International Journal of Scientific Research in Physics and Applied Sciences
Vol.6, Issue.4, pp.95-96, August (2018)
Research Paper
E-ISSN: 2348-3423

Evaluation of Optical performance of Solar Concentrator with Laminated Steel Reflectors

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Available online at: www.isroset.org

Accepted: 17/Aug/2018, Online: 30/Aug/2018

***Abstract*—** Experimentation on reflector and concentrator is required for their effective utilization in energy-intensive sectors. In this connection, the present research work was devoted to experimentally assess the basic characteristics of reflector and concentrator as per BIS and MNRE specifications. It was found that the reflectance of laminated steel reflector was 80.0%. It was also found that the attainable stagnation temperature by using concentrator was 250.2°C. The experimentation revealed that the optical performance of solar concentrator was 51.1%. As the optical characteristics of the components determine the thermal and optical performance of the concentrators, it could be concluded that the novel reflector of laminated steel material would be utilized in solar concentrators.

***Keywords*—** Solar concentrator – Laminated steel reflector – Enhanced reflectance-Elevated optical performance.

I. INTRODUCTION

Solar concentrators are used worldwide for harvesting solar energy. It is reported that heating of water and steam generation are the special applications of solar concentrators [1]. It is also reported that the experimentation on reflector and concentrator is necessitated for their effective field utilization in energy-intensive sectors [2]. In these perspectives, the present investigation has been devoted (i) to assess the optical characteristics of reflector (ii) to estimate the stagnation temperature by using concentrator and (iii) to evaluate the optical efficiency of concentrator. The standard methodology was adopted and the research outcomes have been documented in this research paper. While the section I contains the introduction, the section II and section III contain materials, methods, results and discussion. At final, the section IV contains the conclusion of the present research paper.

II. MATERIALS AND METHODS

The samples of the present research included solar reflector and parabolic concentrator. In the case of solar reflector, the optical characteristics with reference to reflectances of laminated steel reflector were assessed by adhering the test procedures set by Bureau of Indian Standards (BIS) [3]. As far as the parabolic concentrator was concerned, the stagnation temperature and optical efficiency were quantified by adopting the test procedures set by Ministry of New and Renewable Energy (MNRE) [4]. It would be worth mentioning here that the optical efficiency was calculated by using the equation 1.

$$F'\eta_0 = (MC_p)'_w (T_f - T_i) / I_b A_p \tau \quad (1)$$

where $(MC_p)'_w$ is the heat capacity of water and that of pot, T_f is the final water temperature (°C) before its conversion into steam, T_i is the initial water temperature (°C), A_p is the reflector cross-sectional area (m^2), I_b is the solar radiation (Wm^{-2} min^{-1}) and τ is the time elapsed up to reaching a suitable cooking temperature (min). It is to be noted that the optical efficiency could characterize the property of the system without any heat losses. It is also to be noted that the optical efficiency would be determined from the value of heating-power near ambient temperature. Usually, this power would be measured from ambient temperature up to 95°C to avoid uncertainty of the exact boiling-point [5].

III. RESULTS AND DISCUSSION

In the present research, the solar reflector and concentrator were tested. In the case of reflector, the measurement of sizes of reflector were taken. In addition, the optical characteristics of the reflector were assessed. As far as the concentrator was concerned, the stagnation temperature was experimentally estimated. In addition, the optical efficiency of the same concentrator was evaluated. All the research outcomes have been documented in this research paper.

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Table 1 Specifications of parabolic concentrator

Parameters	Specifications
Aperture diameter (length based)	1.38 m
Aperture diameter (width based)	1.42 m
Surface area of reflector	2.31 m^2
Number of facets of reflector	37
Length of each facet	86.0 cm
Focal length of concentrator	22.5 cm
Size of focal spot of reflector at the bottom of vessel (Diameter)	25.0 cm

Table 2 Estimation of reflectivity of solar reflector

Experiment No.	Level of radiation (W/m^2)		Reflectivity (%)
	Level of reflected radiation	Level of incident radiation	
1	684.1	855.2	80.0
2	665.2	831.5	80.0
3	656.5	820.6	80.0
4	649.2	811.5	80.0
5	655.8	819.7	80.0
6	659.4	824.3	80.0

Table 3 Estimation of stagnation temperature

Time (min)	Solar radiation (W/m^2)	Ambient temperature (˚C)	Temperature of oil (˚C)
0 (11:00)	780.1	29.5	28.0
5	787.3	29.7	66.2
10	790.5	29.9	115.8
15	788.3	30.1	170.0
20	795.8	30.2	200.0
25	801.8	30.4	213.2
30	804.8	30.5	228.6
35	809.6	30.6	236.2
40	817.8	30.7	246.8
45	828.0	30.7	250.2
50	812.0	30.8	250.2
55	833.0	31.0	250.2
60 (12:00)	836.7	31.1	250.2

The measurements on reflector were taken and it was observed that the measured values adhered with the standard specifications. Subsequently, the incident and reflective parameters of the reflector were observed experimentally for six times as per specifications and the reflectance of the reflector was calculated from the relation $R= (R_1 / R_2) \times 100$ [6]. The reflectivity values showed that the average value of reflectivity of reflector was 80.0 % and this average value could be comparable with those of high reflecting materials.

The measurement and tests on materials of concentrator showed that the technical details of the present concentrator were in line with the standard specifications. The stagnation temperature by using the concentrator was experimentally found to be 250.2˚C and this temperature could be achieved in 60 minutes with the average solar radiation of 806.6 W/m^2. The recorded stagnation temperature was generally found to be comparable with those of similar concentrators. The optical efficiency of solar concentrator was experimentally assessed with suitable volume of water in the vessel. The optical efficiency was found to be 51.1% and it was also found to be comparable with those of similar type of concentrators. The estimated stagnation temperature and optical efficiency could be correlated with the size of the reflector, material of the reflector and reflectivity of the reflector. They could also be attributed to the test conditions, technical factors and meteorological parameters [7-8].

IV.CONCLUSION

As the specifications of components cause the characteristics of concentrators, it could be concluded that the present technical specifications would be adhered in designing and fabricating concentrators. As the optical characteristics of the components determine the thermal and optical performance of the concentrators, it could also be concluded that the novel reflector of laminated steel material would be utilized in solar concentrators.

REFERENCES

[1]. P.Jeyasankar, K.Uma Maheswari, R.V.Jeba Rajasekhar, "Studies on nano-sized carbon coated fin, C/Al_2O_3 coated absorber and TiO_2/SiO_2/Ag thin film coated reflector", Proceedings of national seminar on modern trends in chemistry,Vivekananda College, Tiruvedakam West, Madurai, India, pp.24-28,2015.

[2]. Aranzazu Fernandez-Garcia, Florian Sutter, Lucia Martinex-Arcos, Christopher Sansom, Fabian Wolferstetter, Christine Delord, "Equipment and methods for measuring reflectance of concentrating solar reflector materials" Solar Energy Materials and Solar Cells, 167,28-52, 2017.

[3]. BIS, Bureau of Indian Standards (IS 12933-2003), "Specifications for flat plate collectors", Ghaziabad, India, 2003.

[4]. MNRE report, "Test procedure for solar cooker: paraboloid type concentrating cooker", Ministry of New and Renewable Energy, Government of India, India, 2006.

[5]. Subodh Kumar, T.C.Kandpal, S.C.Mullick, "Experimental test procedures for determining of the optical efficiency factor of a parabollid concentrator solar cooker", Renewable Energy,145-151, 1996.

[6]. P.Rajmohan, R.V.Jeba Rajasekhar, S.Shanmugan, K.Ramanathan, "Energy and economic evaluation of fixed focus type solar parabolic concentrator for community cooking applications' Energy Education, Science & Technology, Vol 26, No.1 & pp.49 – 59, 2010.

[7]. Ajay Chandak, Sunil K.Somani, Patil Milind Suryaji, "Performance of Industrial oven with 16 sqm scheffler solar concentrator", Journal of Solar Energy Society of India, Vol. 19, Nos.1 and 2, 18-25, 2009.

[8]. P.Jeyasankar, R.V.Jeba Rajasekhar, "Preparation, characterization and evaluation of thermal efficacy of nano carbon-MnO_2 coated solar absorber", International Journal of Scientific Research in Physics and Applied Sciences, Vol.6, Issue 2, pp.52-54, 2018.

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