Analysis of various factors affecting the life of concentrated solar power systems in real Environmental condition.

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Abstract.

Thermal solar concentration collectors use mirrors to reflect sunlight and focus it on a receiver. These collectors can be parabolic or linear, depending on whether they focus sunlight on a focal point or a segment of a straight line. The fluid that exits the panel from this one spot is heated to a temperature of more than 100°C.This study, which examined how optical defects affected the interceptor factor and, ultimately, the optical efficiency or performance of a solar parabolic trough system, focuses on the parabolic trough collector (PTC). The optical efficiency was evaluated using solar trace for slope errors, 0–6 m rad secularity errors, tracking errors, and misalignment errors. In the ensuing simulations, a parabolic trough collector with a focal of 1.84 m, a length of 5 m, and a receiver radius of 0.035 m is used. In the simulations, three different concentration ratios—20, 30 The findings demonstrate that mistakes in slope and specularity have an effect on the heat flux concentration on the receiver's absorber tube. Additionally, they demonstrate that optical efficiency rapidly decreases as slope errors rise.

Keywords. Parabolic trough collector: PTC, Monte Carlo Ray Tracing: MCRT, Heat Collection Element HCE, Concentration Ratio CR.

1. INTRODUCTION

Numerous studies have helped to significantly lower the cost of concentrated solar thermal electricity. Solar energy has many uses and has been regarded as a clean and sustainable energy source since the 1970s, according to a study by Zhiyong Wu, Shidong Li, Guogeng Yuan, Quang Qiang Lei, and Zhifeng Wang published in 2014. Three-dimensional numerical analysis of the heat transfer performance of parabolic dish receivers demonstrates this. A key element of parabolic trough systems is a collector, which is a parabolically coiled mirror with a high reflectivity for capturing incident solar energy. The heat collection element (HCE), also known as the receiver tube, is where the solar rays that strike the mirror are focussed and reflected, creating thermal energy. The receiver is made of a metallic absorber tube that is enclosed in glass. The glass envelope and tube are separated by a vacuum to lessen receiver Additionally, this absorber tube is selectively coated to provide it maximum incoming radiation absorption and low infrared emission.The design of the collector, the materials used in construction, and the numerous mistakes that were made both during the development and operation of the system all have an impact on the optical performance of the PTC, which affects the performance of the overall system (3. Güven and Bannerot, 1986).The optical performance will be impacted by 4 mistakes on the interceptor factor. The interceptor factor is the ratio of energy reflected by the concentrating collector to Guven and Bannerot's formula for the optical performance of a parabolic trough system is where the interception factor is and the product is, respectively, the reflexion, the transmittance, and the absorptance. It displays the compositional characteristics. Guven and Bannerot claim that the impact of the angle of incidence, including cosine losses and end losses, affects optical performance. However, this quantity is equivalent to 1 in situations with a fully tracking collector or when the angle of incidence is zero. As a result, we won't consider this effect of angle of incidence in this study and instead focus on the optical performance that was mentioned earlier.These academics provide an in-depth explanation of the many PTC fault categories. One of these is a material error, which includes flaws in the glass cover's transmissivity, the reflectivity of the reflecting material, and the coating's absorptivity on the absorber tube. 2: manufacturing and assembly problems, such as incorrect local slopes, reflector misalignment during assembly, and incorrect receiver tube placement. 3: operational errors, such as tracking errors, wind loading errors, and temperature impact problems. To determine how these inaccuracies affect the interceptor factor, numerous research have been conducted. This study employs an optical modelling programme called Sol Trace that is based on Monte Carlo Ray Tracing to analyse optical data and determine the real heat flux distribution on the receiver's absorber tube (4. SolTrace, 2012)

Parabolic reflector: It is the mirror in the form of parabolic shape which reflects all the radiation at the focus of a parabola. This reflector is mounted over a structure which can move from east to west with the help of sun tracker.

Absorber tube or receiver: It is a metal pipe or tube coated with black nickel or chromium and sealed with glass tube. Black coating increase the absorption of tube while glass glazing decreases the convection losses from tube. The sun tracker is the mechanism that rotates the entire building from east to west. It uses a sensor-based algorithm and a timer algorithm to function. The system's geometry needs to be specified in order to achieve the PTC's maximal optical performance. A parabolic trough collector system under consideration is seen in 3D in figure 1. The real parabolic trough systems are constructed from a variety of panels that have been combined. It is expected that the performance of the system would not be significantly impacted by the space between the various panels. This illustration depicts a condensed collector with a continuous parabolic surface.

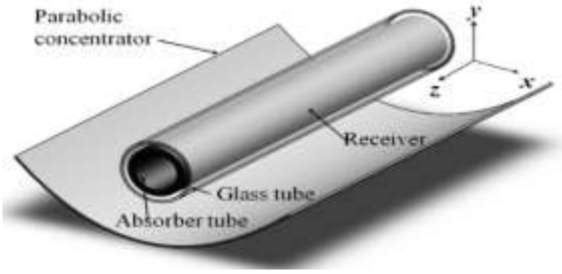


Figure 1: schematic of the parabolic trough collector

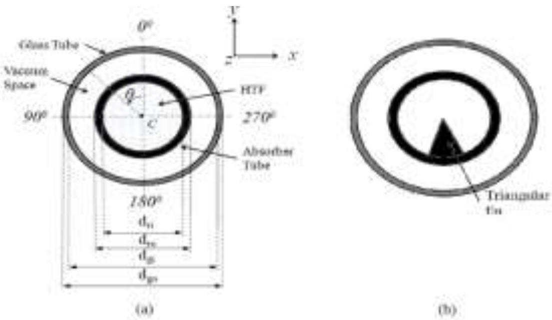


Figure 2: Cross sectional view of receiver (a) plain absorber tube (b) finned absorber tube

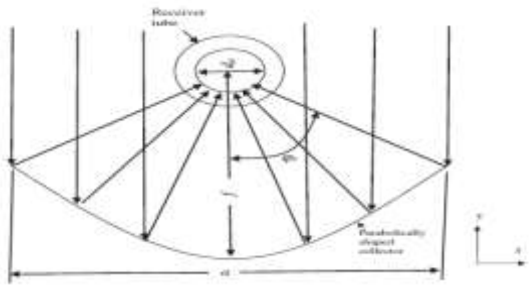


Figure 3: Cross sectional view of the PTC system with a trace of some incident rays

The figure 3 above shows a cross sectional view of the collector The equation of a parabola gives the following description of the collector's geometry:

$$x^2 = 4fy$$

The aperture's width and rim angle are connected

$$f = a/4\tan(\varphi_r/2)$$

Any two parameters can be used to define the shape of the collector using these two equations. For each of the next three simulations on the programme SolTrace, the concentration ratio C r, which links the predicted area of the collector to the projected area of both the absorber tube, will be altered.

$$:C_r = \frac{A_a}{A_r} = \frac{a \times L}{d_{ri} \times L}$$

For the next simulations, we want to have C_r equals to 20,30 and 40. For this we calculate the aperture and we put 4,398 m for the concentration ratio 20 , 6,597 m for 30, 8,796 m for 40.

Parameter	Symbol	Value
Aperture width	W	5m
Glass tube inner diameter	d_{gi}	0.109m
Glass tube outer diameter	d_{go}	0.115m
Absorber tube inner diameter	d_{ri}	0.066m
Absorber tube outer diameter	d_{ro}	0.070m
Focal length	f	1.84m

Parameter	Symbol	Value
Absorber tube absorptivity	α_r	0.92
Absorber tube reflectivity	ρ_r	0.08
Glass tube transmissivity	τ_g	0.935
Glass tube reflectivity	ρ_g	0.045
Mirror reflectivity	ρ_m	0.93
Mirror transmissivity	τ_m	0

Table 1: *optical and geometrical properties of PTC system used in the current study*

A simulation using ray tracing was run for the PTC system described in Table 1presents the optical characteristics of the PTC components taken into consideration in the investigation. For all ray tracing simulations, the tracking mechanism of the PTC was considered to be flawless, and the direct normal irradiation was set at 1000W/m². For the ray tracing simulation, the mirror's slope and specularity error were taken into account as 3 mrad. The thermal analysis covered in the following part introduces the sun flux distribution discovered using ray tracing as a boundary. Figure 4 is a sample SolTrace

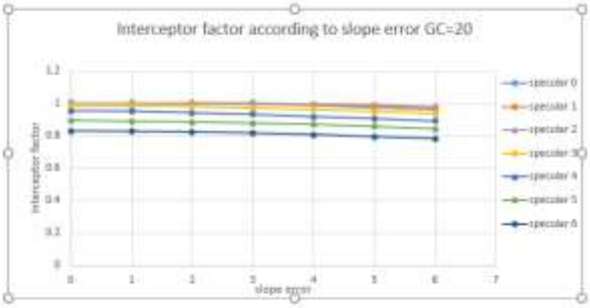
Figure 4: Ray tracing in SolTrac

RESULTS & DISCUSSION

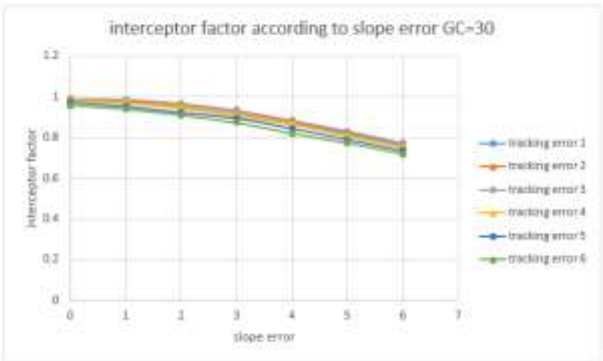
Concerning the simulations, several errors were considered like the slope error,the specular error, the tracking error and the misalignement following x and ywhere the effect of the errors on the optical performance which is $\eta_{opt} = (\varphi \mathrm{T}\ \alpha)\ \gamma$ with $\gamma = \frac{E_{abs}}{E_{ref}}$ is the interceptor factor.

i) Slope error and specular error

Also, we don’t see clearly the effect of the slope error on the tracking error in comparison with what we saw in the other graphs ploted before. The effect of the tracking error on the interceptor factor is less appearant thant that of the slope error**.**



ii) Slope error and tracking error



Exploring the platform of the Sheffler dish

Because of the rain and the inconvenient weather in Dehradun, I can’t do the optical or the thermal experiments on the parabolic trough collector. For this, I learn more about the Sheffler dish.The point of focus is the axis of rotation. As long as it is in place, it collects concentrated heat, which is then transferred to water thru the receiver to produce hot water or high-pressure steam.Water from the header pipe travels to the recipient (thermosiphon principle). The header pipe collects the hot water or steam gathered at the receiver and transports it to the intended use.

Figure 6: Températures' sondes (inner, outer)

Conclusion

This study examines the effects of tracking, slope, specularity, and misalignment errors on a parabolic trough system's optical and electronic properties. The study's results demonstrate that slope inaccuracies have a substantial impact on the heat flux distribution on the absorber tube of the receiver. As a result, the optical efficiency declines as the slope. Additionally, it was shown that tracking or specularity faults on the heat flux distribution on the recipient's absorber tube do not significantly affect the interceptor factor. It is demonstrated that when the slope error is fixed at 3 mrad, the misalignment after z is significantly altered compared to the misalignment following due to the optical characterisations completed throughout the course of my internship's first two months, I have come to the conclusion that the error slope has the greatest impact on optical performance. Studying the thermal characterization and assessing the thermal efficiency in relation to this slope inaccuracy would be interesting.

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