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Novel Method for Evaluation of Intercept Factor of Solar Line Concentrator System

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ABSTRACT

Intercept factor is the ratio of energy intercepted by the receiver to the total energy reflected by concentrator. The first step in evaluating intercept factor is to measure the flux variation across the focal plane. When a new design for a solar collector is developed it is necessary to guarantee that its intercept factor is good enough to produce the expected thermal output. This factor is directly related with the fidelity of the trough geometry with respect to its theoretical design shape. This paper shows the work carried out to determine the real shape and the intercept factor of a new prototype of solar line concentrator. Measuring the width of reflected image shape on the focal line observation of energy across the focal line is done with the help of solar pyranometer .The results are plotted and normal distribution curve is obtained. At each point in the adjusted surface are calculated and used to determine the intercept factor. Deviations between adjusted shape and the theoretical one suggest mounting errors for some mirror facets, resulting in a global intercept factor slightly below the commonly accepted limit for this type of solar collector.

Keywords— Beam radiation, aperture area, concentrator, receiver, reflector surface, focal line

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I. INTRODUCTION

Important parameter used for the evaluation of concentrator performance is optical efficiency. This depends upon properties of material used in the fabrication of concentrator, the reflector size, the angle of incidence and intercept factor.. The intercept factor mainly depends upon dimensions of receiver, the surface angle error of the reflector and solar beam spared. To evaluate the intercept factor A ray-trace computer code called EDEP (Energy DE Position computer code) is used by Guven and Bannerot (1985).The intercept factor can also be calculated by a closed-form expression developed by Guven and Bannerot (1985). This expression considers both random and non-random errors. These errors are encountered in the construction and/or in the operation of the collector. An artificial neural network was trained to learn the γ-values based on the input data of collector rim angle, random and non random errors, and the EDEP results. The output is compared with the EDEP results which are considered to be the most accurate, the results of a simple program developed by Guven (1987) using the trapezoidal integration method, and a multiple linear regression analysis. In this paper a no from all the above it is shown that the results obtained by the artificial neural network system approximates the results of the ray-trace model, extremely well with an R2-value equal to 0.999.

Parabolic trough collectors are structurally simpler than other types of collectors (i.e. flat-plate collectors) although some form of tracking must be employed and the parabolic surface must be accurate, to ensure high efficiency.

The performance of a PTC depends on many parameters. One of them is the optical efficiency which is defined as the ratio of the energy absorbed by the receiver to the energy incident on the concentrator's aperture. The optical efficiency depends on the optical properties of the various materials involved, the geometry of the collector, and the various errors encountered in the construction and/or in the operation of the collector. These errors affect the intercept factor which is defined as the ratio of the energy intercepted by the receiver to the energy reflected by the focusing device, i.e. parabola. Its value depends on the size of the receiver, the surface angle errors of the parabolic mirror, and solar beam spread.

Global thermal efficiency of parabolic trough collectors (PTC) depend on several factors but geometric agreement to parabolic profile design is the most important one and is the one considered here. The objective of this article is to determine, for a PTC segment with a new supporting structure design, the deviation of its shape with respect to the theoretical one and estimate its intercept factor (the fraction of the reflected radiation that is incident on the absorbing surface of the receiver)
The intercept factor measures the percentage of rays that inter-sect the absorber tube against the total of all the reflected rays. For such calculation the diameter of the absorber must be considered. A typical value can be 11 cm. It should be noted that distance between collector and absorber pipe is variable depending on the area of the concentrator that is being considered. Closer zone is the area in the parabola vertex. Simulated behavior of the reflected rays in a 1 m width section with strong deformation. This deformation can be appreciated on the edge of the collector section. Sunlight can be seen simply as straight lines (as we have done in this study) or they can be considered as functions of energy distribution over a volume of a given solid angle. These features are usually set for some latitude terrestrial value and they define what is called a ‘‘Sun-shape.’’ In practice, these complex calculations are not required. It should be noted that the overall efficiency of the collector is also affected by the accuracy of the orientation, solar tracking driving system and other mechanical factors

II. LITERATURE REVIEW

In our case, we measure intercept factor a sun meter fitted with a new supporting design structure. This sun meter has been assembled alone for measurement purposes and there is no receiver tube installed. At this point of the process, we are only interested in testing and measuring intensity of solar radiation at different sensor opening.

In off-the-shelf photogrammetric equipment, they measure a collector module fitted with a new supporting design structure. This module has been assembled alone for measurement purposes only and there is no receiver tube installed. At this point of the process, manufacturer is only interested in testing the rigidity of the structure compared with the mechanical design specifications. Thus they have measured the module in vertical and horizontal positions to assess that the new designed structure can maintain the parabolic shape for the collector. Due to this special configuration of the collector, receiver tube misalignment, angular non-random errors (misalignment of collector with respect the sun) and random errors can be excluded as influence factors. Incidence angle is also not affecting the intercept factor at normal incidence [1]. Consequently, only the profile errors in the collectors are considered in this study. Profile errors depend on the degree of adjustment for this set of 28 mirrors to the parabolic cylindrical geometry. Movements and deflections of the supporting structure under its own weight and under external forces like wind affect the geometry of the collectors. Different support designs exist on the market [2]. Each new design of the structure supporting the mirrors must be tested to find if this design and the associated assembly process are able to maintain the geometry within reasonable limits of solar ray concentration. Errors in mirror assembly and alignment influence the efficiency of electricity production very much [3]. There are several situations where a collector must be geometrically controlled. First, during mirror mounting in the assembly facility [4], generally near the solar field location, where only the supporting structure and mirrors are present. Second, when placed on the solar field for the first time, to control surface deviations caused during transportation and after receiver tube installation [5]. Third, during normal operation to control evolution and stability against winds and sun track movement [6] .In addition every new collector design must be controlled and measured to ensure the supporting structure effectiveness and a minimum intercept factor capability. Platform Solar Almeria (PSA) [7] is one of the companies that carry out this assessment by providing the appropriate certification to the company owning the design.

III.MATERIALS & METHODS

As shown in Fig.1. Experimental setup of solar circular line concentrating system consists of

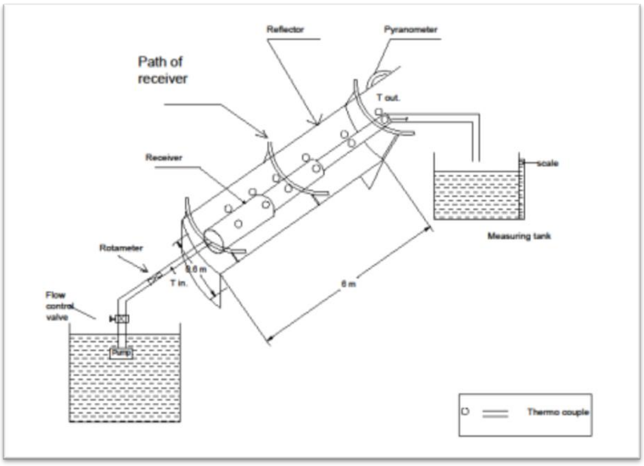


Fig.1. Experimental setup of solar circular line concentrating system

Fig.2 Site .Photograph for Experimental setup of solar circular line concentrating system

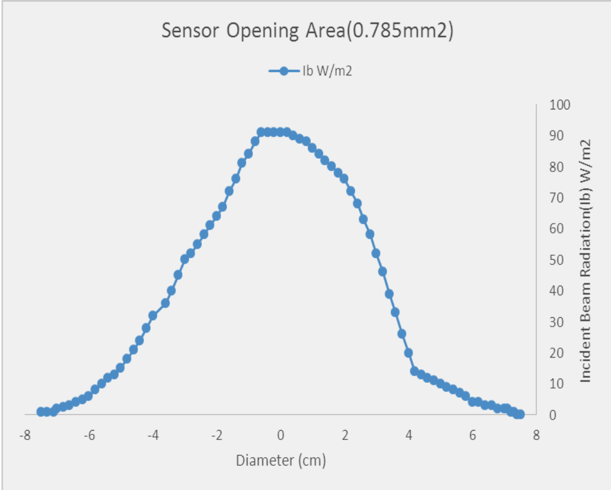
Fig 3

Fig 4

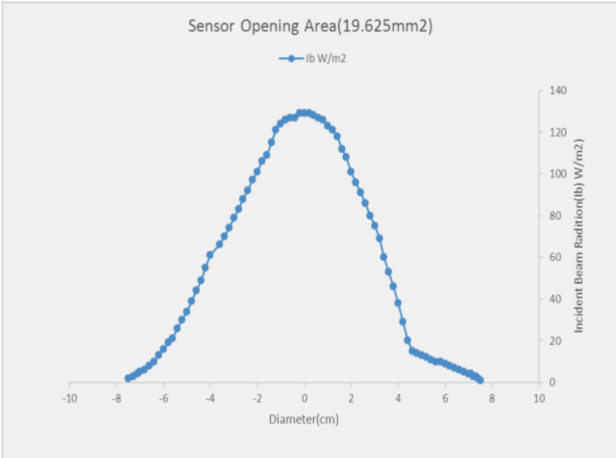
Fig.5Mesurement of focal line distance from the surface of circular concentrator

IV.RESULTS AND DISCUSSION

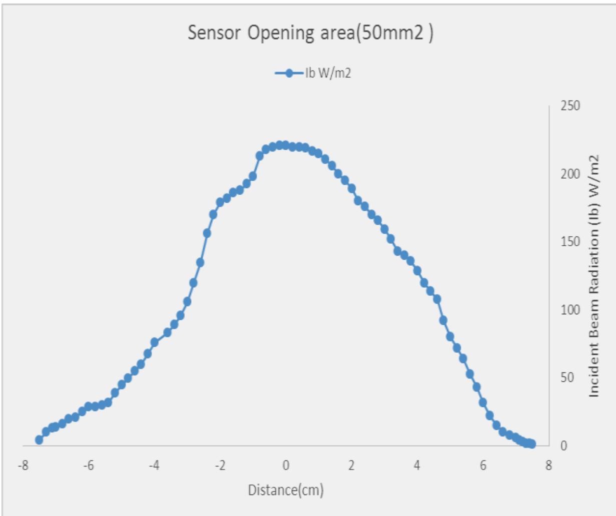
A. Graphical Results



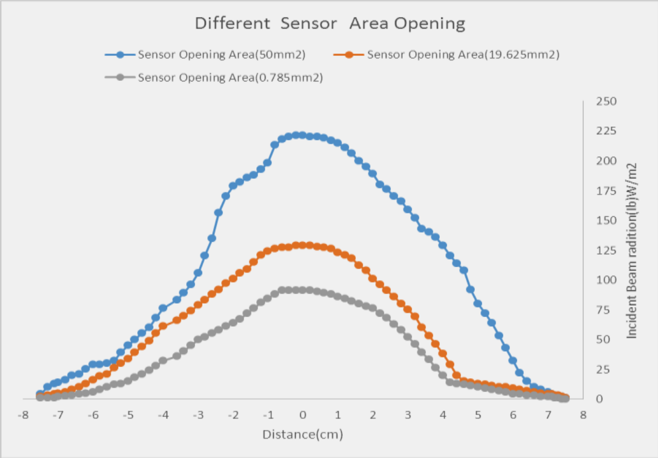
Graph 1: Incident beam radiation Vs Diameter Sensor Opening Area 0.785mm^2



Graph 2: Incident beam radiation Vs Diameter Sensor Opening Area 19.625 mm^2



Graph3: Incident beam radiation Vs Diameter Sensor Opening Area 50 mm^2



Graph4: combined Incident beam radiation Vs Diameter

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