Amirkabir Journal of Mechanical Engineering

Amirkabir J. Mech. Eng., 50(6) (2018) 419-422
DOI: 10.22060/mej.2017.13206.5567

Design, Manufacturing and Performance Evaluation of a Fixed Focus Scheffler Concentrator in Kerman

M.A. Talebizadeh[1], E. Jahanshahi Javaran[1*], M. Rahnama[2]

[1]Department of Energy, Institute of Science and High Technology and Environmental Sciences, Graduate University of Advanced Technology, Kerman, Iran
[2] Department of Mechanical Engineering, Shahid Bahonar University of Kerman, Kerman, Iran

ABSTRACT: Scheffler fixed focus concentrator is used for domestic and industrial applications in various parts of the world. This concentrator has an elliptical frame and designed in such a way that can provide fixed focus during a year with proper rotation. In this research, design and manufacturing principles of a Scheffler standing concentrator with an area of 2.7 m2 is presented. To this end, concentrator and its receivers were designed using Solidworks software.. Thermal efficiency of a manufactured concentrator was obtained from its operation for many days with different conditions. The results show that a concentrator with an area of 2.7 m2 can provide incident radiation up to 9.82 times that on the horizontal surface at the focal point. In addition, results of the experiment show that this concentrator can provide enough heat for boiling of 12 liters of water in less than 2 hours. A thermal efficiency of 37% was obtained for a receiver with surface of black color and glass cover. Finally, the standing concentrator was used to heat 100 lit of water resulting in an increase of water temperature to 60 °C.

Review History:

Received: 27 July 2017
Revised: 26 October 2017
Accepted: 30 October 2017
Available Online: 3 November 2017

Keywords:

Solar energy
Scheffler concentrator
Receiver
Tracker
Fixed focal point

1- Introduction

Scheffler fixed focus concentrators are successfully used for low temperature applications in different parts of the world. These concentrators are taken as lateral sections of paraboloids which have an elliptical frame. It provides a fixed focus away from the path of incident beam radiations throughout the year (Fig. 1). In order to concentrate on the fixed focus, this concentrator uses two different kinds of tracking systems, namely daily and seasonal tracking. For daily tracking, these concentrators rotate along an axis parallel to the polar axis of Earth at an angular velocity of one revolution per day. For seasonal tracking, the reflector rotates half the solar declination angle using a telescopic clamp mechanism [1].

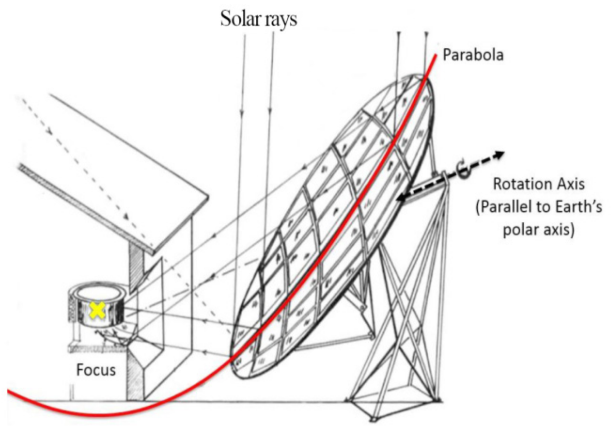

Fig. 1. Schematic of a Scheffler concentrator [2]

Corresponding author, E-mail: e.jahanshahi@kgut.ac.ir

To the best of authors' knowledge, there is no published work on design and construction of Sheffler dish in Iran. This paper describes design principles as well as construction details of a Scheffler concentrator with an aperture area of 2.7 m^2 along with experimental results which is obtained in Kerman.

2- Design Principle of Scheffler Reflector

The first step in designing a Scheffler concentrator is to decide the equation of the parabola and the start and end point of reflector for equinox. To simplify subsequent calculations, the parabola is set to have its vertex at the origin, taking form:

$$P(x) = m_p x^2 \tag{1}$$

which will then be revolved around the y-axis to form the three dimensional paraboloid. The paraboloid must then be sliced by a plane to define the dish section. The slice will create the dish with an elliptical rim (Fig. 2). It should be mentioned that a computer program is written which can be used for any concentrator design with desired area.

For the construction of the Scheffler reflector, it is necessary to know the exact position of the crossbars on the reflector frame. This can easily be calculated using equation of ellipse. The first crossbar needs to be located at the center of the ellipse and coincident with the x axis while the other crossbars should be equally spaced to both ends of the ellipse and parallel to each other (Fig. 3). After the calculation of equations for different crossbars, the depths and lengths of arcs for different crossbars are calculated for the construction of the scheffler reflector.

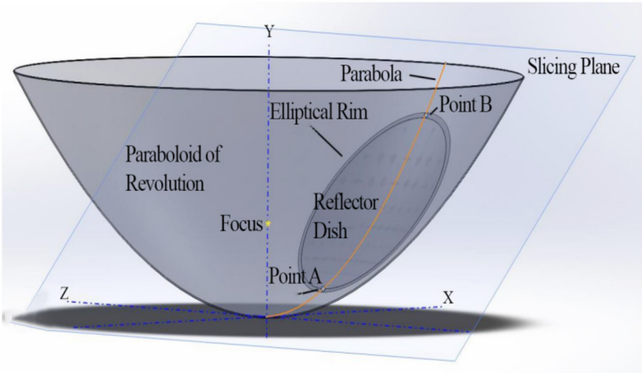

Fig. 2. Parabola forming Scheffler concentrator [3]

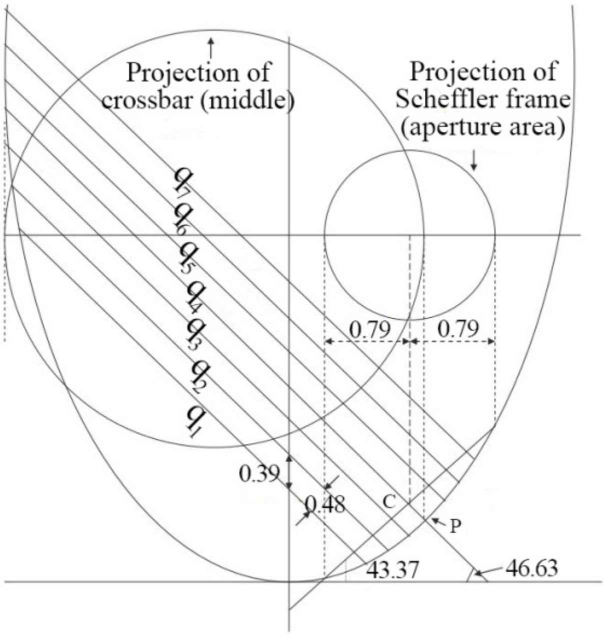

Fig. 3. Scheffler reflector crossbars [1]

3- Manufacturing Procedure

After calculating the required parameters, a detailed drawing of the concentrator is prepared using Solidworks software. At the end, manufacturing of different parts as well as their assembly is done.

Installation of a Scheffler reflector requires the axis of rotation to be fixed precisely at an angle equal to the latitude of the site. For daily tracking these reflectors rotate alone an axis parallel to polar axis with an angular velocity of one revolution per day. The daily tracking is accomplished with the help of an electric motor, gearbox, battery and a digital timer. In order to adjust the reflector with respect to changing solar declination, the reflector has been provided with a telescopic clamp mechanism. A receiver was made of steel sheet with circular cross section which contains 12 liters of water (Fig. 4).

4- Results and Discussion

In this research, the effect of using black color and glass cover on the receiver surface to increase energy absorption has been studied (Fig.5).

Results of the experiment show that this concentrator can provide enough heat for boiling of 12 liters of water in less than 2 hours. Thermal efficiency of 37% was obtained for a receiver with surface of black color and glass cover. Also the concentrator was used to heat 100 lit of water (Fig. 6) resulting in an increase of water temperature to 60 °C for a receiver with black color surface which has a glass cover.

Fig. 4. A view of the manufactured Scheffler concentrator with its receiver

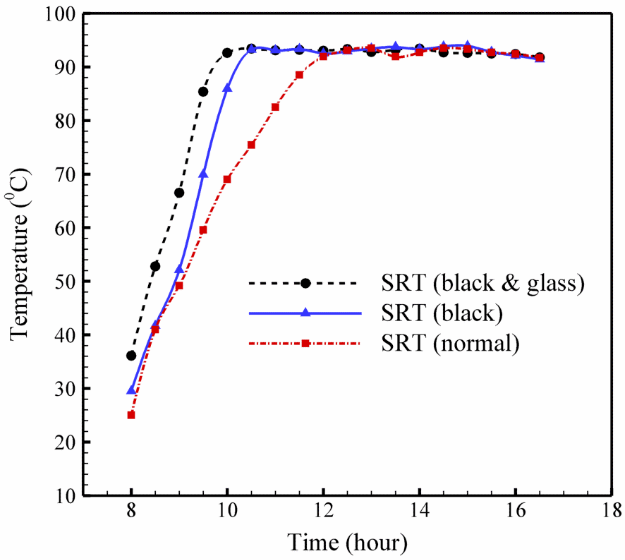

Fig. 5. Comparison of water temperature inside receiver at three cases: without black color and glass, with black color and without glass, with black color and glass

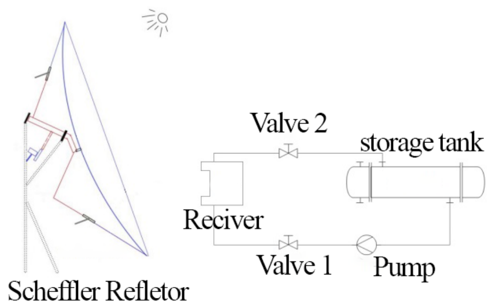

Fig. 6. Schematic of water heating system

5- Conclusion

Scheffler fixed focus concentrators are successfully used for low temperature applications in different parts of the world. These concentrators are taken as lateral sections of paraboloids which has an elliptical frame. It provides a fixed focus away from the path of incident beam radiations throughout the year. In order to concentrate on the fixed focus, this concentrator uses two different kinds of tracking systems, namely daily and seasonal tracking. In this research, design and manufacturing principles of a Scheffler standing concentrator with an area of 2.7 m^2 are presented. The results of testing Scheffler concentrator in Kerman show that the performance of this kind of reflector is so high, even with a low aperture area it will be able to provide hot water in area with low energy resources. The results showed that the concentrator with the approximate area of the 2.7 m^2 can provide incident radiation up to 9.82 times that on the horizontal surface at the focal point. Also, it is concluded that the use of black paint on the surface of the receiver increases the amount of energy absorbed up to 69%. Using glass cover for receiver surface increases reflector efficiency; similar behavior is observed for receiver with black color. However, glass cover absorbs some radiation itself and its use should be justified in this regard.

References

[1] A. Munir, O. Hensel, W. Scheffler, Design principle and calculations of a Scheffler fixed focus concentrator for medium temperature applications, *Solar Energy*, 84(8) (2010) 1490-1502.

[2] W. Scheffler, S. Bruecke, G. von Werdenbergstr, Introduction to the revolutionary design of Scheffler reflectors, in: 2006 *Solar Cookers and Food Processing International Conference*, Granada, Spain, July, 2006, pp. 12-16.

[3] S. Alberti, *Analysis and Optimization of the Scheffler Solar Concentrator*, (2014).

Please cite this article using:

M.A. Talebizadeh, E. Jahanshahi Javaran, M. Rahnama, Design, Manufacturing and Performance Evaluation of a Fixed Focus Scheffler Concentrator in Kerman, *Amirkabir J. Mech. Eng.*, 50(6) (2018) 1303-1318.

DOI: 10.22060/mej.2017.13206.5567