

Experimental Design and Analysis of Parabolic Trough Collector

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Abstract- In this examination, a trial plan and examination of an altered little measured sun oriented allegorical box authority (PTC) has been done to research its exhibition. A PTC framework with 4.075 m² gap territory was assessed in this paper. The trial arrangement is comprised of excited iron (GI) reflector with an intelligent film. The presentation of PTC was examined in investigation. Execution examination was finished by utilizing typical illustrative box gatherer and changed allegorical box authority and a correlation was finished utilizing investigation. Both the cases were concentrated by utilizing water as the warmth move liquid.

This investigation was led for discovering the betterblend of explanatory box for gatherers and it was utilized to discover better warm effectiveness of PTC in differed climate condition

Keywords- Parabolic trough collector, modified design parabolic trough, water-heat transfer fluid, thermal efficiency

Among all the concentrating and non-concentrating sunlight based energy advances, PTC is the most reasonable and utilized innovation.

Test examination on PTC was directed by different scientists to explore and upgrade its exhibition. J.Macedo-Valencia, J. Ramírez-Ávila, R. Acosta, O.A. Jaramillo and J.O Aguilar [6] exploratory investigation has been done on the subject of "Plan, development and assessment of illustrative box authority as decisive model" The phases of configuration, displaying, and assessment of an allegorical box gatherer (PTC) for warming water as an expressive model are introduced. In the plan it was viewed as the illustrative opening of 0.5 m wide and 0.95 m long. The plan was finished utilizing PC helped plan and assembling. The aftereffects of the assessment to decide the warm exhibition of the illustrative box gatherer have a greatest outlet temperature of 47.3 °C for a direct sun powered radiation of 783 W/m² at a stream pace of 0.200 L/min.

I. INTRODUCTION

Populaceblastandheadwaysinadvancesincrementworl d'senergyinterest.As ofnow,themajorityoftheseenergyrequestsar esatisfyingbythenon- sustainable power sources like petroleum derivatives: coal, oil and flammable gas. These fuel sources produce hurtful outflows alongside power age which is perilous for human wellbeing and to the climate. Accordingly, thought of sustainable power sources is vital to decrease hurtful gases and to meet the necessities of the living populace. On our planet, sustainable power sources are available in different structures like sunlight based energy, hydropower, geothermal energy, wind energy, biomass force and others. Sunlight based energy is one of the greatest fuel sources among every one of these environmentally friendly power sources. It is one of the promising and most demonstrated sustainable power choices to substitute these non-sustainable power sources. Sun powered energy on the earth surface can be saddle by different concentrating and non-concentrating advancements like level plate authority, direct Fresnel gatherer, explanatory box authority (PTC) and allegorical dishauthority.

II. MODELING

SPTC is a warmth trading kind of innovation that changes over sun powered energy into nuclear power and eventually assists with creating power and high temp water dependent on the territory of utilization. Significantly it comprises of two sections, a reflector, fundamentally a metal sheet that bended as parabola with indicated measurements in two ways and straight one way and a beneficiary cylinder. Reflector is utilized to gather sun powered energy and concentrates towards the central line of reflector. A beneficiary cylinder is set at the central line of reflector which contains a warmth move liquid, flowing through it. In this framework, collector tube gets immediate sun powered radiations on its upper surface and focused radiations on its lower surface. Warmth move liquid coursing through it, gets warmed through heat moving cycles. It is fundamentally utilized for high temperature application like power age. Medium temperature applications, for example, modern cycle warming, homegrown utilizations and private reasons for existing are additionally vital which can diminish the utilization of power created by ordinary strategies. It will at

last diminish the ecological contaminations brought about by petroleum derivatives.

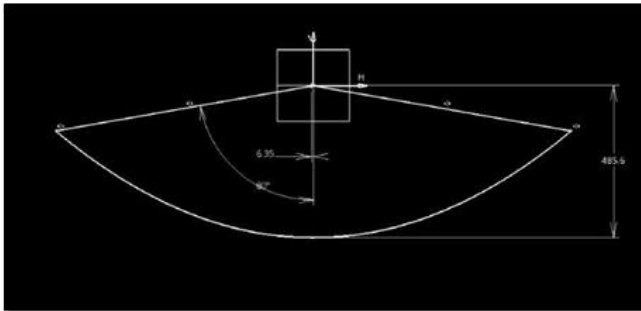


Figure 1. Across sectional view of modified PTC (all dimensions are in mm)

Mathematical boundaries incorporate edge point, focus proportion, central length, particulars of the recipient tube and the authority. Every one of these boundaries are mathematically identified with one another. A portion of these are appeared in Fig. 1. Edge point central length, focus proportion, gap width, gap territory and compelling opening region of PTC can be determined by the accompanying conditions.

- Rim angle (θ): It is the angle between the optical axis and the line between focal point and collector rim. It is calculated by using the following relation:

$$\cos \theta = \frac{r}{f} \tag{1}$$

Where W , is aperture width (m) and r is the radius of a parabola (m).

- Focal length (f): It is the distance between the focal point and collector rim.

$$f = \frac{W^2}{4 \tan^2 \theta} \tag{2}$$

- Concentration ratio (C): It is the ratio of collector's aperture area and receiver's surface area.

$$C = \frac{A_c}{A_r} \tag{3}$$

Where D , is the outer diameter of the receiver tube (m).

- Aperture width of collector:

$$W = 4 \tan \theta \cdot f \tag{4}$$

- Aperture area of collector:

$$A_c = \pi \cdot W \cdot L \tag{5}$$

- Effective aperture area of collector: Aperture area that receives direct solar radiation:

$$A_{eff} = (A_c - A_r) \cos \theta \tag{6}$$

Where L , is the length of the collector (m).

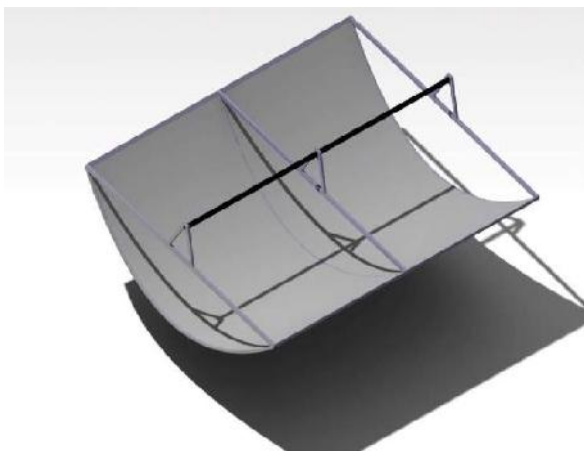


Fig2- 3D view of Modified PTC

III. METHODOLOGY

A little measured PTC framework was created based on the planned boundaries and furthermore changed PTC was manufactured. The determinations of trial arrangement are recorded in Table 1. This test arrangement comprises of explanatory box (reflector), recipient tube, stockpiling tank, circling lines and supporting stand. The reflector is made of mirror completed treated steel sheet of 88% reflectivity which is upheld on a supporting edge made of hardened steel ribs. The PTC was built by crossing two parabolas in the counterbalance from point of convergence of 12.7mm like as show in fig1(b). The 3D displaying is appeared in fig 2. Copper for the recipient tube is utilized in this examination; properties are recorded in Table 2. Collector tube is covered with matte dark paint that absorptivity is 92%. The matte dark paint as covering on the collector tube surface is chosen to expand absorptivity of the beneficiary surface. The recipient tube is encircled by a concentric glass with an annulus hole of 1.73 cm. The annulus hole is loaded up with still air to decrease convection and radiation misfortunes from the outside of the recipient tube by opposing the development of air introduced in encompassing of the collector tube external surface. An acrylic tube has been utilized as substitute of glass cylinder and air is utilized in annulus hole rather than vacuum utilized in regular PTC frameworks. An emptied beneficiary cylinder has not been utilized as it is extravagant and furthermore it was not effectively accessible all over the place. An acrylic tube has numerous benefits over a glass tube as it has transmissivity of 92%. It has low weight and commonly more grounded than a glass tube. It is reasonable for little measured financially savvy PTC framework. The recipient tube is situated at the central line of reflector to get the concentrated warmth transition from thereflector.

The trials on PTC framework were directed at ESEC (Erode Sengunthar Engineering College) situated in Perundurai, disintegrate (DT).

(11°18'52.2"N 77°33'00.9"E), TamilNadu, India. The PTC framework is arranged in North-South pivot and single hub manual following is embraced along east-west heading to follow the sun beams to get the most extreme measure of occurrence sun oriented radiation. The tests were led in the long stretch of March 2021. In this current work, we chose water as HTF. The properties of water are recorded in Table2. The readings were taken from 8:00 am to 5:00 pm and noted at a time frameminutes

Table 1: Specification of PTC system

Focal length (F)	0.485 m
Outlet focal point distance from focal point (L)	0.005 m
Aperture radius (R)	1.64 m
Length of collector (L)	2.5 m
Rim angle (θ)	80°
Aperture area (A _a)	4.07 m ²
Effective aperture area	4.1 m ²
Copper tube (m)	Inner diameter: 0.0234, outer diameter: 0.0254
Concentration ratio	20.1/(for copper tube)

Table 2: Physical properties of receiver tube material and water

	Copper tube	Water
Density (kg/m ³)	8930	1000
Thermal conductivity (W/m-K)	384	0.6
Specific heat (J/kg-K)	380	4182
Viscosity (kg/m-s)	0.001004	0.001003

IV. RESULTS AND DISCUSSION

Direct Solar Radiation (DSR) for ordinary PTC and altered PTC are appeared in Fig 3. It tends to be seen that the measure of DSR is limit of 716.6 W/m² at 13.00 p.m. in the event of ordinary illustrative box gatherer. Variety in the delta and outlet temperature of HTF with time for two unique conditions is appeared in Fig. 4. Since cold water stockpiling tank was kept to the side close to the PTC framework and it was getting diffused radiations. Hence, little temperature addition can likewise have seen at bay state of the collector tube.

The delta temperature of HTF is expanded from 8.00 a.m. upto 14.00 p.m. furthermore, after that variety become more slow because of low radiation up to 16.00 p.m. The power source temperature of HTF is low in the first part of the day altogether the cases because of low DSR. It very well may be seen that outlet temperature of water in the event of copper tube is diminished at 8:30 a.m. because of low DSR around then in contrast with different cases. After that as the warmth motion increments from 8:30 a.m. up to 13.30 p.m. The power source temperature additionally increments if there should arise an occurrence of copper beneficiary cylinder at 0.01 kg/s mass stream rate and the most extreme temperature of 44.6°C is seen at 13:30 p.m. at DSR of 623 W/m². However, the radiation is most extreme at 13.0 p.m. The power source temperature arrives at the greatest at 13.30 p.m. As the sun based radiation will diminish the power source temperature won't diminish promptly because of high warming limit of the beneficiary around then. because of high warmth misfortunes from the recipient surface at most extreme DSR. we saw that at low mass stream rate recipient is performing better even at high radiation in light of the fact that at low mass stream rate, HTF is possessing adequate energy for appropriate show heat move from the collector internal surface to HTF and that will likewise decrease heat misfortunes from the beneficiary

external surface. If there should a rise a no occurrence of ordinary PTC, DSR is greatest, 717.1 W/m² at 11:30 p.m. also, outlet temperature is limit of 39.6° Cat 14.00 p.m. It is seen that at same mass stream rate copper tube is showing preferred warm execution over tempered steel tube. This is because of the great warm conductivity of copper than treated steel. Warm effectiveness for both the cases is appeared in Fig. 6. It emphatically relies upon the sun based radiation. Greatest effectiveness of 35.9% was gotten in typical PTC. We realize that a copper tube has better warm execution even at a high mass stream rate in examination of treated steel tube. The bend of the warm productivity would show diminishing pattern where the variety of the temperature augmentation will be lower than the variety of sun based radiation. It will occur because of warmth misfortunes from the recipient external surface. The expanding example of warm effectiveness shows that the variety in temperature is more than the variety in sun powered radiation.

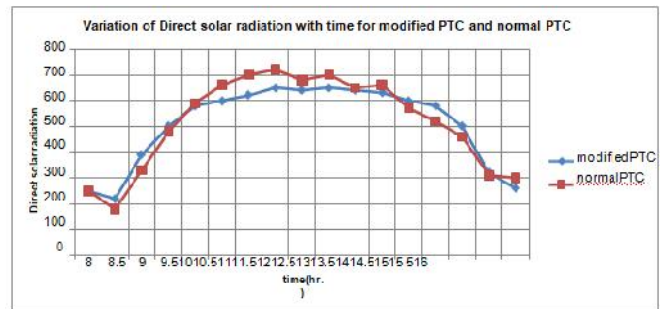


Fig3

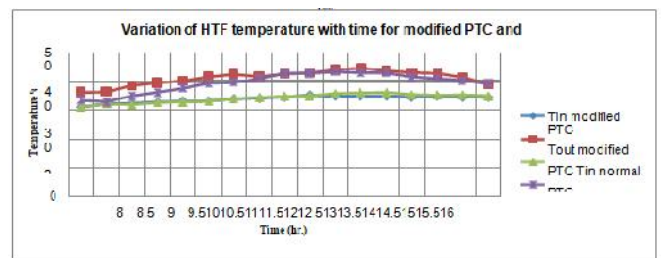


Fig4

V. CONCLUSION

The exploratory examination was directed on a little measured sun oriented allegorical box gatherer at (Erode Sengunthar Engineering College) situated in perundurai (11°18'52.2"N 77°33'00.9"E), TamilNadu, India.. The exhibition of PTC was researched in two cases. In the main case, execution examination was finished by leading trials typical explanatory box authority. In the subsequent case, an exhibition examination was finished by leading analyses changed explanatory box authority.

Both the cases were contemplated utilizing water as the warmth move liquid. This examination was directed for discovering the better effective PTC model . From the principal case, it was seen that copper recipient tube is showing better execution. The most extreme warm productivity of 35.9% is acquired if there should arise an occurrence of a copper recipient at 0.01 kg/s mass stream rate. From the subsequent case, the greatest temperature contrast of 18.1°C and warm proficiency of 61.4% was gotten in the event of a collector with an acrylic tube. Accordingly, adjusted allegorical box authority is preferred proficient over ordinary explanatory box gatherer.

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