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Non-Linearity Measurement in Low Profile Compound Parabolic Concentrator (CPC) Photovoltaic Thermal (PVT) System

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Abstract

This study investigates the nonlinearity performance in a low-profile compound parabolic concentrator (CPC) photovoltaic thermal (PVT) system. For that, we design the low-profile compound parabolic concentrator CPC using solid work. Trace Pro is the application that we used to design the low-profile compound parabolic concentrator. After design, we will go for implementation. In implementation, we used LDR (light-dependent resistor) as a solar panel to find the intensity of light. The LDR is connected in a line and eight lines are made to make it a panel. The parabolic shape is made to patch the concentrator and the concentrator which is to focus the light into the LDR panel. From Figures 5 and 6 we can see that the light is nonlinear with the concentrator and the average power incident is twice.

Keywords: compound parabolic concentrator, PV system, Solar power.

1. INTRODUCTION

The electrical efficiency of the solar cell is around 13% and 22% and the other portion is transformed into heat. The lower will be the electrical efficiency when the temperature of the solar cell increases. Every CPVT becomes more prominent [1].

Solar energy technology said to be PVTs can use the heat produced by photovoltaic cells to simultaneously create electricity. The Heat Transfer Fluids (HFTs) underneath the solar panel section receive the thermal energy transmission. As a result, it is possible to reduce the loss of electrical efficiency caused by elevated PV cell thermal temperatures and to make use of this thermal energy. These have the potential to greatly increase performance overall. To lessen undesirable heat dissipation in a solar cell, researchers are becoming more and more interested in creating more efficient systems [2].

The first PVTs were designed by both Russell and Kern in (1978). They found that whenever water and air flow between photovoltaic panels the thermal energy transferred from the photovoltaic panel to overcome the heat of the photovoltaic panel and for that, it increases the electrical efficiency [3].

In (1999) Gurg and Adhikari both experimented with the thermal modeling of a hybrid PVT air collector that may be integrated with the CPC and the electrical efficiency and heat outcome of the system will be more efficient with CPC [4].

In (2005) Coventry investigated the performance of PVT system solar collectors. The outcome shows that electrical with heat efficiencies are approximately 11% and 58% [5].

Eventually a double-pass photovoltaic solar air collector with the CPC and fins on the back side of the receiver region. It has been discovered that this system's efficiency is increased [6].

In (2008) Tchinda studied every conjunction regarding CPC with the Solar Air heater. It was discovered that whenever the total rate of flow of air rises then the temperature will decrease [7].

Such types of concentrators have a higher concentration ratio. On the other hand the higher rate of concentration of photovoltaic thermal cells outcome in thermal energy dissipation, some damage to the PV cell, and cases of major drop in PV performance because of high temperature in photovoltaic cells. For such a system, it needs the sun tracking because of their low acceptance angle. The lower concentrating non-image collector will be able to solve such a problem when it doesn't need the sun tracking system because of its broad acceptance angle and comparably lower thermal energy it produces. Such that the CPC is observed as a wonderful static concentrator of thermal energy collection [8].

2. CPC DESIGN

We design the compound parabolic concentrator (CPC) using solid work. We will simulate the design using Trace Pro.

From Figure 1 we can see the simple CPC design using solid work.

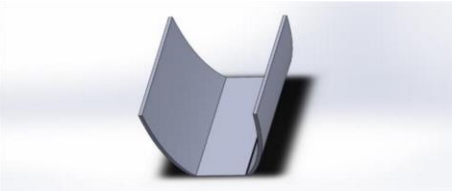

Figure 1 CPC with absorber using solid work

Firstly we design the low-profile compound parabolic concentrator (CPC) photovoltaic thermal (PVT) system using solid work. Trace Pro is the application that we used to design the low-profile compound parabolic concentrator. For that, we measure the nonlinearity of light and hot spots on the surface of the solar panel (PV). Firstly we open the application (trace pro) then we go on insert and select the primitive solid (block). On the x-axis of the block, the length is 60 cm, and y-axis of the block the width is 45cm and the thickness is 0.1 cm. We can see from Figure 2.

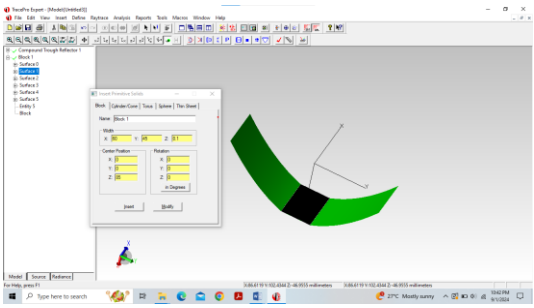

Figure 2 Primitive solid of CPC implemented on trace pro

Again we will go on the insert and select the reflector and from there we choose the compound trough concentrator. The length of the concentrator is 60 cm, the thickness is 0.1, the front depth is 45cm, the back depth is 40 cm, the lateral focal shift is 22cm, and the focal length is 50 cm. Figure 3 shows the reflector of CPC.

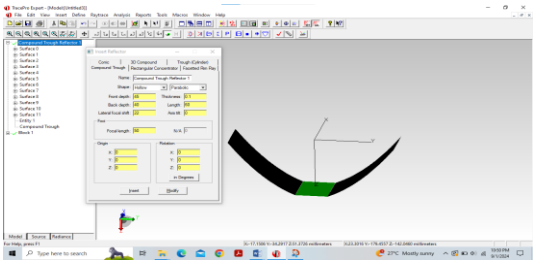

Figure 3 Reflector of CPC implemented in Trace pro

To check the performance of CPC, an optical simulator based on ray tracing software Trace Pro is used. Figure 4 in which the source is applied to the compound parabolic concentrator (CPC).

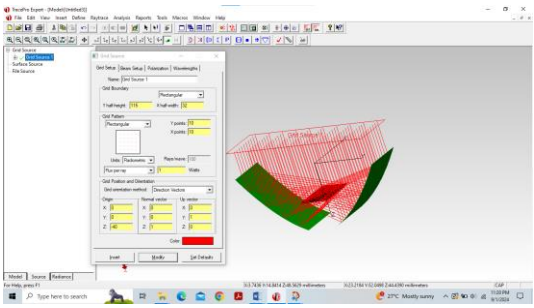

Figure 4. Optical Simulation Design of Implemented CPC

3. RESULTS

The result of the optical simulation of CPC without a concentrator shown in Figure 5 gives the optical power incident and absorbs on the absorber without CPC. The average incidence rays on the absorber is 1.837e + 006 W/m^2.

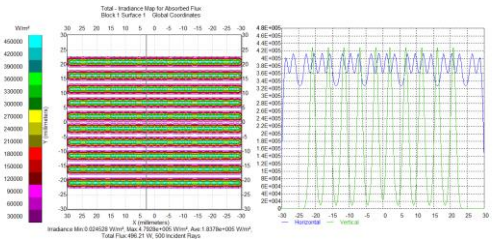

Figure 5. Rays map without CPC

The result of optical simulations of CPC with concentrator shown in figure 6. The average incident power is 4.778e+005 W/ m²

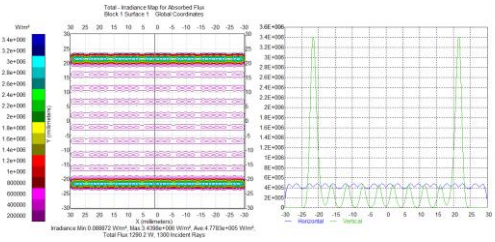

Figure 6. Rays map with CPC

According to the result which is twice to the average power incident without a concentrator. Which is shown in Figure 5.

4. CONCLUSION

This paper presents the nonlinearity of light in low-profile compound parabolic concentrators (CPC). Trace Pro is the application that is used to design the low-profile compound parabolic concentrator. From there, the result shows that the light is linear without a concentrator and nonlinear with a concentrator which is shown in Figures 5 and 6. Without a concentrator, the average incident power is 1.837e + 006 W/m². And with a concentrator, the average incident power is 4.774e+006 W/ m². Which is twice as without a concentrator. with cpc

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