March-April 2020
ISSN: 0193-4120 Page No. 1457 - 1460

Cost-Efficient Solar Concentrating System

[1]Zeineb M. Al-Sheikh, [2]Mohammed Shehata, [3]Wadee Al Halabi
[1,2,3]College of Engineering, EFFAT University, An Nazlah Al Yamaniyyah, Jeddah 22332 Saudi Arabia
[1]zelsheikh@effatuniversity.edu.sa, [2]mshehata@effatuniversity.edu.sa
[3]walhalabi@effatuniversity.edu.sa

Article Info
Volume 83
Page Number: 1457 - 1460
Publication Issue:
March - April 2020

Article History
***Article Received**: 24 July 2019*
***Revised**: 12 September 2019*
***Accepted**: 15 February 2020*
***Publication**: 14 March 2020*

Abstract
The experiment aims to develop cost efficient solar concentration system model in converting solar energy to electrical energy. The existing solar concentrating systems are expensive and less convincing to use. In this experiment, the prototype consists of primary concentrator, secondary concentrators and receiver. This system is converted solar-thermal energy to electrical energy. The 3D models of primary concentrator were designed by Rhinoceros software. The primary concentrator is collected, focused and reflected upward sunlight from the sun. The secondary concentrator was used to concentrate sunlight and reflected to end of solar collecting field. Overall system was tested which primary concentrator was giving focal line, secondary concentrator was reflected focal line but second focal line was larger area and less density.

***Keywords:** Solar energy; primary concentrator; secondary concentrator; temperature*

1. Introduction
The Nowadays, many power generation plants preferring non-renewable sources as primary resource. The developing countries are concentrating in inexhaustible and alternative energy resources such as wind, hydro, biomass and solar [1]. Solar energy is most popular among other renewable energy because other resource needs mechanical support such as chemical support, motors or generators [2]. There are approximately 1000W/m2 sun power reaching the earth while earth receiving total energy of 1353W/m2 daily [3,4]. Even though, the earth receiving tiny fraction but still a massive energy amount.

There are two ways to produce electricity from solar energy such as solar concentrating system and photovoltaic (PV) cell [5-8]. The photovoltaic (PV) cell which convert sunlight directly into electricity. Meanwhile, solar concentrating system is using mirrors to concentrate sunlight to heat the fluid [9-11]. High temperature fluid is used to rotate turbine or power an engine which drives generator to produce electricity.

In this experiment, the solar concentrating system was created based on solar concentrating system which invented by Reif. This solar concentrating system consists part of solar radiation, concentration and solar energy absorption parts. The experiment aims to develop cost efficient solar concentration system model in converting solar energy to electrical energy.

2. Methodology
In this experiment, the prototype consists of primary concentrator, secondary concentrators and receiver. The function of secondary concentrator was tracked sunlight reflection and partially from primary concentrator and reflected solar energy to the metal sheet for temperature measurement. The secondary concentrator horizontal positioning accuracy was approximately between 1 cm and 2 cm that achieved by conventional linear stepper motor.

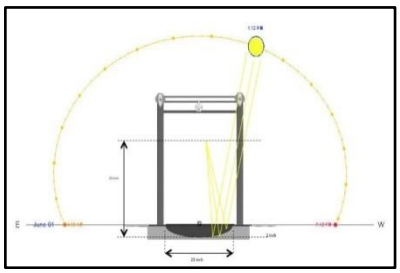

Figure 1: Experiment prototype consists primary and secondary concentrator

March-April 2020
ISSN: 0193-4120 Page No. 1457 - 1460

The stepper motor function is controlling the rotation numbers, direction and rotational speed. Meanwhile, the stepper motor to be controlled form an IBM -compatible PC parallel port in this experiment. A unipolar stepper motor is interfacing with primary concentrator parallel port to control secondary concentrator.

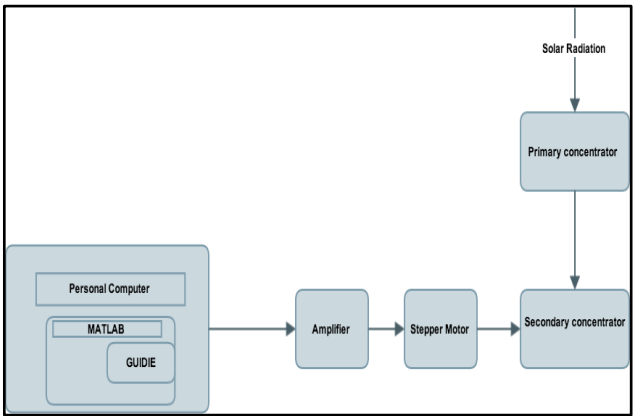

Figure 2: Block diagram of architecture system.

2.1 Hardware Implementation

The primary concentrator is collected, focused and reflected upward sunlight from the sun. Besides, primary concentrator are located on the ground in flat and stationary position. The resultant parabola was used to construct primary concentrator. The parabolic shape in primary concentrator also helped in concentrated sunlight since the changed in sun movement and this shape was covered and fully received sunlight for whole day. The primary concentrator was constructed using wood and covered with Reflective Mylar foil roll which acted as reflector.

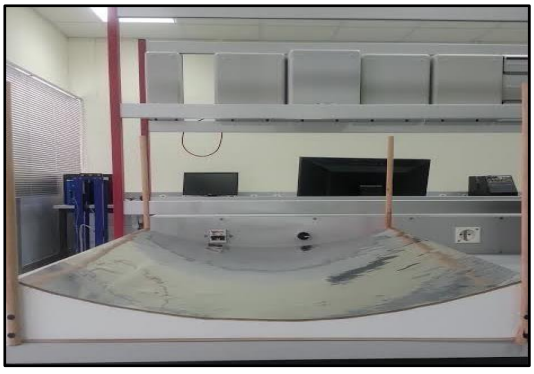

Figure 3: The primary concentrator model.

The real model was designed in ellipse shape with semi-major axis of α=90cm with focus point of 40 cm.

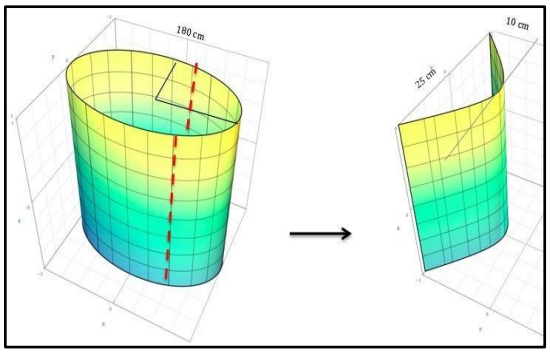

Figure 4: 3 dimensions of primary concentrator.

The 3D models of primary concentrator were designing used Rhinoceros software in Figure 5. The primary concentrator had surface area of 47x52cm in square shapes.

The stationary primary concentrator is cheaper since its located on the ground compared conventional solar concentrators was supported by metal superstructure. The upper surface is covered with concaved stainless steel super mirror with 90% reflection and thickness of 0.8 mm.

Meanwhile, secondary concentrator was used to concentrate sunlight and reflected to end of solar collecting field. The secondary concentrated is oriented north and south parallel with trough axis of primary concentrator. Three secondary concentrator were designer and designed mathematically same as primary concentrator.

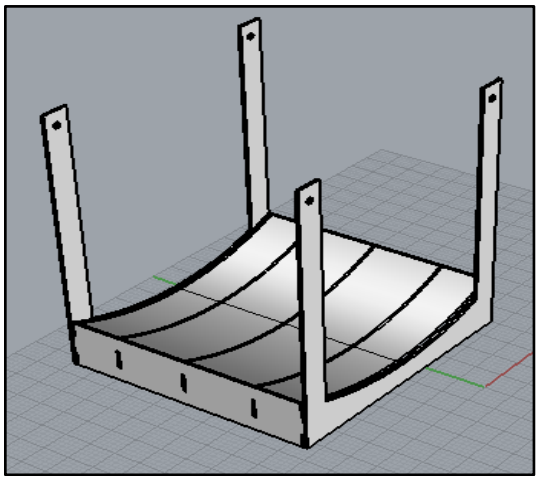

Figure 5: 3D model of primary concentrator using Rhinoceros software

March-April 2020
ISSN: 0193-4120 Page No. 1457 - 1460

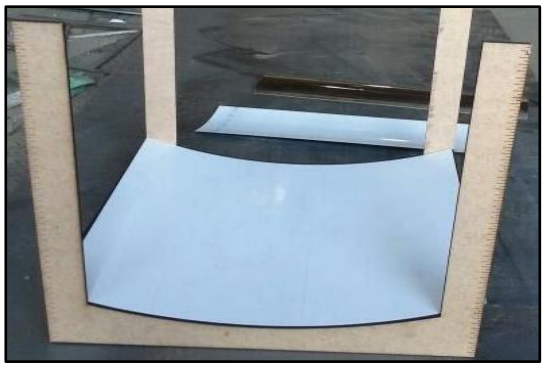

Figure 6: Final primary concentrator prototype

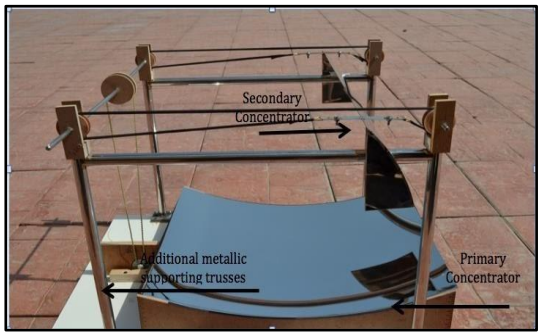

Figure 7: Secondary concentrator supporting metallic structure

The secondary concentrator was in the horizontal west-east direction as showed in Figure 7. The movement also needed to make sure secondary concentrator was correct positioned at each time. The system was comprised of primary concentrator and secondary concentrator and tracking requirement geometry which summarized as primary concentrator had single extended focal line and moved from west to east, secondary concentrator was faced sunlight from primary concentrator and secondary concentrator focal line direction was coincide with primary concentrator focal line.

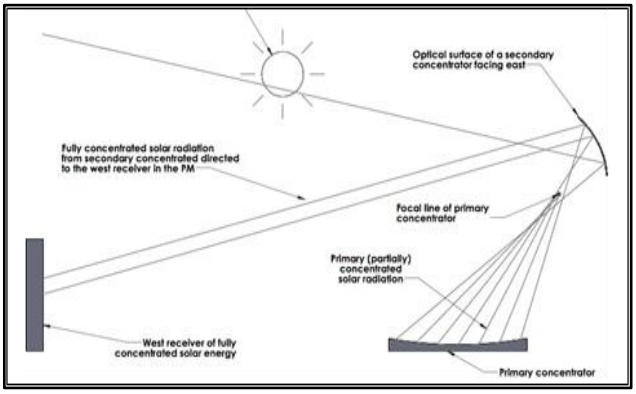

Figure 8: Illustration showed secondary position which focal line was coincided with primary concentrator focal line.

The secondary concentrator had rotational movement from west to east translational tracking. The east-facing surface was used from early until middle of the day and secondary concentrator only shifted slightly to west.

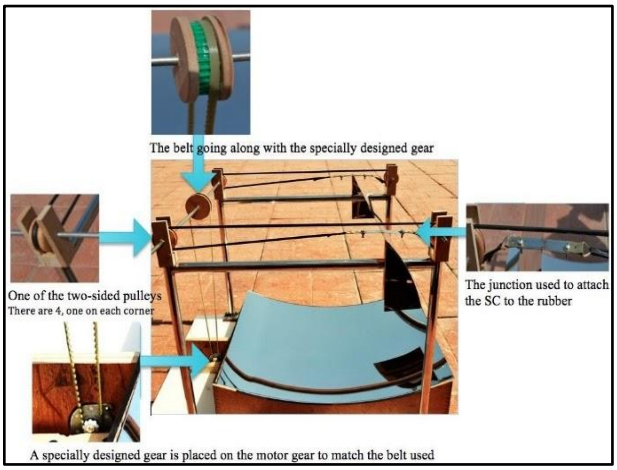

Figure 9: Stepper motor was attached to the gears.

In Figure 9, the support metallic rod holds up the secondary concentrator and secondary concentrator was attached with controlled rubber belt which secondary concentrator move freely together with support metal rod. The control cable ran parallel to the support metal rod which fixed and served as control system for moving together with east-west axis. The controlled stepper motor was moved main belt attached to the gear and contributed to the sided pulleys movement. The rubber belt caused secondary concentrator to move either forward or backward depended on stepper motor shaft direction.

3. Verification and Validation

Overall system was tested which primary concentrator was giving focal line, secondary concentrator was reflected focal line but the second focal line was larger area and less density. The focal line was changed with ranges of 3 cm and temperature measurement for each hour was recorded. During temperature analysis, the actual temperature was measured while temperature of primary concentrator focal line and secondary concentrator focal line was fixed in a place at EFFAT University. The result was represented in Table 1 and Figure 10.

Table 1: Temperature measurement among actual temperature, primary concentrator focal line temperature and secondary concentrator focal line

Time interval	Actual temp.	Primary concentrator focal line temp.	Secondary concentrator focal line temp.
10am	29 °C	47 °C	32 °C
12pm	29 °C	57 °C	34 °C

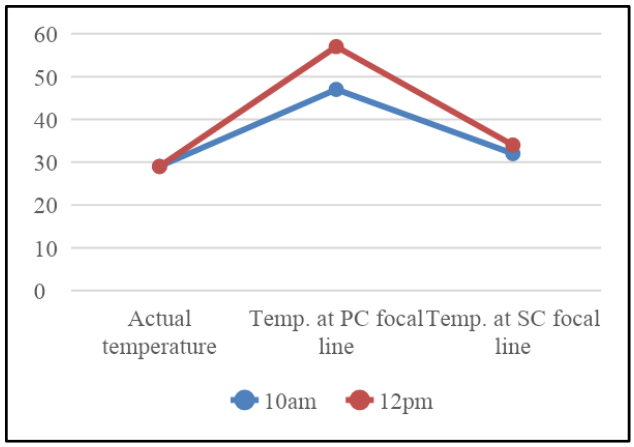

Figure10: Temperature measurement in different period

4. Conclusion

In conclusions, the cost-efficient solar concentration system had been obtained. The designed prototype mechanism was worked properly and overall result had met experiment aims. In future, the secondary concentrator angles will adjust for achieve more accurate results. A feedback system will be implemented using solar tracker sensor for secondary concentrator.

References

[1] Shukla, A. K., Sudhakar, K. and Baredar, P. 2017. Renewable energy resources in South Asian countries: challenges, policy and recommendations Resource-Efficient Technologies. 3, 342-346.

[2] Gomesh, N., Daut, I., Irwanto, M., Irwan, Y.M. and Fitra, M. 2013. Study on Malaysian's perspective towards renewable energy mainly on solar energy. Energy Procedia. 36, 303-312.

[3] Oji, J.O., Idusuyi, N., Aliu, T. O., Petinrin, M.O., Odejobi, O. A. and Adetunji, A.R. 2012. Utilization of solar energy for power generation in Nigeria. International Journal of Energy Engineering. 2,2, 54-59.

[4] Rompicherla, S. M. 2013. Solar energy: the future. International Journal of Engineering Trends and Technology. 4,6 (Jun.2013), 2513-2517.

[5] Muhammad-Sukki, F., Ramirez-Iniguez, R., McMeekin, S.G., Steward, B.G. and Clive, B. 2010. Solar concentrators. International Journal of Applied Sciences.1,1.

[6] Arora, P.R.2013. A vital role of concentrating solar power plants of Rajasthan in future electricity demand of India. International Journal of Scientific and Research Publications. 3,6 (Jun.2013).

[7] Pilawjian, G. 2012. Analysis of photovoltaic concentrating solar energy systems. ARPN Journal of Systems and Software.2,3 (March.2012).

[8] Barbosa, F.V., Afonso, J.L., Rodrigues, F.B. and Teixeira, J.C.F. 2016.Development of a solar concentrator with tracking system. Mechanical Sciences.7, 233-245.

[9] Vyas, N.P., Kadam, K.V., Nandurkar, P.S. and Gaigole, K.K. 2013. Concentrating solar power (CSP) systems. International Journal of Electrical, Electronics and Data Communication,.1,9 (Nov.2013).

[10] Hussain, A., Abdullah, A., Husni, H., & Mkpojiogu, E. O. C. (2016). Interaction design principles for edutainment systems: Enhancing the communication skills of children with autism spectrum disorder. *Revista Tecnica de La Facultad de Ingenieria Universidad Del Zulia*, *39*(8), 45–50

[11] Hussain, A., Mkpojiogu, E. O. C., & Kamal, F. M. (2016). Mobile video streaming applications: A systematic review of test metrics in usability evaluation. *Journal of Telecommunication, Electronic and Computer Engineering*, *8*(10), 35–39