EUROPEAN ACADEMIC RESEARCH
Vol. XI, Issue 12/ March 2024

Impact Factor: 3.4546 (UIF)
DRJI Value: 5.9 (B+)

ISSN 2286-4822
www.euacademic.org

Low profile compound parabolic concentrator

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Abstract

In the course of time, the demand of energy is escalating. As a result, the conventional energy sources are decreasing day by day. The concept of benefiting solar energy has been proposed to compensate for energy demand. In this regard solar thermal collectors have been reported. This work investigated the performance of a compound parabolic concentrator. In particular low profile CPC based t solar thermal collector not only improve the system throughput but it gives better performance compared to thermal collector without concentrator. The optical performance was evaluated by TracePro. The results revealed that the optical performance of CPC based thermal collector is better than flat and system without concentrator.

Keywords: compound parabolic concentrator, solar flat panel, thermal collector. Solar panel

I. INTRODUCTION

With passing time the ecological system and the weather has change which has resulted in high demands for renewable energy for this purpose the solar thermal collector needs are much greater than it was 20 years ago .as it has many advantages of being a generator of heat ,cheaper comparing to other storage devices ,and easy to use[1] .

This solar concentration technology has two major areas i.e. imaging and non-imaging concentrators [2] .the most common and popular application is non-imaging concentration from long time. A very common example of non-imaging concentrator is CPC(compound parabolic concentrator) .which is constructed for stationary/inactive tracking containing suitable concentration ratio .and it absorbs both direct and indirect sun rays ranging with in the acceptance angle .

Solar thermal collectors are classified into three major types based on temperature of HTF (heat transfer fluid).the first one is low temperature solar thermal collectors contain flat plate collectors and evacuated tube collectors it operates on temperature ranging from 50-80℃[3]. Second type is high temperature solar collector which is operated on temperature ranging from 400-1000℃ and it gives out high level steam which is used in steam generator. Its example are parabolic trough concentrator .linear Fresnel collectors .heliostats and solar tower it .the highly reflecting systems containing evacuated tubes, tracking system and high cost absorbers [4]. The applications of the thermal energy are mostly used in industrial process such as solar cooling [5], food processing [6] and thermal desalination [7]. These all applications the third type solar thermal collector which operate on medium temperature ranging from (80-250℃).

Researchers have been conducting on how to increase performance and how to decrease cost of CPC. LCOH (localized cost of heat) is a process of calculating the cost of a thermal collector .it is a financial calculation of heat-generating system. The rate depend on the fuel which is used I.e. natural gas, fossil fuel, electricity etc. [8] since the invention of all solar collector the medium temperature applications are the one which are used the most .because of low heat loss in the ecosystem.evacuated tube solar collectors also contain high efficiency because of being able to receive solar radiations and reflect them .in demand to increase the efficiency of the solar collectors many researchers have been conducted by different constructors in these all the glass collectors are being seen for water temperature to varies from flow rate . It should also be remembered that parabolic concentration of the external compound suffers from deposition of dust on the reflector due to a absence of casing content such as glass. Previously designed solar thermal collectors based on medium temperature (100e140°C) failed to implement on applications due to its increase cost [4]

II. CPC design

The flow chart for CPC design is depicted in Figure 1:

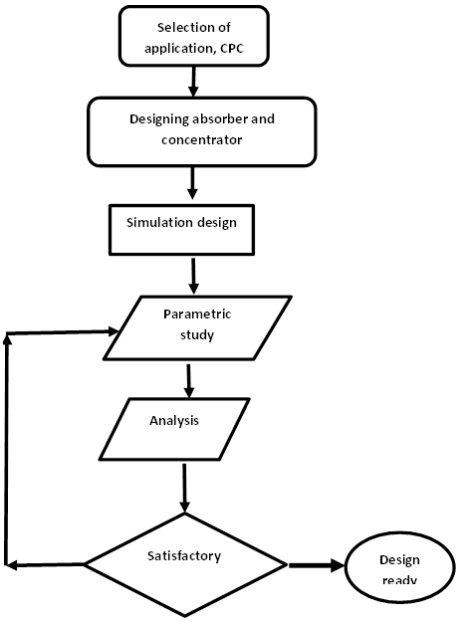

Figure 1: Flow Chart for CPC design for optical and thermal systems

The sample CPC is design in CAD tool named Solid Works. The design is depicted in Figure 2.

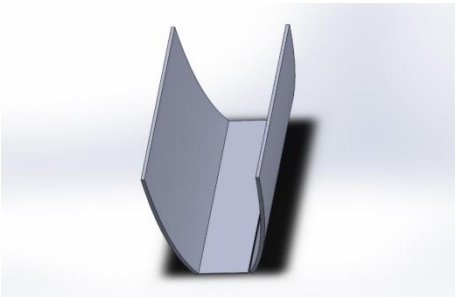

Figure 2: CPC with absorber using Solid Works

To check the performance of the said concentrator, optical simulator based on ray tracing software TracePro is used. The simulation setting and the window panel of the said software is depicted in Figure 4.

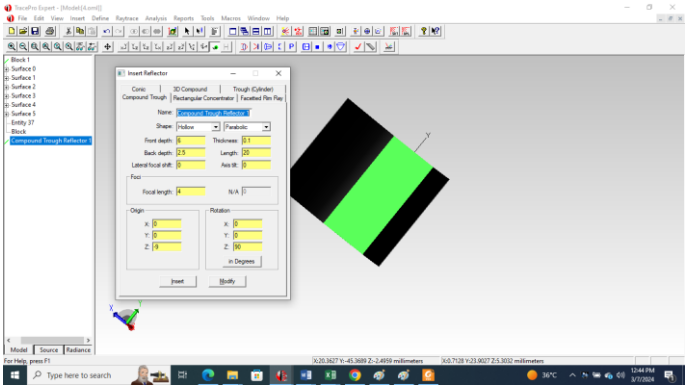

Figure 3: CPC Implemented in TracePro

The length of the concentrator is selected 20m and focal length 4. The parameter used for design is also depicted in the Figure 2.

After implementing design the Optical simulation is carried out. The Figure 4 gives the simulation detail of the designed CPC with absorber.

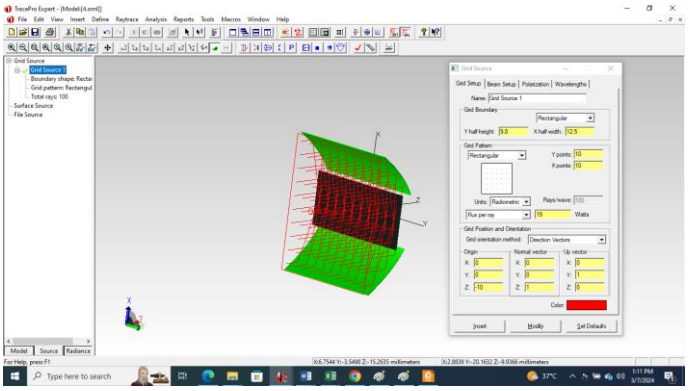

Figure 4: Optical Simulation design of Implemented CPC

IV RESULTS:

The result from optical simulation with and without CPC is depicted in this section. Figure 5 gives the optical power incident and absorb on the absorber without CPC. It is evident that the average irradiance on absorber is $3.78*10^8$ W/m^2

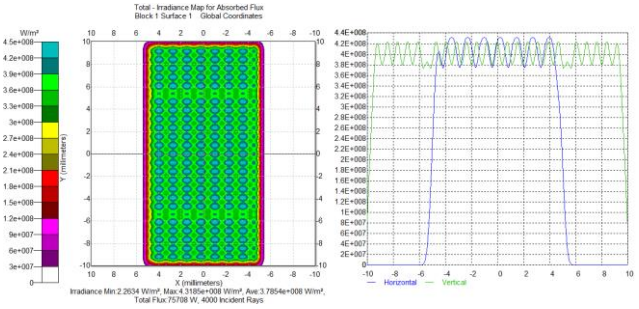

Figure 5: Irradiance map without CPC

For the system with CPC the irradiance map is depicted in Figure 6.

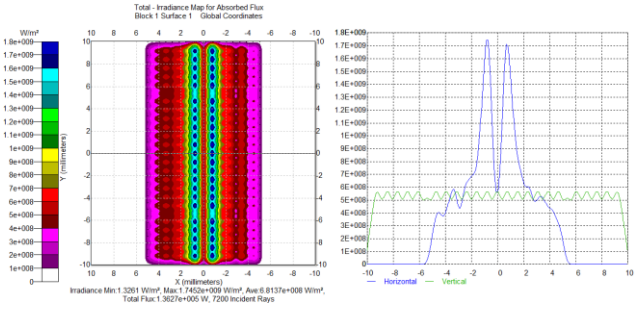

Figure 5: Irradiance map with CPC

From Figure 5, the average power incident on absorber is $6.8*10^8$W/m^2. On comparing the result with Figure 4 it is evident that power in CPC based system is almost twice the power as that of system with cpc

V CONCLUSION:

In this paper the optical and thermal performance of CPC based system has been presented. The optical simulation is carried by TracePro. The results from optical simulation shows that the average power with CPC for thermal or PV system is increased from $3.75*10^8$ W/m^2, without CPC, to $6.8*10^8$m^2. The system can be used for cold climate regions. For thermal Simulations, Simscape may be used to evaluate the heat energy gain in terms of temperature rise/kg of water which is the content of future work.

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