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Enhance the Performance of Absorber Tube using Helical Twisted Tapes Inserts in Solar Parabolic Trough Collector

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ABSTRACT: A novel idea implemented to improve the thermal performance of solar parabolic trough collector to some extent. The newly SPTC is constructed with plain tube absorber has been taken for experimental analysis and three different helical twists ($Y=2$, $Y=3$ and $Y=4$) are used in the absorber tube for investigation. The thermal performance characteristics of absorber device with twisted tape of two different twist ratios have been discussed. As ratio of twisted tape decreases, thermal gain of the absorber tube increases. It is noted that the absorber using twisted tape enhance the overall performance of the solar parabolic trough collector.

KEYWORDS: Solar parabolic trough collector, Plain tube absorber, Helical twisted tapes inserts, Thermal performance.

I. INTRODUCTION

Many techniques are employed to increase the overall efficiency of heat exchangers. The different shapes of inserts are also practiced to increase the overall performance of heat exchanging devices. The passive development technique of helical twisted tapes insert is cheaper one. It is easily attached with heat exchanger devices to enhance the thermal performance. The SPTC absorber with insert helps to maximize the efficiency so that losses are minimized. Solar PTC efficiency is defined as the ratio of energy absorbed by the working fluid to the solar beam radiation incident upon the collector aperture. The Solar energy collection is vital one for transferring heat even under a small temperature difference. So many researchers are attempted to enhance the performance of PTC using various insert technique. Chang et al [1] investigated experimentally that the use of eccentric leads to higher performance. In Particular performance evaluation criterion is recorded more than unity. Ghasemi et al [2] investigated the impact of porous rings in absorber tube and observed that the convective heat transfer rate improved, Nusselt number increases up to 50% and pressure drop is higher than the plain tube. The traditional types of passive heat transfer enhancement technique is also apt for the solar parabolic trough collector (PTC), it was discussed by several researchers like Song et al [3] and Wangal et al [4] have discussed the possible mechanisms for the improvement of heat transfer and noticed that the thermal and hydro dynamic boundary layers are reduced, flow disrupted abruptly, velocity gradient increased near to the wall and chaotic mixing happened between wall to core which in turn increases the heat transfer rate. Jaisankar et al. [5] analyzed that the special effects of the helical twisted tape on heat transfer and flow friction characteristics of forced circulation in solar water heater system. Kumar and Prasad [6] found that the twisted tape inserted solar water heater enhances the convective heat transfer. Al-Fahed et al. [7] conducted experimental work on heat transfer and compared the micro tube with twisted tape inserts in laminar flow. The newly solar parabolic trough collector is constructed with plain tube absorber has been taken for experimental work and three different helical twists ($Y=2$, $Y=3$ and $Y=4$) are used in the absorber tube for investigation.

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II. EXPERIMENTAL SETUP

The solar parabolic trough collector is constructed as shown in fig.1 and experimental investigations have been conducted. It consists of collector is made up of high reflective steel material, the black coated copper tube enclosed with glass tube, a storage tank insulated with glass wool, a circulating pump, a flow meter and other measuring devices. The use of receiver of a PTC is to capture the fraction of incident direct normal radiation and transfer the radiation energy to the working fluid which is flowing through the absorber tube. The RTD PT 100 type thermometer helps to measure the temperatures of water at inlet and exit of the absorber. The mass flow rate of water is adjusted using by-pass valve. The U tube manometer was used to measure the pressure drop. The Pyrheliometer was employed to measure the solar radiation intensity. The positive displacement pump circulates the water from a collecting tank through the receiver tube of the collector system and back to the storage tank. The PTC is rotated with a single axis tracking north-south axis to obtain the maximum incidence solar energy.



Fig.1. Experimental set up of PTC

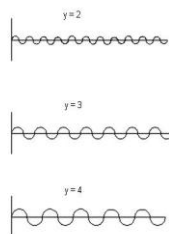


Fig.2. Schematic representation of helical twisted tape inserts

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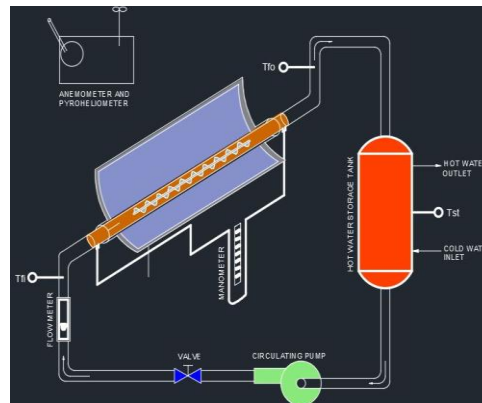


Fig.3. Schematic representation of PTC with helical insert

Initially, De-ionised water is used in plain tube for experimental investigation and tests have been conducted, then three different twist ratios ($Y=2$, $Y=3$ and $Y=4$) are used as shown in Fig.2. The helical tapes were inserted and tests are repeated.

III. RESULTS AND DISCUSSION

3.1. Heat transfer study

Fig.4. shows the variations of Nusselt number for the different values of Reynolds number for the twist ratio of $Y=2$, $Y=3$ and $Y=4$ in the test section, de-ionised water is used as the working fluid. The observations shows that the trend line for the plain tube and three different twist ratios of inserts. The Nusselt number increases with Reynolds number, as lower twist ratio of the helical twist tape fixed in the test section promotes higher Nusselt number than higher twist ratio. It is because of disturbance of boundary layers created a strong swirl flow and so that the heat transfer rate is increased.

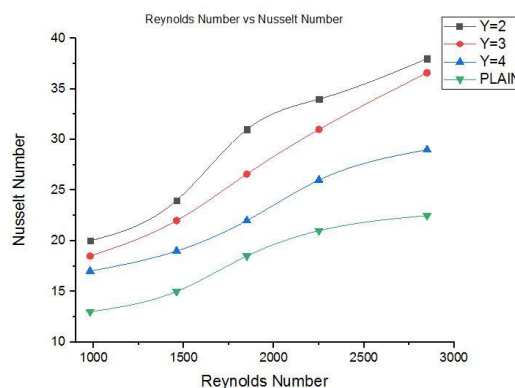


Fig.4. Nusselt number Vs Reynolds number under laminar flow

Nusselt number enhancement with different twist ratios of $Y=2$, $Y=3$ and $Y=4$ using DI water was 66.76%, 54.38% and 47.45%. The results clearly indicate that the higher performance recorded for the lower twist ratio than the plain for the range of Reynolds numbers.

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3.2. Pressure drop study

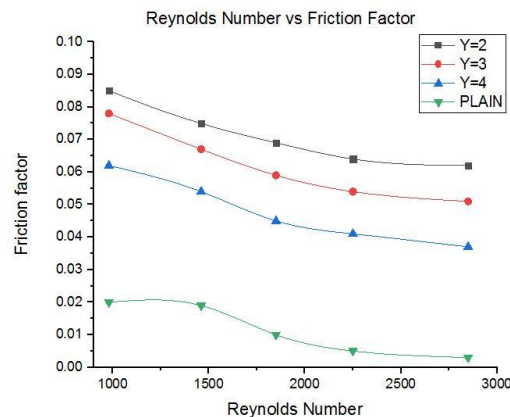


Fig.5. Friction factor versus Reynolds number under laminar flow

Fig.5. exhibits that the variation of friction factor with Reynolds number for the two different Helical twisted tapes inserts fitted in the test section. It is noted that the behaviour of the curve showed that the increase in Reynolds number decreases the friction factor it is due to the momentum of the flowing fluid also the friction factor increased for the less twist ratio of $y = 2$. This was due to the residing time and more contact surface areas. However, the pressure loss occurring due to interaction between the pressure forces and inertia forces in the thermal and hydrodynamic boundary layers. The effect of insert $y=2$ offered higher friction factor of 4.5 times than plain tube.

IV. CONCLUSION

In this investigation, the Nusselt number and friction factor characteristics are studied for all the helical twisted tape inserts experimentally. The obtained result illustrates that the heat transfer rate increased for the minimum twist ratio of helical twisted tapes inserts in the absorber and its surface is significantly enhances the shear-produced turbulence effect with moderate pressure drop. The Nusselt number enhancement for twist ratios, $Y=2$, $Y=3$ and $Y=4$ using DI water was 66.76%, 54.38% and 47.45%. The results clearly indicate that the higher performance recorded for the lower twist ratio than the plain for the range of Reynolds numbers. Hence it's concluded that significant increase in nusselt number occurs for lower twist ratio of helical twisted tapes inserts in the absorber tube.

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