EXPRIMENTAL AND ANALYTICAL STUDY OF A PARABOLIC SOLAR CONCENTRATOR IN EL OUED CITY

L BOURAS . Pr. Ferhat REHOUMA

[1] Département de physique, Faculté Sciences exactes, Université Echahid Hamma Lakhdar d'El Oued, Algérie,

Laboratoire d'Exploitation et de Valorisation des Ressources Energétiques Sahariennes ***(LEVRES)***

ABSTRACT

This study is focused on the parabolic solar concentrator, called the collector as well as the solar dish. The work is divided into two parts: Firstly, analytical analysis was done to study the effect of the geometrical and optical parameters on the spot focal. Secondly, to design a mini-prototype reflector with 63cm diameter, 6.2cm height, an aperture area of 1.24 $m^2$and focal distance of 42 cm, the reflector surface was covered by silver chrome film. The cylindrical receiver is made of aluminium with 8.5cm diameter and 15cm length. The obtained results showed a significant increase in the temperature of the optical spot ranging from 200 to a maximum value of 850 °C. The distribution of the temperature on the receiver surface area showed clearly that the flux intensity increases gradually and a peak at the focus.

Keywords: solar radiation, parabolic solar concentrator, solar receiver, optical spot.

L. BOURAS, e-mail: leila.brs.tec@gmail.com

1. INTRODUCTION

Enormous Demand of electric energy throughout all over the world; the need for electric and electronic systems increase, which are a part of modern society; the tendency of global demand reveals that the emerging economies will begin to require more and more electricity energy , which gave us its exponential growth. Increased greenhouse gases like carbon dioxide (CO2), which aside from contaminating the environment also bring devastating consequences for climate change, show us that our dependence on current finite fossil fuels (oil, coal, natural gas, and other oil derivates), and that they are not the only alternative for energy production. Stemming from this problem, we must embark on a continuous research for new inexhaustible energy sources. The sun, as the main source of light and heat for the earth, is considered an inexhaustible energy source with easy access, free, clean, and renewable.

Currently, many countries are focusing on renewable energies. The daily amount of solar irradiation received by the earth is estimated at 1000w / m^2 [1].

Recently, there are theoretical and experimental research and many commercial products that are taught in the best exploitation of solar energy of both types: solar cells and concentrated solar power. This study is focused on the parabolic solar concentrator, called the collector as well as the solar dish. The application of solar energy can be grouped into two main categories: high temperature applications (solar concentrators and solar collectors under vacuum), and low temperature applications (the generally flat plate collect). View of Algerian's geographic location, the country has great availability of the solar resource. Algeria has a large solar deposit, due to its climate. Table **1** shows the maximum solar power in all parts of our country is about 1Kw / m^2. The average maximum daily energy (clear skies, July) exceeds 6 KW / m^2 and the maximum annual energy in Algeria is of the order of 2500 KW / m^2[1]. The Sahara: characterized by an arid and dry climate such as the site of El-Oued [2].

Table.1. ***The received sunshine annually in Algeria***[2]

The Tell	4	2650	1700
The high	10	3000	1900
The Sahara	86	3500	2650

2. PARABOLIC SOLAR CONCENTRATOR

solar concentrating systems using Fresnel lens [3] or comprise a reflective surface in the shape of paraboloid of revolution intended to concentrate solar energy on an absorbing surface, which makes it possible to reach a high temperature.

2.1 Parabolic geometry: The shape of a parabola means that incoming light rays, which are parallel to the dish's axis, will be reflected towards the focal point of the dish (focus). Geometrical parameters the equations in the calculations below were used in the of this work as shown in Fig1 parabolic solar concentrator.

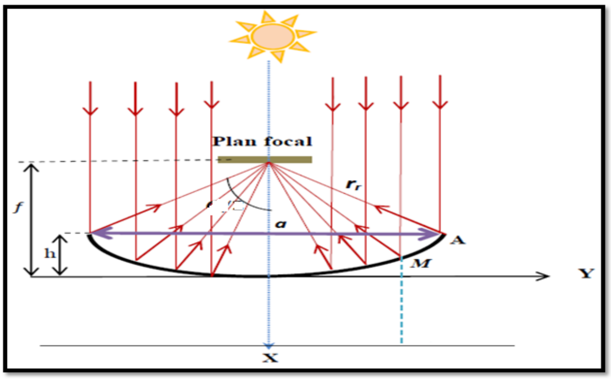


Figure1 Parabolic geometry

The equation for the parabola in cylindrical coordinates whose focal distance f [4,5] :

$$X^2 + Y^2 = 4.f.Z$$

The surface of a paraboloid of diameter of opening a is given by [4, 5] :

$$A_{ref} = 8.\pi.f^2\{((a/4f)^2+1)^{3/2}-1\}$$

The rim angle is [4], [5]:

$$\tan\psi = (f/a)/(2(f/a)^2-(1/8))$$

Parabolic radius, distance (RF) between the curve of the dish and the focus is [4], [5] :

$$r_r = 2f/(1+\cos\psi)$$

The surface of opening of a paraboloid is [4], [5]:

$$A_a = \pi.a^2/4$$

The focal distance is given by the following expression [4], [5]:

$$f = a^2/16h$$

h is the depth of the dish.

3. EXPERIMENTAL PART:

We have achieved the experiment of a mini-prototype reflector in the state of EL oued in-Algeria in exploitation of Saharan energy resources laboratory **(LEVRES).**

The design contains of a reflector, a receiver and manual tracking of the sunusing as illustrated in Fig 2**.**

Figure 2. dish solar system

3.1 Reflector

Has the properties described in the Table 2**.** Its interior surface is covered with a reflecting layer [6]. Which reflect solar rays on the face of a receiver placed at the focal position of the concentrator [7]. The reflecting CHROME MIRROR VINYL layer covering the surface of the parabola is abased on steel with a reflecting coefficient near 0.94.

Table 2 :Design parameters of reflector.

a(m)	0.63
h(m)	0.06
f(m)	0,42
$\varphi(^{o})$	41.01^{o}
$A_a(m^2)$	0.311
$A_{ref}\,(m^2)$	1.246
C_g	0.01614

3.2 Receiver

The cylindrical receiver is made of aluminium. Receiver must absorb as much as concentrated solar flux as possible **[7]**, and convert it into thermal energy, this heat is transferred into a fluid of a certain type (liquid or gas). The surface of the receiver must have high conductivity and thermal diffusion. The characteristics of receiver are shown in the **Table 3.**

Table 3: Characteristics of receiver

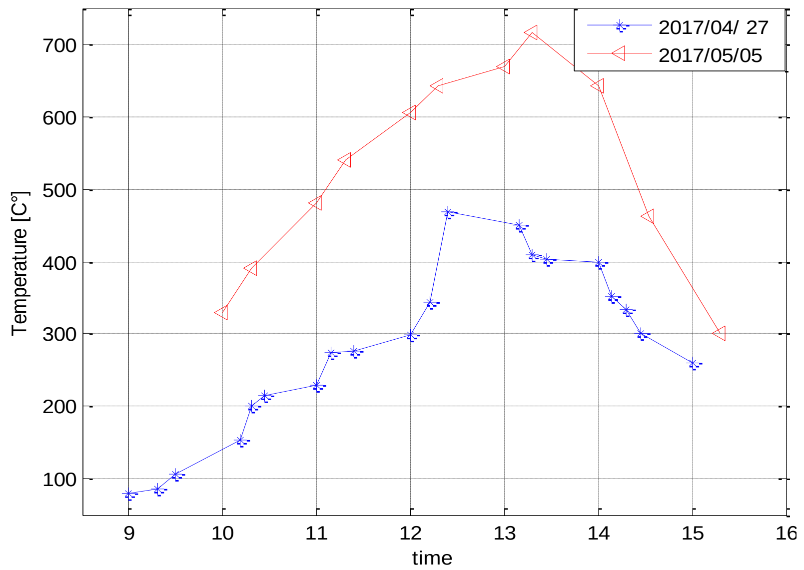
a(m)	0.085
l(m)	0.15
$S_{caption}(m^2)$	0.00502
$S_{tot}(m^2)$	0.1028

4. RESULTS

4.1 Optical spot temperature

The experiment was conducted at 27/04/2017 and 05/05/2017 during the period from 9h to 16h to determine the optical spot temperature. The values given by the thermo-couple are represented. Fig 3 shown the variation of the temperature of spot optical during the period mentioned above. The maximum temperature of 750 ^{0}c at focal zone.

Figure 3 the variation of optical spot temperature for a day



4.2 Distribution of temperature on the surface of the receiver

Fig 4 and 5 represented respectively the distributions of the heat flux intensity at each distance from the receiver. It appears clearly that temperature increases gradually to a peak of 740 ^{0}c which coincides with the focal zone of the parabolic concentrator.

Figure 4 distributions of temprrature each distance from the receiver to day

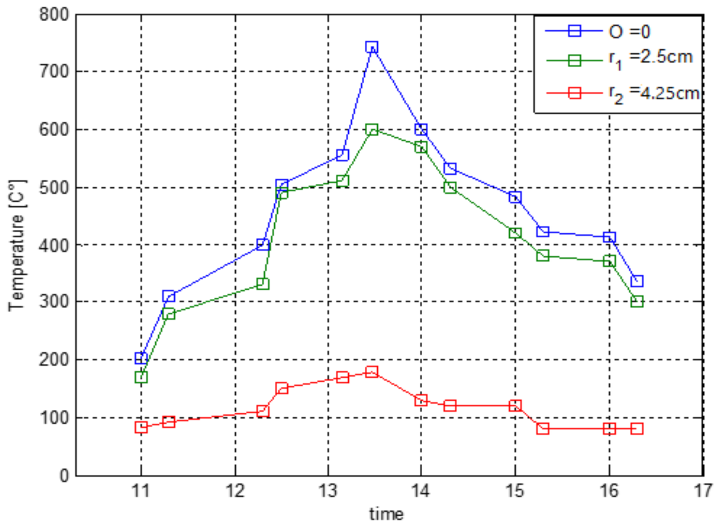
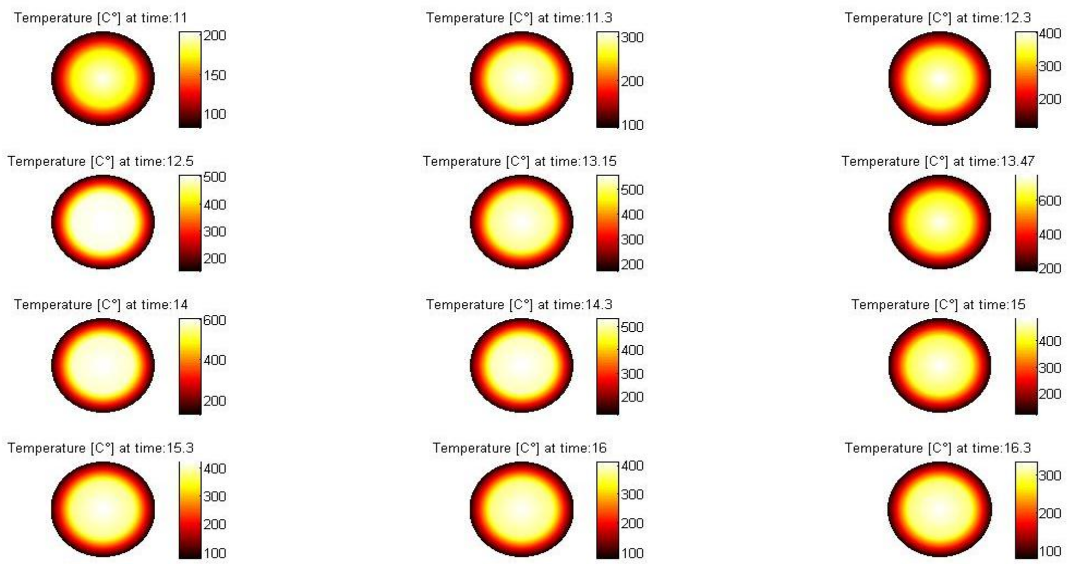


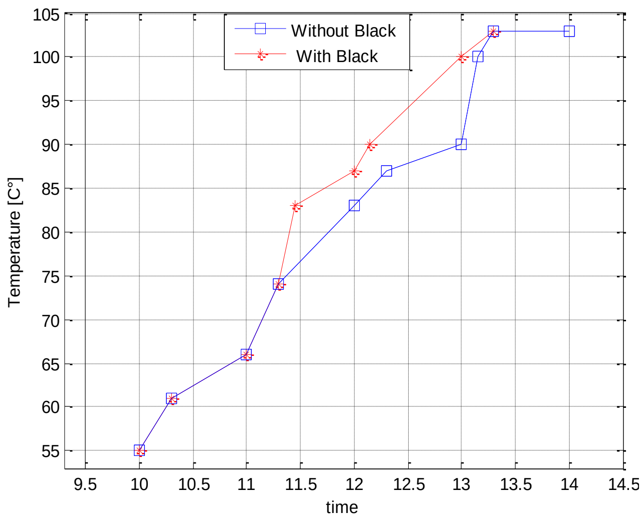
Figure 5: 2. Distribution of temperature at certain moments on the surface of the receiver



4.3 The temperature of the water with and without a black coating

The design and development of a parabolic dish solar water heater for domestic hot water application (up to 100°C) is described. [8]. Use of Black Epoxy coating selection of black the coating for the receiver surface is based on the following conditions. The selected coating surface should consider the following properties receiver should be good absorber of heat energy and high thermal conductivity and low thermal resistance [**9**]. From Figure **5** it is seen that as the the boiling temperature of the water increases with **cov** water the temperature with a black coating compared to without a black coating.

Figure 5 The temperature of the absorbent water with and without a black coating



5. CONCLUSION

The obtained results in El-Oued state showed a significant increase of the temperature of the optical spot ranging from 200 to a maximum value of 850 °C. The distribution of the temperature on the receiver surface area showed clearly that the flux intensity increases gradually and a peak at the focus. We can exploit these results in several areas of heating such as heating, cooking, power generation, fiber systems for daylighting systems [10] .To continue with the research project, we propose pumped solar laser applications [11].

6. REFERENCE

[1] .Bensafi ,S.Zegnoum ,B.Droui , Journal of Science Research N 5, p. 43-47 **2013**

[2] Mokhtar Ghodbane and all International Journal of Energetica 2543-3717 Volume 1. Issue 1. **2016**

[3]W.T.Xie and all Renewable and Sustainable Energy Reviews 15 (**2011**) 2588 -2606

[4] A.R.El ouderni and all ,Revue des Energies Renouvable ,12 ,(**2009**) ,395- 404.

[5] A..El majid Kaddour ,Université Tlemcen ,Docteur en Physique Énergétiques et Matériaux ,(**2013**).

[6] TABET Ismail Université DES FRERES MENTOURI CONSTANTINE , Docteur en Physique Énergétiques ,(**2016**).

[7] Rosani Affandi and all ,Procedia Social and Behavioral Siences 195(**2015**) 2382-2390

[8] Y aseen Hamid and all , Journal of Environmental Science and Engineering A 4 (**2015**) *225-232*

[9] Mr.Shashikant G. Mane and all International Research Journal of Engineering and Technology Volume: 02 Issue: 09 | Dec-2015

[10] Irfan Ullah and all Energies **2015**, 8, 7185-7201

[11**]** Mohanad Mousa Azzawi University of Baghdad Doctor of Philosophy in Physics **2011**