coils were selected to enhance the heat transfer rate increases. It provides better results in all modes of flow is constructed. The testing setup was fully designed following the requirements of EN12975-2 and completed the performance tests under the same boundary conditions.Sunil. K. Amrutkar et. al. [6] In this setup studied a domestic solar water heater with a fluid temperature of less than 100℃. The work has been carried out on three main parameters Observer, heating pipes, and shield. Various geometry has been studied on changing the values. Found that the efficiency and performance parameters varied with storage tank temperature. Fabio Struckman [7] The active solar system has been studied with several accessories heat storage systems, heat exchangers, fluid flow patterns, and various control systems. During a cloudy day, a fluid took heat from a heat storage system or directly from hot water. The overall heat loss coefficient. And other performance-effecting parameters are not constant values observed at the time of setup performed.Mustafa et. al. [8] Studies has been carried out on cover glass, the flow of fluid per hour, and an economizer. Three-layer glass cover has been compared with a single-layer cover. With the use of an economizer decreases the efficiency of a Flat plate collector. The conclusion state that three layer of glass cover with more flow rate increases the solar water heater's performance. Rakesh Kumar et. al. [9] In the literature, the author studied a corrugated absorber surface. Higher characteristic length is used in a modified solar collector for convective heat transfer between the absorber and water. Due to that solar collector having more surface area exposed to solar radiation with more time. It means it absorbs more heat. However, this modification has reduced the performance of the system marginally. Hence author concludes that the conventional system is more efficient that the corrugated absorber. Ramesh Tiwari et. al.[10] By using a different riser tube in a flat plate collector experiments has been carried out. The result found that increasing the diameter and reducing the length of the riser increases the performance of a solar flat plate collector. Due to low cost, this system beneficial in rural areas to reduce their dependence on electric power. H. Vettrivel et. al. [11] The author studied solar flat plate collectors using a MATLAB tool. A mathematical one-dimensional transient model simulation is done. The model considers steady unsteady parameter-dependant thermo-physical properties and convective heat transfer coefficients and is based on solving equations that describe the energy transformation for the glass cover, air gap between cover and absorber, absorber, working fluid, insulation, and the storage tank.

Experimental setup

The temperature is achieved at 200 ℃in the solar collector in the conditions without fluid in a collector. It uses to select a high thermal resisting material. Mostly the material used in a solar flat plate collector is metallic viz. cooper, steel or aluminum. The housing material of a collector is of metallic, non-metallic or plastic also. Make sure that collector is dustproof as well as back heat resistant.

The back side of the collator must be highly insulated to avoided any type of heat loss. Due to the difference in temperature gradient hat loss happen in the mode of convection and radiation way. the convection losses happen due to spacing between the glass cover and tube of flat plate collector. The loss of radiations at the time of heat exchange. Main function any observer is to less the amount of solar irradiant, at minimum loss of energy transfer the heat to the fluid, and reflectivity of radiation must be less.

Zigzag Pattern with water tank and all set up of Flat plate collector shows in Figure1.

Materials used in the flat plate collector which I used in modified setup are as men in below Table No. 1.

Table No. 1: Material used in the flat plate collector

Absorber tube	Aluminum
Fins	Aluminum
Insulation	Polythene foam
Casing	Wood
Selective coating	Si based black chromium paint
Cross section area of flow	Elliptical
Thermal conductivity of aluminum	200 w/m k
Glass cover	Toughened glass
Glass cover emissivity	0.88

Below is Table 2. Which Shows the specification of a flat plate collector in geometrical parameters with a flat plate collector.

Table 2: Material used in the flat plate collector

Dimension	1m x 2m x 0.130 m
Aperture area	1.71m^2
The Length of the absorber plate	1800mm
Flow cross section	Elliptical
Dimension of the flow path	Major diameter- 28 mm Minor diameter- 12.5mm
Tube center-to-center distance	120mm
No of flow path used	4
Bottom insulation thickness	50mm
Side insulation thickness.	50 mm
Air gap between glass and absorber plate	25mm
Width of fin	200mm

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Figure 1: Zigzag Pattern with water tank and all set up of Flat plate collector

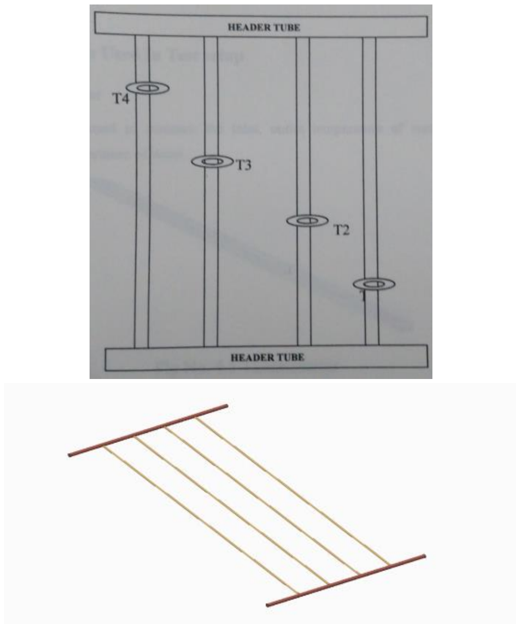

Figure 2: Thermocouple position on a flat plate collector

2. Modeling and Simulation

By using a Fluent work tool in ANSYS workbench for finding the Velocity, pressure and temperature at a different flow rate of water ia n

Zig-Zag pattern of flat plate collector at 1-LPM. 2-LPM.

The below mentioned figure shows a result of Pursuer velocity and Temperature ithe n Fluent tool at 1 LPM at contact diameter as shown in fig No. 3.

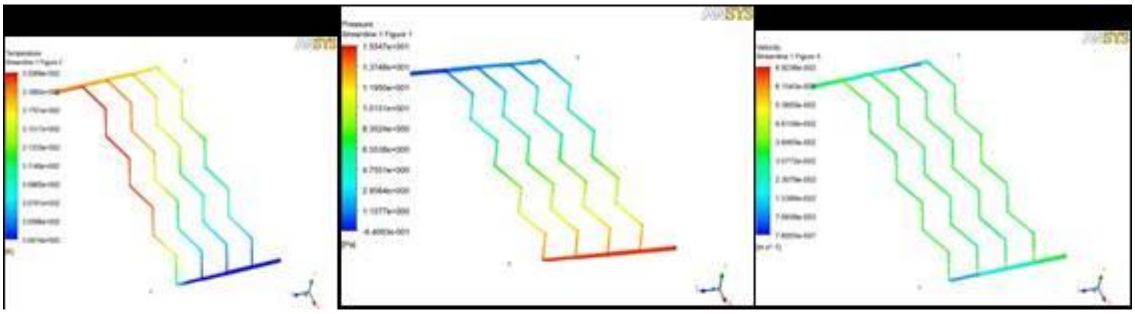

Figure 3: Results of Temperature, Pressure and Velocity

The below mentioned figure shows a result of Pursuer velocity and Temperature in Fluent tool at 2-LPM at contact diameter as shown in fig No. 4

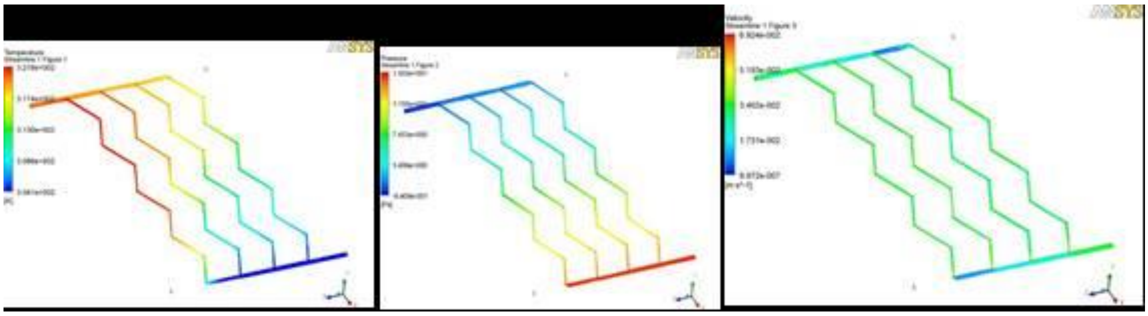

Figure 4: The result parameter of Temperature, Pressure and Velocity

3. **Result and Discussion**

The below shown figure values are represented in a Below shown diagram with all temperature, velocity and Pressure in Figure No 5.

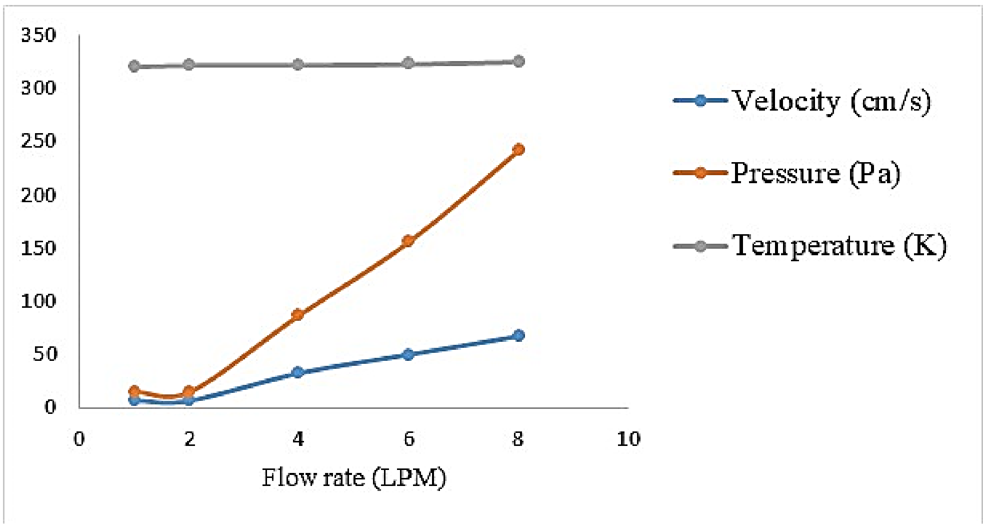

Figure 5: The result parameter of Temperature, Pressure and Velocity

By using a Fluent work tool in ANSYS workbench for finding the Velocity, pressure and temperature at different flow rate of water in Zig-Zag pattern of flat plate collector at by charging a geometry of Water tube inside a flat plate collector at constant flow meter i.e. 2 LPM as shown in Figure 06.

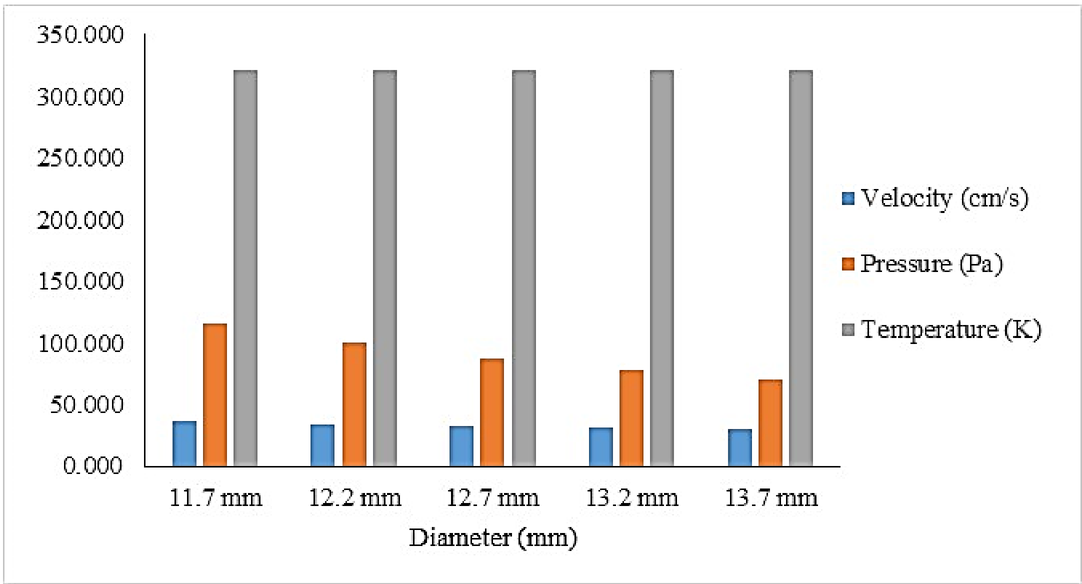

Figure 06: shows the result parameter of Temperature, Pressure and Velocity with change in geometry i.e. Diameter

By using a Fluent work tool in ANSYS workbench for finding the Velocity, pressure and temperature at different flow rate of water in Zig-Zag pattern of flat plate collector at by charging a geometry of Water tube inside a flat plate collector with various diameter at different spacing as shown in Figure 7.

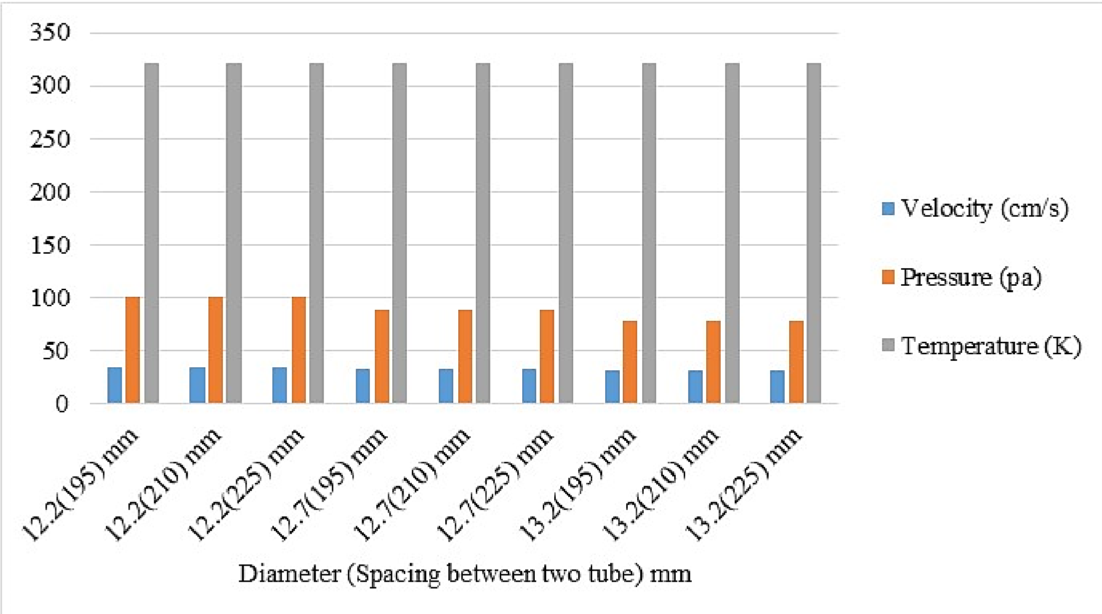

Figure 07: The result parameter of Temperature, Pressure and Velocity with change in geometry i.e. Diameter as well as spacing between two tube

The mentioned fig shows the relation between four different sensors assembled on a flat plate collector and different mass flow rates as shown in Figure 8. It is found that the temperature is increased by 14%.

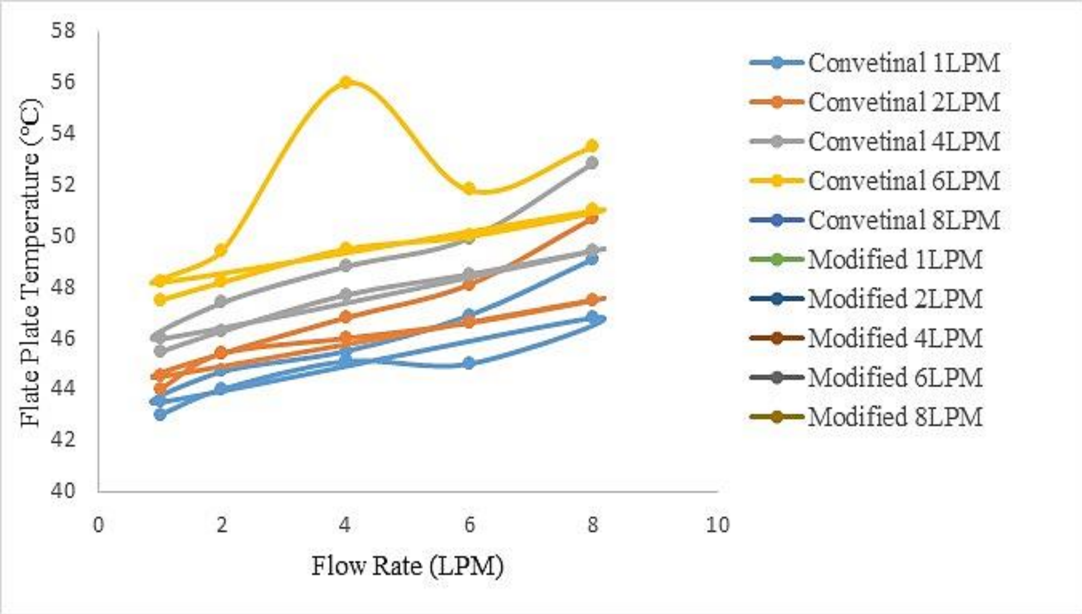

Figure 8: Temperature of a conventional and modified flat plate collector at various flow rates

The below-mentioned figure compares the performance of a friction factor with a velocity of a fluid. It is found that a Modified flat plate collector has a less friction factor which is help to increase the overall performance of a system as shown in Figure 9.

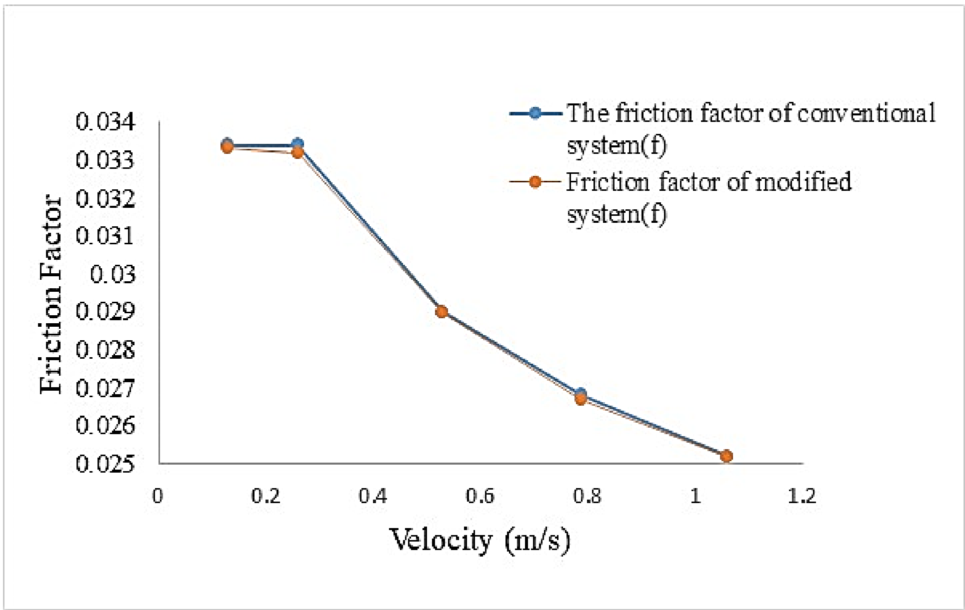

Figure 9: Comparison of the system in terms of friction factor with velocity

The below-mentioned figure define the performance of a Heat transfer coefficient with a velocity of a fluid. It is found that the Modified flat plate collector has a more in heat transfer coefficient which is increased by 58.14 %. The Figure 10 shows the comparative observation of modified and conventional systems of flat plate collectors.

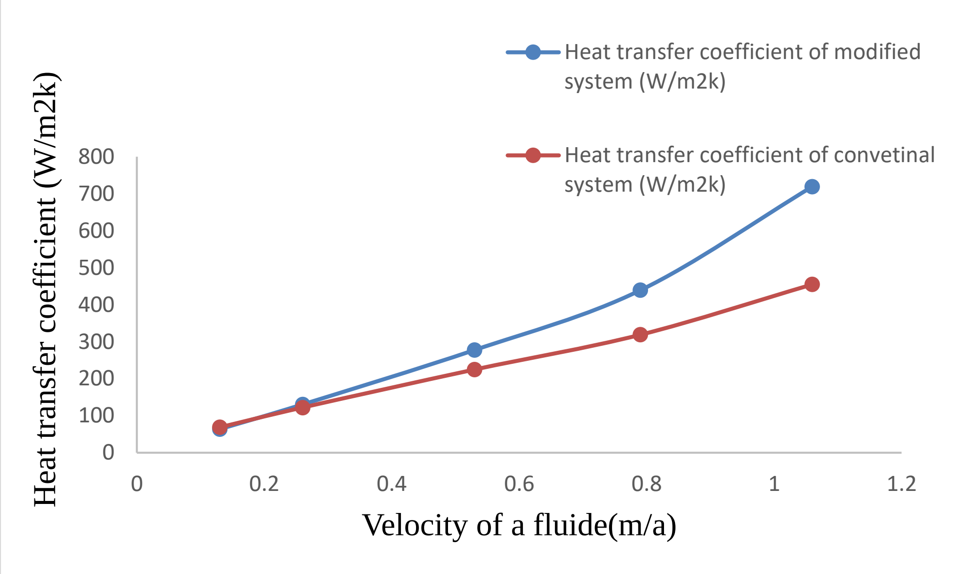

Figure 10: Comparison of system in term of Heat transfer coefficient with velocity

Conclusions:

After successful completion of mathematical as well as experimental setup testing The flat Plate collector of the ZIG-ZAG pattern is more efficient in performance than a conventional flat plate pattern in the below manner.

The Heat transfer coefficient of a zigzag pattern increases by 18.14%.

- The Temperature of a zigzag pattern increases by 14%.
- The friction factor of a zigzag pattern increases by 17.26%.
- The relative decrease in frictional factor for the zigzag riser tube is 3.38 % more than the straight riser tube.
- The relative Reynolds number for a zigzag riser tube is 8.50% higher than straight riser tube

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