Experimental Investigation and Efficiency Analysis of Solar Parabolic Trough Collector

Sekar M[1], Arunkumar S[2*]

[1]*Professor, Department of Mechanical Engineering, Government College of Technology, Coimbatore – Tamilnadu, India*

[2]*Research Scholar, Department of Mechanical Engineering, Government College of Technology, Coimbatore – Tamilnadu, India*

[1]*msekar@gct.ac.in*

[2]*arunkumarresearch2018@gmail.com*

Abstract

Parabolic trough collector (PTC) is basically a solar energy conversion technology that is employed for heat application. PTC is employed normally in an industrial application intended for thermal together with power generation's applications. The solar PTC encompasses an Absorber Tube (AT), centred on which, the solar PTC performance is varied, in addition, the lifetime's measurement of the specific AT material is an imperative one. This work concentrated on the experimental investigation together with efficiency scrutiny of PTC that has Alumina (Al_2O_3) in addition to Tungsten Carbide (WC) coating on the stainless steel AT. This investigation comprises '3' parts. First, the PTC together with absorber tube materials is modelled. Here, the tungsten carbide and aluminum oxide is coated by utilizing the Superjet Eutolloy thermal spraying gun technique. Next, the experiment's set-up of PTC with stainless steel, stainless steel with WC coating, stainless steel with an Al_2O_3 coating, and copper absorber tube is elucidated. Finally, efficiency is computed. In the experiment's assessment, stainless steel with WC material encompasses high efficiency with less Corrosion Rate (CR) than the other materials. Lastly, this exploration scheme exhibits that the stainless steel with tungsten carbide renders a higher lifetime along with efficiency contrasted to the aluminum or copper.

Keywords: Absorber tube materials, Superjet Eutolloy thermal spraying gun method, Solar water heating system, Tungsten carbide and Aluminium oxide coating.

[*] Corresponding Author

1. Introduction

Energy is basically an imperative input for socio-economic developments. The rate upon which energy is employed by a nation often reveals its prosperity level that it can attain [1]. Solar energy establishes itself as a tremendously possible energy source for sustainable advancement [2]. The major elucidation of solar energy conversions is split into '2' very important divisions i.e., electrical along with thermal conversion units [3]. Solar thermal energy is environmental-safe and sustainable energy, which probably has the maximum potential for any single renewable energy region [4]. Therefore, thermal energy conversions are made by utilizing a trough collector system [5]. Several solar thermal power technologies have progressed and advanced that the technologies can well be modelled at disparate figures, like spherical, cylindrical, parabolic, along with trapezoidal [6].

Amongst all the intense solar power method, the parabolic troughs solar power technology is largely appropriate for air-water heating along with power generation. Since the PTC technology comprises several benefits, like higher power density, higher thermal efficiency, modularity, together with versatility [7]. In addition, the PTC is commonly engaged for a steam generation on account of its higher collector's capability at the mid-temperatures (about 300°C) [8]. Solar power technologies function on the norm of focusing solar radiation into a little region to create steam or hot air, which can well be utilized for electricity generation utilizing traditional power cycles [9]. The PTC comprises a unique tube labelled the AT. A Heat Transfers Fluid (HTF) goes via the AT to gather the heat as well as transport it to the power generation system [10, 11].

Entirely, the PTC encompasses '3' factors: a mirror reflector, solar absorbers (volumetric or tube absorbers) along with HTF [12]. In the current years, numerous kinds of PTC have been mainly examined and experienced [13]. These techniques commonly aim to amplify the heat transfer co-efficient in the flow to accomplish advantageous heat transfer conditions in the flow [14]. As well, the current work concentrated on ameliorating the efficiency in solar PTC but the amelioration of the effectiveness of demanding topics these days. Higher solar absorption, ameliorated heat transfer to a functional fluid, along with lessened thermal loss is significant factors for enhancing the PTC’s effectiveness. Thus, the proposed work paper experimentally examines and enhances the solar PTC’s effectiveness utilizing disparate AT.

The work is set as: Section 2 examines the associated work regarding the proposed work. Section 3 displays a concise discussion about the design, experimental set-up, and efficiency calculation of the Solar Parabolic Troughs Collectors (SPTC). Section 4 analyses the system’s performance. Last, of all, section 5 wrapped up the paper.

2. Related Work

Muhammad Sajid Khan *et al.* [15] modelled and examined the ‘3’ disparate AT geometries (smooth AT, AT with warped tape insert along with tube with longitudinal fins) of commercially presented LS-2 collector. The cause of a disparate amalgamation of inlet temperatures as a functional parameter on the energy along with exergy efficiencies, pressure drop, exergy destruction, heat transfer co-efficient, together with receiver temperature was examined. The outcomes of the review demonstrated that the adapted AT geometries had an important augmentation in exergy along with energy efficacies when weighted against the traditional smooth AT geometry. Li Xu *et al.* [16] illustrated a mathematical design of the transient thermal behaviours of Parabolic Troughs Solar Collectors (PTSC). After that, to authenticate the transient model, its numerical outcomes were contrasted with the investigational data. These were gathered as of a utility-scales loop of PTSC. The contrast betwixt the design predictions and the investigational data illustrated a reliable along with the sensible agreement. Therefore, the design was utilized to execute a parametric study to make analyze of necessary impact factors on transient behaviours of PTSC. These aspects contained the HTF's temperatures at the inlet, the initial setting, together with the optical effectiveness. Seiyed E. Ghasem and A. Ranjba [17] demonstrated the forced convections heat transfers turbulent flow within the receiver tube of solar PTC with NanoFluids (NF). The scheme employed for CuO-water along with Al_2O_3-water NF. The examination was implemented centred on $k-\varepsilon$ the re-normalizations group turbulent design for disparate heat flux setting. The consequence of NF's volume fraction in thermal along with parabolic trough's hydrodynamic performance was elucidated. Outcomes illustrated that NF ameliorated the heat transfer features of PTC contrary to pure water. The outcomes implied that by augmenting the NanoParticle (NP) volume fractions, the average Nusselts Number (Nu) along with friction factor was augmented for NF.

Kun Hong *et al.* [18] examined the thermal along with the flow features of a PTSC. The turbulent flow within the receiver tube was modelled via the finite volume system, whilst a non-uniform intense heat flux was foisted on the AT. A Cu–water NF was given as the HTF. The outcomes illustrated that augmenting the Cu nanoparticle concentration led to an augment in the Nu. In addition, the effectiveness of Cu nanoparticle addition on the heat transfer improvement became extra important as the Reynolds number reduced. The word offered new comprehension into the impact of Cu nanoparticle addition on the thermal along with flow features of PTSC.

Pablo D. Tagle-Salazar *et al.* [19] demonstrated a PTSC's thermal design for heating applications centred on NF as HTF. The thermal model was centred on a thermal resistances circuit to attain the heat fluxes via the receiver's surfaces. The design utilized energy balance to decide the collector's thermal performance. It was a customized adaptation of the Forristal model, wherein the convective heats transfer co-efficient of the HTF was attained not only for familiar fluids utilized in PTC systems, like water along with thermal oil but also for Al_2O_3-water NF. The experimentation was done over an array of process parameters centred on alumina-water NF as HTF. Amir Menbari *et al.* [20] planned and executed to examine the absorption along with the thermal conductivity of binary NF and to estimate the features concerned in their optimal stability. For this reason, '2' different NP, explicitly, CuO (with higher absorption properties) along with γ-Al_2O_3 (with higher scattering properties), were selected to organize a binary NF. Outcomes illustrated that the NF's thermal conductivity along with aggregation was maximal in addition to minimal, correspondingly, below optimal stability terms. Experimentations with the Direct Absorption Solar PTC (DASTPC) also exposed that the thermal effectiveness of the scheme was improved by augmenting NP volume fraction along with the NF flow rate.

3. Modeling and experimental investigation of solar parabolic trough collector

Solar energy usage is a propitious Renewable Energy source that covers a range of energy requirements of this society. This paper modelled and also experimentally examined the solar PTC. The proposed paper comprises '3' phases: i) design of PTC, ii) experimentation set-up, and iii) efficiency calculation. In the preliminary phase, the specifications concerning the PTC is elucidated that implies the Focal Length (FL), Rim Angle (RA) in addition to Concentration Ratio (CR) are computed since solar collector (SC) that resembles a parabolic mirror just reflects the incident solar energy on the SC's longitudinal axis. This line is termed the parabolic collector's focal axis. Thus, the proposed paper computes the FL centred on the aperture value. After that, the RA is also computed centred on the FL. Subsequently, the coating materials of the AT are modelled utilizing the thermals spray procedure. In the 2nd phase, the experimentation was performed for stainless steel (SS), stainless steel with WC coating (SS+WC), stainless steel with an Al_2O_3 coating (SS+Al_2O_3) along with copper AT. Finally, the proposed solar PTC's efficiency is examined. The proposed system's block diagram is exhibited in Figure 1.

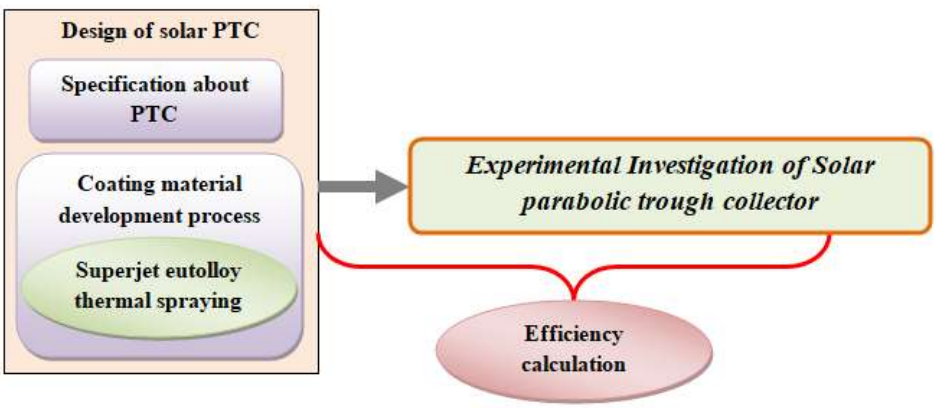


Figure 1. Architecture of the Presented System

3.1 Design of PTC

First, this paper elucidated the PTC's design. PTC is recurrently employed for a solar steams generation since comparatively higher temperatures can well be attained devoid of serious deprivation in the collector efficiency. Here, the collector is modeled with simple parabolic equations. The parabolic section's geometrical relations are exhibited in equation (1). The sheet was curled to make a parabolic trough module of 1.2m length in addition to 0.6m aperture. The simple parabolic equation on Cartesians coordinates is,

$$u^2 = 4 f_l v \tag{1}$$

Wherein, u and v imply the Cartesian co-ordinates and f_l signifies the focal length. As of the equation (1), the parabola's height concerning the FL is derived as,

$$f_l = \frac{(A_c)^2}{4h} \tag{2}$$

Wherein, A_c implies the aperture width of collector as well as h signifies the height. Next, the PTC's RA is computed, which is associated with the aperture and FL, which is specified by,

$$\tan \varphi_{rim} = \frac{8(f_l / A_c)}{16((f_l / A_c)^2 - 1)} \tag{3}$$

Wherein, φ_{rim} implies the rim angle and it stands as the angle betwixt the axis and a line (for the line the focus is given to the concentrator's physical edge). Together, the FL and RA of a parabolic concentrator entirely describe its cross-sectional geometry. After that, the geometrical CR is computed for the PTC, which is stated as the collector aperture's area divided by means of the receiver's surface area, such as,

$$Con_r = \frac{A_c}{S_r} \tag{4}$$

Wherein, Con_r implies the concentration ratio and S_r signifies the receiver's surface area. The chosen data of the designed model has subsequent values as exhibited by table 1.

Table 1. Specifications of PTC

Description	Specification
Absorber tube materials	Stainless steel, Copper
Coating materials	Tungsten carbide, Alumina
Absorber tube length	1.5m
Outer Diameter of tube	25mm
Inner Diameter of tube	22mm
Reflector	0.4mm thickness Aluminium sheet
Reflectivity	0.90
Emissivity	0.12
Aperture	0.6m
Length	1.2m
Concentration ratio	7.32
Focal length	97.8mm
Rim angle	74.9^0

As of table 1, the proposed PTC system regards the SS in addition to copper as the AT materials, and the WC in addition to Al_2O_3 is regarded as the coating materials. The design of those materials is elucidated in subsection 3.1.1, and the AT's length is 1.5m and the tube's inner and outer diameter is 22mm and 25mm. The parabolic trough reflector's thickness is 0.4mm and also the reflector is formed of the aluminum material. The reflector's reflectivity and emissivity are 0.90 and 0.12. The aperture of the parabolic is 0.6m, length is 1.2m and also the CR is 7.32. The FL in addition to the RA of the proposed design of PTC is 97.8mm and 74.9^0.

3.1.1 Coating material development process:

The coating material development process is elucidated in this section. The coating materials are WC along with Al_2O_3. The WC and Al_2O_3 coating was performed by the thermal spray procedure. This method places the particulate semi-molten, molten, or solid on a material to be coated. The spraying method is a direction to produce such particles 'stream'. The Layer can well be created when the particles can bend plastically with the substrate at higher force, which is probably simple if fused or solid. The WC and Al_2O_3 coating are supplied-as powder, and it is turned to a molten or semi-molten state by heating, and, hastened in the direction of substrates on the micro-meter size particles form.

Combustions or electrical arcs discharge is typically employed as the energy source aimed at thermal spraying. The combustion along with electrical arcs discharge utilize the dissimilar methods for thermal sprayings, for example, higher-velocity oxygen-fuel spray (HVOF), flame spray, pulshing arc, Detonation gun spray, et cetera. This paper utilizes the Superjet Eutolloy thermal spraying gun, which is the versatile power delivery system. The functioning theory of the gun is that a heavy-pressure wave is produced by a repetitive ignition of the fuel blend, usually, acetylene along with oxygen within a long, narrow pipe. Additionally, the spray gun method proffers outstanding wear resistance correlative to plasma spray coatings to abrasion along with erosion.

Table 2. Process Parameters of the Thermal Spray Process

Description	Specification
Spray gun	Superjet Eutolloy
Nozzle diameter	2mm
Spray distance	25mm
Acetylene pressure	0.5 bar
Oxygen pressure	1.5 bar
Number of passes	2
Thickness achieved	50µm
Materials (Powder)	Tungsten carbide, Alumina
Size of particles	60 microns

The chemistry along with working settings to deposit the coatings is expressed in Table 2. In this above-given table, the nozzle diameter, materials, spray distance, acetylene pressure, size of particles, oxygen pressure, together with thickness achievement parameters are characterized. The proposed technique regards that the acetylene together with the oxygen pressure of the gun is 0.5 bars and 1.5 bars. The 50µm thickness is attained centred on this pressure.

3.2 Experimental investigation

The experimental examination procedure is executed here. Fundamentally, every parabolic collector is completed up of two major fractions, for example, i) the concentrator in the form of a concave mirror, normally, composed of glass or polished steel plate takes the radiant energy as of the sun as well as transmutes it to helpful thermal energy in the HTF, along with ii) AT including a metal tube. This experimentation system comprises of the parabolic trough (reflector), reservoir tank, ball valve, AT, circulating pipes along with supporting stand. Now, the PTC's base structure was composed of waterproof plywood, and also it was completely connected to make the structure, and the AT of solar PTC was composed of SS, SS+WC, SS+Al_2O_3 coating along with copper.

In this experimentation set-up, the reservoir tank was entirely full of water. The reservoir was enclosed with polystyrene material. For experimentation purposes, polystyrene sustains the water temperature less than atmospheric temperature. The ball valve is utilized to sustain the water flow as of the reservoir tank to the AT. The valve is sustained at the smallest opening position and also the flow rate is managed by means of the valve position. The one ending of the AT is linked with the water reservoir tank. The heat achieved by HTC is observed for the mass flow rate of 0.0068 Kg/sec. The experimentation was made for SS, SS+WC, SS+Al_2O_3 along with copper AT. A thermometer is utilized to gauge the inlet along with the outlet temperature of the AT. Here, '2' collectors with disparate AT material were examined, simultaneously. Structure of the proposed experimentation set-up is exhibited in Figure 2.

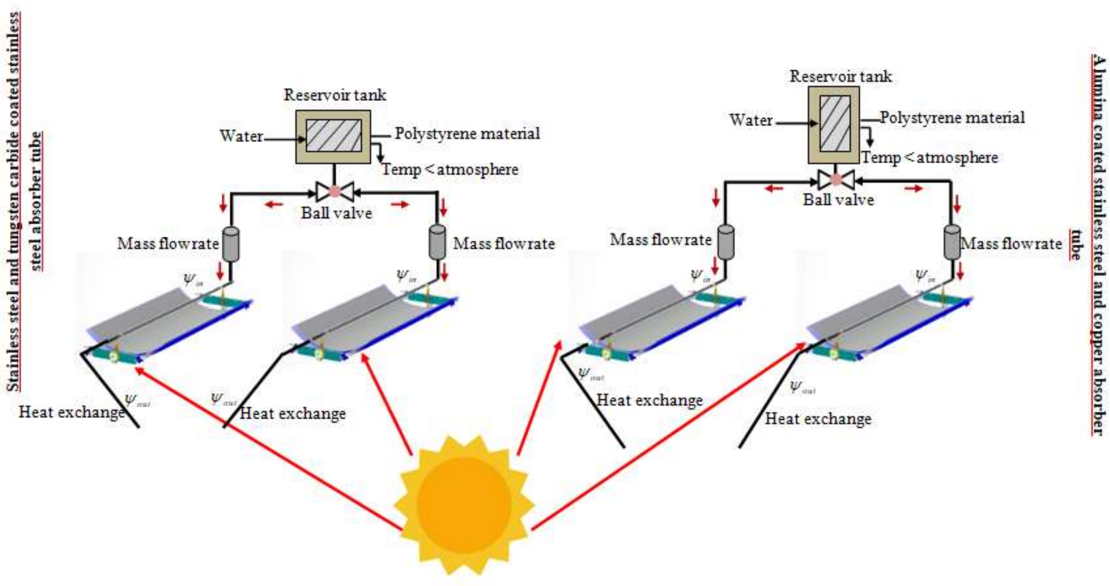


Figure 2. Structure of the Presented Solar PTC Experimental Set-up

3.3 Efficiency calculation

Here, the proposed experimental set-up's efficiency is computed. The thermal efficiency and helpful heat gain are computed.

Thermal efficiency: The collector's thermal efficiency is stated as the ratio of the instantaneous usable heat gained by means of the HTF and the immediate direct solar radiation incident (D_s)on the specified aperture area (A_e) of the collector:

$$\chi = \frac{H_g}{H_j} \quad (5)$$

Wherein, H_g signifies the helpful heat gain, χ implies the thermal efficiency output and H_j signifies the D_s on the rendered A_e of the PTC. The quantity of heat gained by HTF flowing via the receiver tube that means the helpful heat gain is gauged by utilizing the equation (6),

$$H_g = \omega . \rho (\psi_{out} - \psi_{in}) \quad (6)$$

Wherein, ω signifies the mass flow rates (kg/sec), ρ implies the particular heat capacity (J/kgK), ψ_{out} signifies the HTF's outlet temperature, and ψ_{in} implies the inlet temperatures of the HTF.

Instantaneous solar beam radiation (D_s) incidents on the rendered aperture area (A_e) of the collector:

$$H_j = D_s . A_e \quad (7)$$

Wherein, D_s implies the direct solar radiations and the unit of this term is (W/m^2). Centred on this computation, the efficiency is computed. The efficiency along with performance is elucidated in the section below.

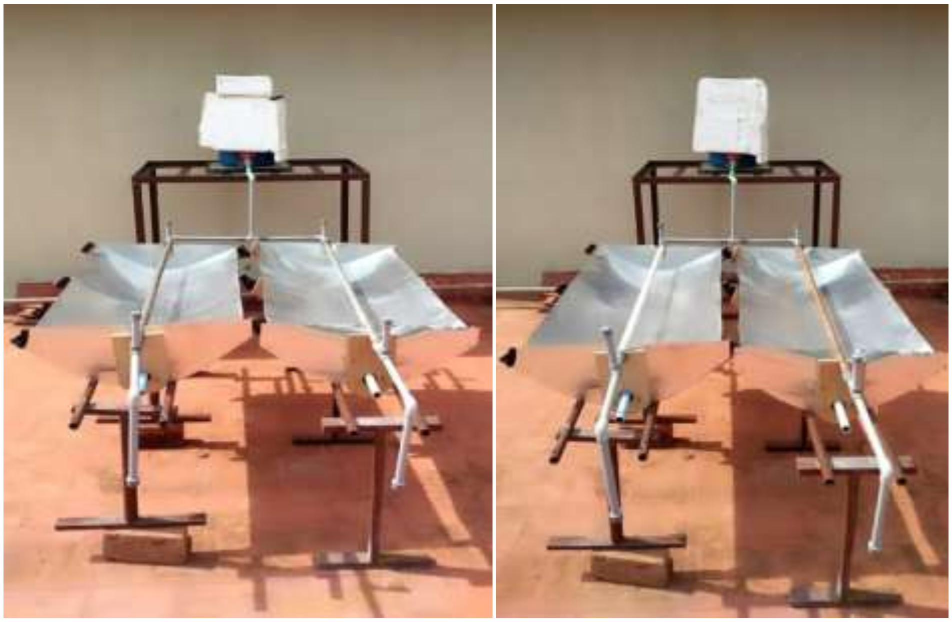
4. Results and Discussion

Here, the solar PTC's performance by utilizing disparate AT is analyzed. The AT is heated at disparate temperatures under solar radiation conditions. The taken PTC is 1.2m length with a 1.5m length SS absorber tube. The operational parameter of the presented performance analysis system is elucidated as,

- Location = Government College of Technology- Coimbatore.
- Latitude = 11.01° N.
- Longitude = 76.95°E.
- Mass flow rate of water = 0.0068 Kg/sec.
- Trough fixed position = North-South.
- Experiment period:

1st absorber tube: March 27,28 and April 03,05,06-2018
2nd absorber tube: April 11, 12, 13, 19, and 20-2018.

In this operational parameter, the experimental period for the SS and SS+WC Coated AT is denoted as the 1st AT, which is analyzed in the day of March 27, 28 and April 03, 05, 06-2018; and 2nd AT denotes the SS+Al_2O_3 and copper AT, which is analyzed on April 11, 12, 13, 19, and 20-2018. The real experimentation set-up of the PTC with SS, SS+WC, and SS+Al_2O_3, Copper AT is exhibited in Figure 3 (a) and 3 (b).



(a) **(b)**

Figure 3. Real Experimental Setups with (a) SS and WC Coated SS Absorber Tube, (b) Alumina Coated Stainless Steel and Copper Absorber Tube.

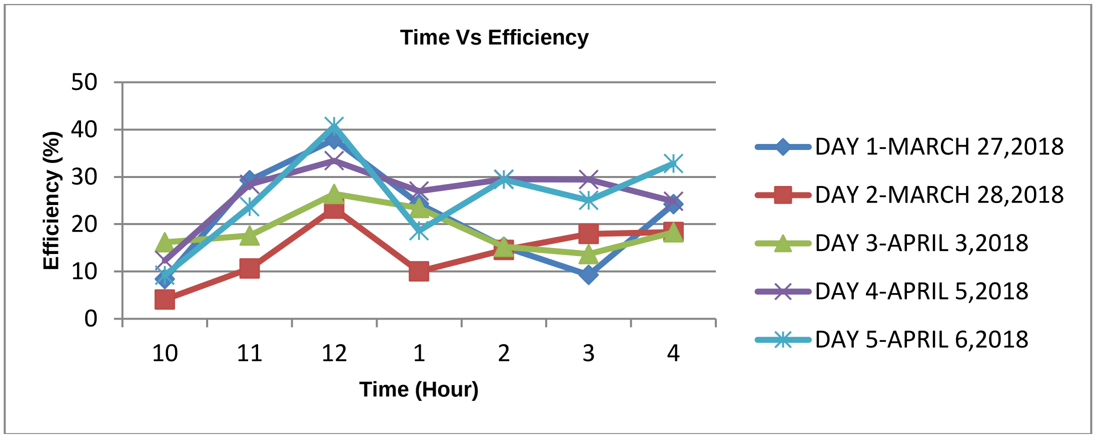
Discussion: Figure 3 shows the same experimentation set-up. Here, the '2' AT linked with the assist of the ball valve. As of the ball valve, the water tank is linked with the AT. The inlet all along with outlet temperatures is offered in Figure 3, and the water tank is enclosed by the polystrene material that sustains the water temperature less compared to the atmosphere temperature.

4.1 Performance of Stainless steel and Stainless steel with Tungsten carbide coated absorber tube

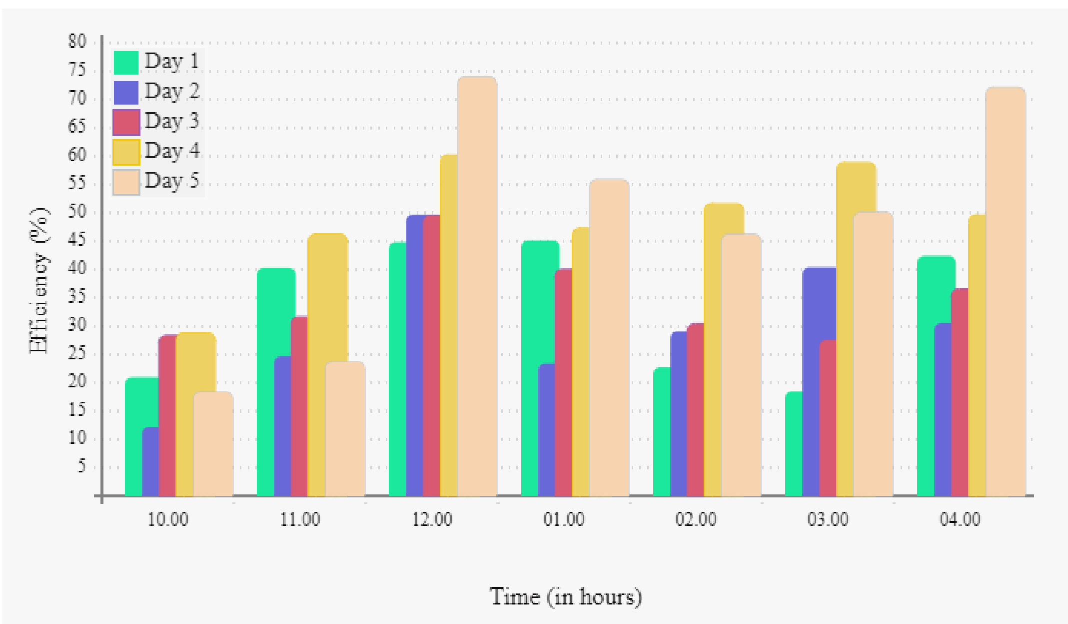
Here, the performance is examined in the sense of solar PTC utilizing SS and SS+WC coated AT. The performance is analyzed in-between 5 days, and it gauged in specific time duration (i.e. 1hr difference).

Discussion: The inlet temperature, outlet temperature, solar radiation, along with the efficiency of the system set-up, which are calculated at time intervals. In addition, on a specific day, this performance is analyzed in day 1 to 5. The solar radiation was exaggerated bit by bit amid the morning and it attained the maximum quantity of 958.53 W/m^2 at 12 noon on April 3, 2018, and also it reduced steadily concerning time in the direction of evening. At this similar time 12 noon April 3, the system's efficiency is augmented.

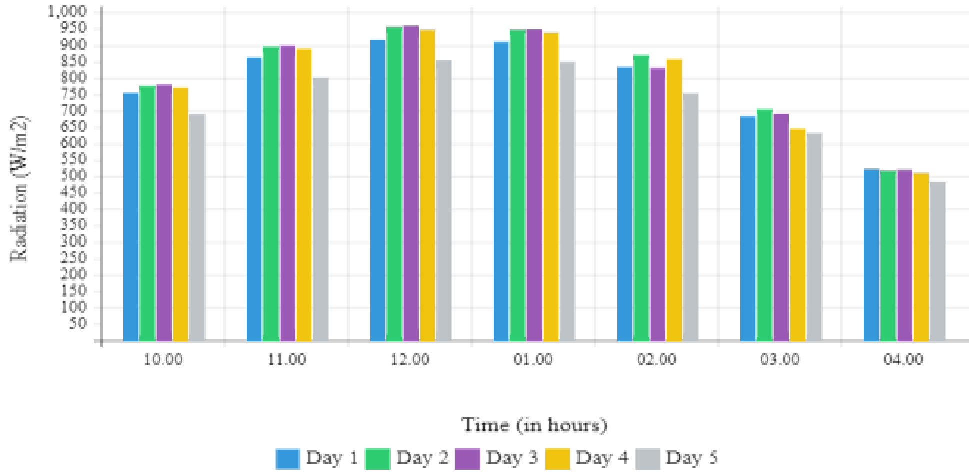
As of observation for every day, the solar radiation along with efficiency reading of the proposed experimentation set-up is augmented and bit by bit reduced in the evening climate. In this April 3rd, 12'o clock duration, the proposed scheme gain high solar radiation along with high thermal efficiency. After that, on the remaining days, the solar radiation at 12'o clock was 917.56 W/m^2 in day 1, 954.97 W/m^2 in day 2, 946.07 W/m^2 in day 4, along with 855.29 W/m^2 in day 5 correspondingly. Finally, the SS+WC coating attains higher efficiency than the raw SS. The graphical demonstration of this reading is exhibited in Figure 4 (a), (b), and (c).



(a)



(b)



(c)

Figure 4. Performance Analysis of (a) Time Vs Efficiency for SS Absorber Tube, (b) Time Vs Efficiency for WC Coated SS Absorber Tube, and (c) Time Vs Radiation for SS and WC Coated SS Absorber Tube.

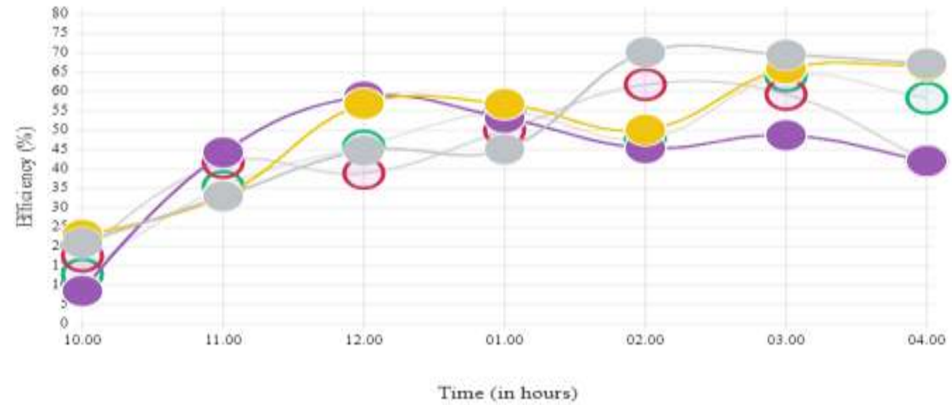
4.2 Performance of Stainless steel with Alumina coating and Copper absorber tube

Here, the proposed PTC's performance by utilizing SS+Al_2O_3 and copper AT is rendered. The performance is examined on April 11, 12, 13, 19, and 20-2018.

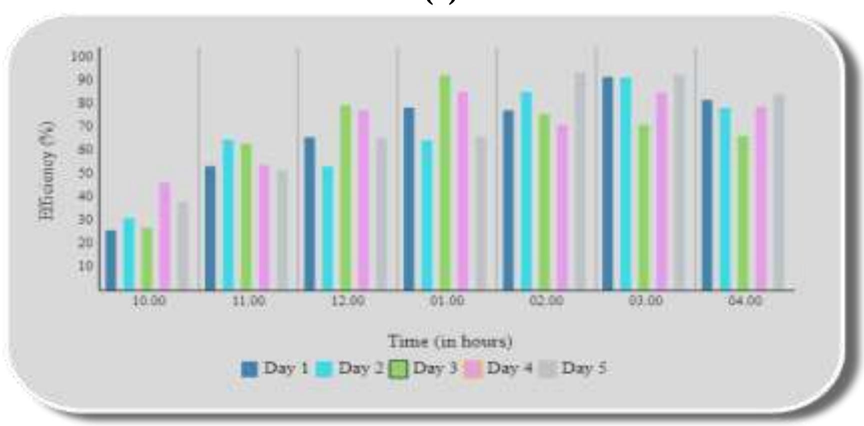
Discussion: The efficiency is calculated centered on a specific day along with time intervals. On day 1, the inlet temperature was 27 at 10'o clock, the efficiency of the Al_2O_3 coating is 12.83% along with the Copper encompass 25.66% efficiency. Likewise, the efficiency along with inlet temperature is varied.

On day 1, the experimentation set-up has high solar radiation in order that the efficiency is augmented at the time and steadily reduced in the evening. Same as for the remaining days, the solar radiation is augmented at noon in order that the AT's efficiency is augmented and bit by bit reduced in the evening.

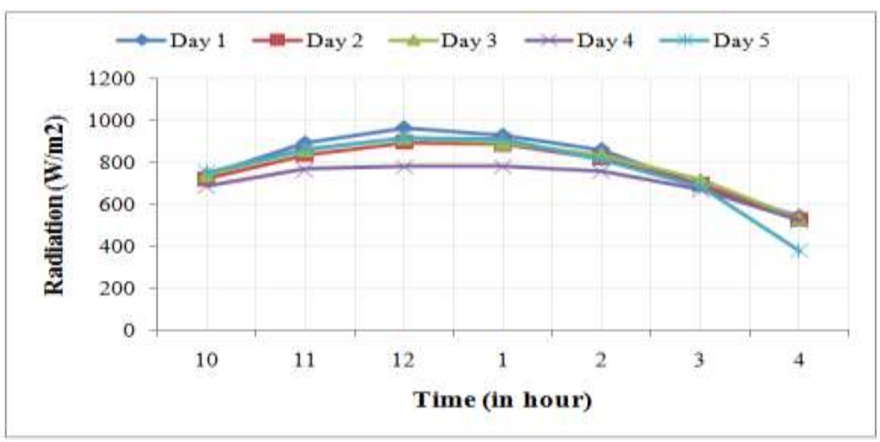
As of observation, in day 2 i.e., April 12, 2018, at 12'o clock, the inlet temperature is cloudy, likewise, in day 3, the inlet temperature of the experimental examination is cloudy, at that time, the scheme's efficiency is low contrasted with the other time intervals. Figure 5 (b) obviously illustrates that the copper AT reaches high efficiency than the Al_2O_3. Therefore, the experimentation reading is pictorially demonstrated in Figure 5,



(a)



(b)

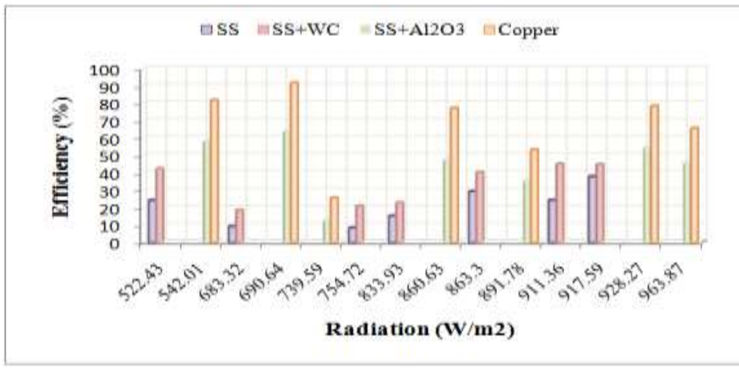


(c)

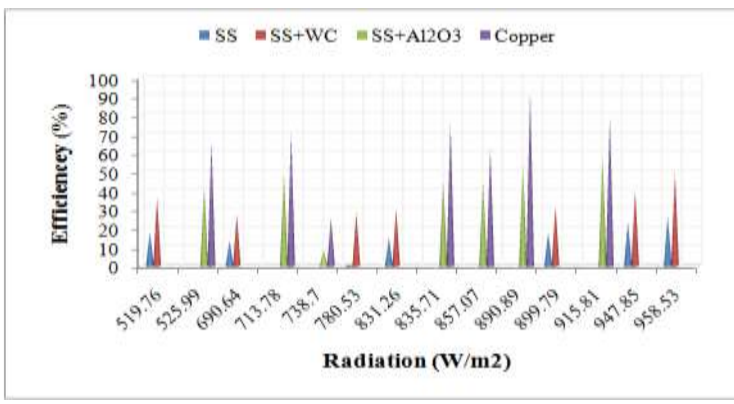
Figure 5. Experimental Analysis in the sense of (a) Time Vs Efficiency for Alumina Coated SS Absorber Tube, (b) Time Vs Efficiency for Copper Absorber Tube, and (c) Time Vs Radiation for Alumina Coated SS and Copper Absorber Tube.

4.3 Overall performance comparison of absorber tube materials

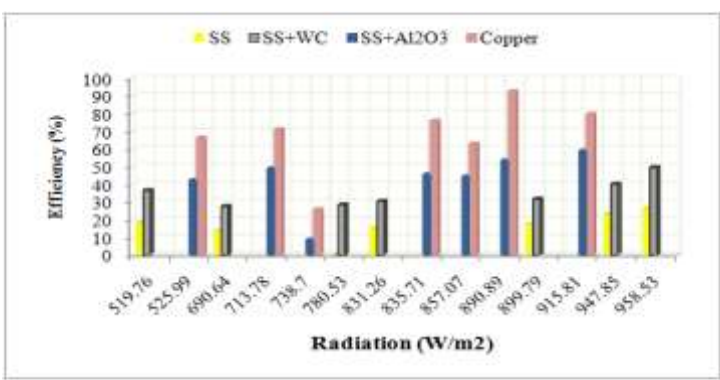
In this 3rd section, the PTC's overall performance with disparate absorber materials, like SS, SS+WC coating, SS+Al_2O_3 coating, and copper AT is rendered. Here, an experiment was performed for the days of March and April 2018 with presented absorber materials. The overall performance is analyzed for all the days is presented in Figure 6,



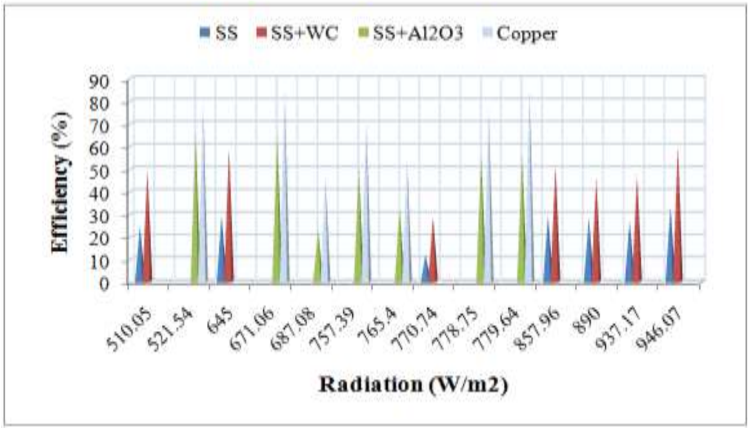
(a)



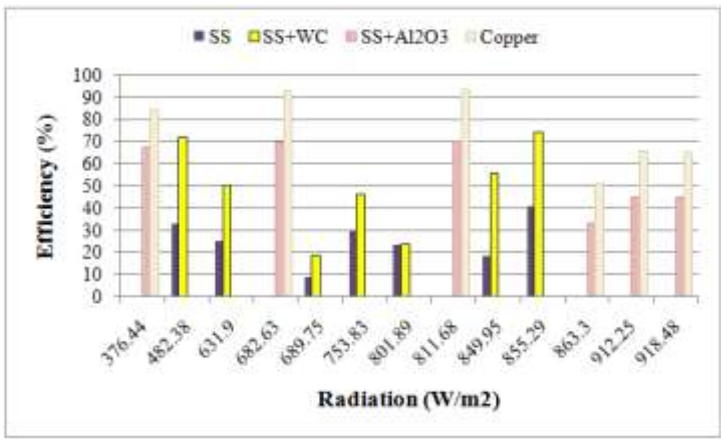
(b)



(c)



(d)



(e)

Figure 6. Radiation Vs Efficiency analysis at (a) Day 1, (b) Day 2, (c) Day 3, (d) Day 4 and Day 5

Discussion: In Figures 6, the overall performance study of the presented experimentation investigation is exhibited grounded on the radiation Vs efficiency. The graphical depiction is offered in day-wise. Since day-wise PTC with both AT materials is calculated. In the Figure, the SS indicates the stainless steel, SS+WC designate Stainless Steel with WC coating material, SS+ Al_2O_3 characterizes the stainless steel by alumina with copper AT. In day 5, the efficiency of the copper material is higher when the solar radiation is 811.68 (W/m^2), and in day 4, while the solar radiation is 779.64 (W/m^2), the copper material has 85.21% efficiency, which is among the other materials. During day 3, the copper material gets high efficiency at 890.89 (W/m^2) solar radiation, and in day 2 for 693.31 (W/m^2) solar radiation, the copper material has 91.25 % efficiency, and in day 1, only copper gets the high efficiency than the other materials.

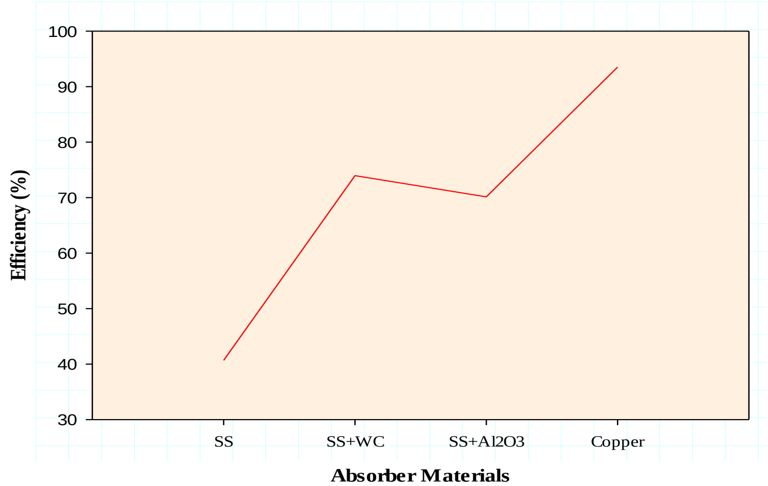


Figure 7. Analysis of Material's Efficiency

Discussion: Figure 7 illustrates the performance examination of disparate materials centred on an efficiency metric. The SS attains 40.68% efficiency, SS+WC achieves 73.97%, $SS+Al_2O_3$ has 70.15%, together with the copper attains 93.53% efficiency, which is higher betwixt other materials. Here, the SS offers the worst efficiency along with the SS+WC offers better compared to the other materials, however, which is also low than the copper material.

4.3.1 Corrosion rate analysis:

Here, the CR is analyzed for every material. The rate of corrosion is the speed upon which any known metal deteriorates in exact surroundings. As well, the Corrosion test is made due to a solar PTC experimentation functioned in open surroundings. The experimentation is performed by immersion of samples in saltwater uncovered to the environmental setting for '7' days.

Table 3. Corrosion Rate Analysis of Absorber Tube Materials

Material	Before Weight (grams)	After Weight (grams)	Weight Loss (grams)	Corrosion Rate (C_{mpy})
Stainless steel	30.15	30.15	0	0
Stainless steel with Tungsten carbide	29.00	28.95	0.05	0.0025
Stainless steel with Alumina	16.20	16.15	0.05	0.0045
Copper	16.45	16.35	0.10	0.0087

The CR is computed in the unit of Mils per Year (mpy). The CR is analyzed as,

$$C_{mpy} = 534 \times \left(W_t / DAT \right) \qquad (8)$$

Where, C_{mpy} indicates the corrosion rate, W_t represents the weight loss in grams, DAT denotes the density of metal in g/cm^3, area of the sample in a square inch as well as exposure time of the metal sample in hours. The CR analysis of disparate materials is exhibited in table 3,

Discussion: Table 3 illustrates the CR analysis of the SS, SS+WC, SS+Al_2O_3, copper AT materials. The SS has zero corrosion that indicates the SS has ameliorated corrosion resistance. Since SS has 18% of chromium. Chromium is mixed to steel for augmenting the resistance for oxidation. The copper offers improved outcome centred on extra metrics, however, in the sense of CR, the copper encompasses a high crossion rate that is 0.0087. SS+WC offers medium as well as improved outcome and also encompasses a lower CR than the other materials, and the CR of the SS+WC is 0.0025 mpy. SS+Al_2O_3 has a low CR, however, it as well high than the SS+WC, in order that this CR examination exhibits that the SS+WC has better material. The graphical depiction of the CR study is exhibited in Figure 8,

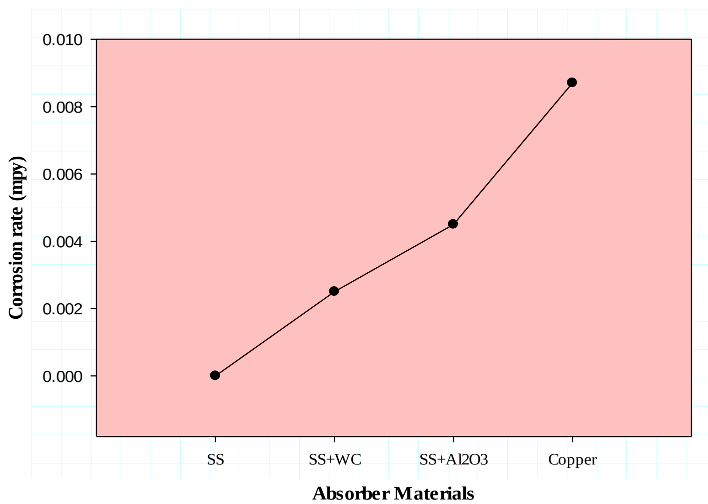


Figure 8 Corrosion Rate Analysis

5. Conclusion

Geometric manipulations of solar field layout along with PTC design that concentrates on solar power plants are proposed to augment the heat collection in addition to lessen optical losses. This work concentrated on the experimental investigation along with the efficiency analysis of the SS Absorber Tube of PTC with and without WC, Al_2O_3 coating. The presented work comprises '3' steps, solar PTC design, experimental set-up, along with efficiency analysis. The comparative analysis is performed by utilizing disparate AT materials centred on the time, efficiency, radiation, in addition to the corrosion rate. The AT with WC and Al_2O_3 coating has exhibited an augmented efficiency than SS. There is an optimum value of water inlet temperature upon which efficiency is high for any solar radiation. The highest efficiency of about 73.97% is attained at a water inlet temperature of 28◦C for solar radiation of 855.29 W/m2, and the corrosion rate is 0.0025 mpy. On average, the WC coated AT collector's efficiency is lower by about 19.56% when weighted against copper AT collector, the corrosion rate of copper is 0.0087 mpy. As of this experimentation investigation, the AT with WC was found to be better than Al_2O_3 coated SS, SS because of its material property and its outcome has exhibited an augmentation in collector efficiency together with the material's lifetime.

References

[1]. Messele, Y, & Assefa, A, "Thermal Analysis, Design and Experimental Investigation of Parabolic Trough Solar Collector", Afro-European Conference for Industrial Advancement, **(2015)**, pp. 245–260.

[2]. Kalidasan, B., Shankar, R., & Srinivas, T, "Absorber Tube with Internal Hinged Blades for Solar Parabolic Trough Collector", Energy Procedia, vol. 90, **(2016)**, pp. 463–469.

[3]. Kasaeian, A., Daneshazarian, R., Rezaei, R., Pourfayaz, F., & Kasaeian, G, "Experimental investigation on the thermal behavior of nanofluid direct absorption in a trough collector", Journal of Cleaner Production, vol. 158, **(2017)**, pp. 276–284.

[4]. Zhang, L., Wang, W., Yu, Z., Fan, L., Hu, Y., Ni, Y., Cen, K, "An experimental investigation of a natural circulation heat pipe system applied to a parabolic trough solar collector steam generation system", Solar Energy, vol. 86, no. 3, **(2012)**, pp. 911–919.

[5]. Heyhat, M. M., Valizade, M., Abdolahzade, S., & Maerefat, M, "Thermal Efficiency Enhancement of Direct Absorption Parabolic Trough Solar Collector (DAPTSC) by Using Nanofluid and Metal Foam", Energy, vol. 192, **(2020)**, pp. 116662.

[6]. Aravind G., Yadav, R. K., Loganathan C., & Sharma, S, "Experimental investigation of cavity absorber in parabolic solar collector", In International Conference on Recent Advances and Innovations in Engineering (ICRAIE), **(2016)**, pp. 1-5.

[7]. Quezada–García, Sergio, Heriberto Sánchez–Mora, Marco A. Polo–Labarrios, and Ricardo I. Cázares–Ramírez, "Modeling and simulation to determine the thermal efficiency of a parabolic solar trough collector System", Case Studies in Thermal Engineering, vol. 16, **(2019)**, pp. 100523.

[8]. Liu, Q., Wang, Y., Gao, Z., Sui, J., Jin, H., & Li, H, "Experimental investigation on a parabolic trough solar collector for thermal power generation", Science in China Series E: Technological Sciences, vol. 53, no. 1, **(2010)**, pp. 52–56.

[9]. Tamta, D., & Saini, R. P, "Design and Investigation of Parabolic Trough Solar Concentrator", Concentrated Solar Thermal Energy Technologies, **(2017)**, pp. 55–65.

[10]. Grami, S., & Gharbia, Y, "Experimental investigation of new designed solar parabolic trough collectors", In IEEE International Conference on Industrial Technology (ICIT), **(2018)**, pp. 972-977.

[11]. Krishna, Y., Faizal, M., Saidur, R., Ng, K. C., & Aslfattahi, N, "State-of-the-art heat transfer fluids for parabolic trough collector", International Journal of Heat and Mass Transfer, vol. 152, **(2020)**, pp. 119541.

[12]. Valizade, M., Heyhat, M. M., & Maerefat, M, "Experimental Study of the Thermal Behavior of Direct Absorption Parabolic Trough Collector by Applying Copper Metal Foam as Volumetric Solar Absorption", Renewable Energy, vol. 145, **(2019)**, pp. 261-269.

[13]. Potenza, M., Milanese, M., Colangelo, G., & de Risi, A, "Experimental investigation of transparent parabolic trough collector based on gas-phase nanofluid", Applied Energy, vol. 203, **(2017)**, pp. 560–570.

[14]. Bellos, E., & Tzivanidis, C, "Thermal efficiency enhancement of nanofluid-based parabolic trough Collectors", Journal of Thermal Analysis and Calorimetry, vol. 135 (1), **(2018)**, pp.597-608.

[15]. Muhammad Sajid Khan, Mi Yan, Hafiz Muhammad Ali, Khuram Pervez Amber, Muhammad Anser Bashir, Bilal Akbar, and Samina Javed, "Comparative performance assessment of different absorber tube geometries for parabolic trough solar collector using nanofluid", **(2020)**.

[16]. Xu, L., Sun, F., Ma, L., Li, X., Lei, D., Yuan, G.,Wang, Z, "Analysis of optical and thermal factors' effects on the transient performance of parabolic trough solar collectors", Solar Energy, vol. 179, **(2019)**, pp. 195–209.

[17]. Ghasemi, S. E., & Ranjbar, A. A, "Thermal performance analysis of solar parabolic trough collector using nanofluid as working fluid: A CFD modelling study", Journal of Molecular Liquids, vol. 222, **(2016)**, pp. 159–166.

[18]. Hong, K., Yang, Y., Rashidi, S., Guan, Y., & Xiong, Q, "Numerical simulations of a Cu–water nanofluid-based parabolic-trough solar collector", Journal of Thermal Analysis and Calorimetry, **(2020)**, pp. 1-13.

[19]. Tagle-Salazar, P. D., Nigam, K. D. P., & Rivera-Solorio, C. I, "Heat transfer model for thermal performance analysis of parabolic trough solar collectors using nanofluids", Renewable Energy, vol. 125, **(2018)**, pp. 334– 343.

[20]. Menbari, A., Alemrajabi, A. A., & Rezaei, A, "Experimental investigation of thermal performance for direct absorption solar parabolic trough collector (DASPTC) based on binary nanofluids", Experimental Thermal and Fluid Science, vol.80, **(2017)**, pp.218–227.