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To Compare the Performance of Secondary Reflector Using Different Reflective Materials in Scheffler Reflector

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Abstract—*This paper presents a study of secondary reflector of scheffler reflector using different reflective materials. In the experimental system the solar radiations after reflecting from the scheffler reflector are directed towards secondary reflector placed in the receiver. The profile and arrangement of Secondary reflector is such that it reflects the radiations upward towards the bottom of a vessel containing water. Two different types of reflecting materials for secondary reflector studied are galvanized iron sheets wrapped with aluminium foil and highly reflecting aluminium sheet. It was found that the temperature of water in case of Galvanized iron sheets wrapped with aluminium foil and highly reflecting aluminium sheet reached 82 ^{0}C and 96 ^{0}C respectively in just one hour.*

Keywords: *Thermal Performance, Scheffler Reflector, Secondary Reflector, Receiver.*

1. INTRODUCTION

In the last decades, the increasing energy crisis in developing countries and climate change hazards has created awareness to promote the renewable energy technologies. A number of studies have been done on different types of solar collector and solar reflectors. Beyond the low temperature applications, there are several fields of application of solar thermal energy at a medium and medium–high temperature level. From a number ofstudies on industrial heat demand, several industrialsectors have been identified with favourable conditions forthe application of solar energy. Few experiments were carried out to utilizethe solar energy at medium temperature range using scheffler reflector to increase the temperature at medium–hightemperature range.A. Muniret. al[1] The paper presents a complete description about the design principle and construction details of an 8 m^{2}surfacearea Scheffler concentrator. The design procedure is simple, flexible and does not need anyspecial computational setup, thus offering the prospect of potential application in domestic as well as industrial configurations.A. Munir and O. Hensel [2] The study was initiated to develop an on-farm solar distillation system for functional, environmental and economic reasons. The system comprises a primary reflector (8 m^2 area), secondary reflector, distillation still, condenser and Florentine flasks. The average power and efficiency of the solar distillation system were found to be 1.548 kW and 33.21% respectively. José Ruelaset. al [3] Develops and applies a new mathematical model for estimating the intercept factor of a Scheffler type solar concentrator (STSC). Fndings show that the highest concentration was obtained with an edge angle of 45^0, which was observed in the parabolic dish as well, but the STSC receiver shows a 7% increase in the thermal efficiency compared with the efficiency of the parabolic dish receiver.G. Angrisaniet. al [4] A new concept of a system based on a Stirling engine for the combined production of heat and electric power is presented. The system uses two renewable energy sources, direct solar (thermodynamic solar) and biomass (indirect solar energy). The possibility to adopt a medium, the fluidized bed, ensuring heat transfer coe fficients about one order of magnitude greater than that typical of systems recovering the heat from the gas phase, greatly helps in achieving a high utilization of the SE. [5] This paper shines a new light on the cultural dynamicsofcooking byshowcasingthe social acceptance of solar cookers. Six cases are presented from two differentcountries, Burkina Faso and India where a particular type of solar cooker (Scheffler reflectors) wasinstalledamong bakeries, sheanut butter producers, and steam kitchensThestudyconcludes that by implementing solar cookers as part of a n existing socio-cultural framework, solarcookersmoveaway from an image of a mere foreign technology to an integrated part of the target society.AnjumMunir [6] research is focused to develop an on-farm solar distillery for the processing of different plant materials. The system comprises of a Schefler reflector and a complete set of distillation system. An 8 m^2‘projected area of the Scheffler solar concentrator was coupled with thedistillation still for the extraction of essential oils. The efficiency of solar distillery was calculated to be 33.21% with 1.548 kW thermal power available for processing in the distillation still. The research concluded that different kind of medicinal and aromatic plants could be processed effectively using solar distillery.José Ruelas [7] This study presents the geometric aspects of the focal image for a Scheffler-type solar concentrator (STSC) using the ray tracing technique to establish parameters that allow the designation of the most suitable geometry for coupling the STSC to a Stirling engine of 3 kWe. The results of the ray tracing software are validated through thermographic images of the STSC solar concentration after modifying the image to establish the geometric areas with the highest temperature. It was found that the most suitable solar image geometry has variations within an elliptical area of 14.25 cm^2 on average with a circular aperture area reflector.

Few researchers have worked on scheffler reflector of different size for different application but no study has been done on secondary reflector.The objective of this paper is to study the thermal performance of secondary reflector of scheffler reflector using different types of reflecting materials. The experimental setup is installed at NITKurukshetra, India (29° 58´ (latitude) North and 76° 53´ (longitude) East).

2. EXPERIMENTAL SETUP

The experiment is performed to investigate the thermal performance of secondary reflector of scheffler reflector using different types of reflecting materials. The experimental setup consists of scheffler reflector, receiver, secondary reflector, vessel as shown in Fig. 1. The experimental setup consists of following components:

- Scheffler Reflector
- Receiver
- Secondary Reflector
- Vessel

2.1 Scheffler reflector

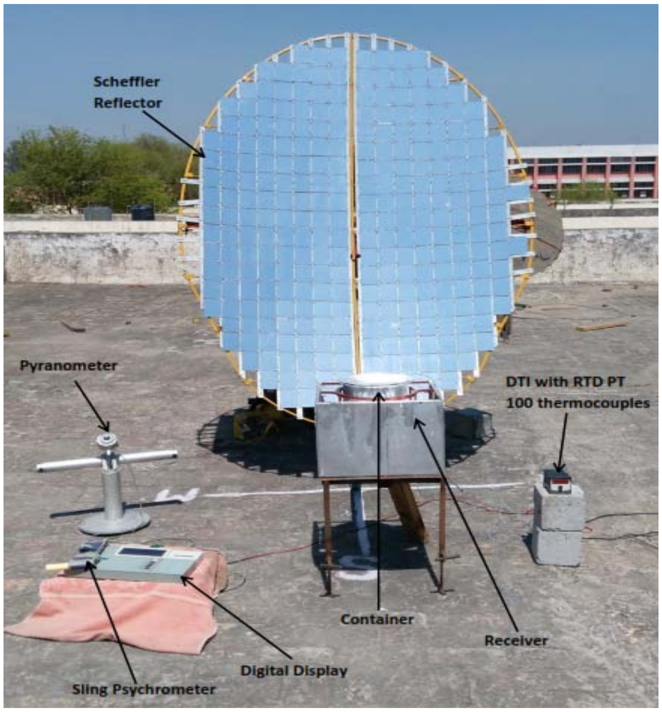


Fig. 1: Experimental Setup

The reflector is a small lateral section of a much larger paraboloid. The inclined cut produces the typical elliptical shape of the Scheffler reflector. The sunlight that falls onto this section of the paraboloid is reflected sideways to the focus located at some distance of the reflector. The focus is located on the axis of rotation to prevent it from moving when the reflector rotates. The tracking of the scheffler is done by the mechanical clock which continuously rotates the scheffler reflector and thus tracks the sun. Specifications of the scheffler reflector are shown in Table 1.

Table 1: Specifications of the scheffler reflector

Major axis	2.2 m
Minor axis	1.6 m
Focal length of reflector	2.45 m
Aperture area of reflector	2.7 m2
Concentration ratio of reflector	135

2.2 Reciever

The receiver is of dimensions 410mm*380mm*280mm (Fig. 2). The receiver is covered by aluminium sheet from all sides except front, top and bottom. The secondary reflector is placed inside receiver such that all the light falling on it is reflected upwards. The opening at top ofreceiver is of270 mm diameter. The container is placedinside it.

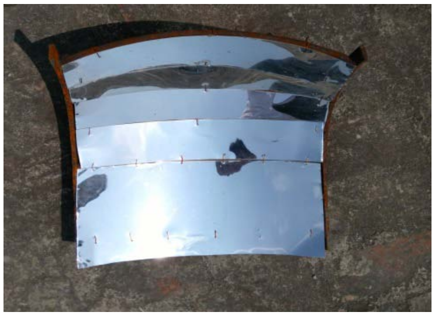
Fig. 2: Photograph of receiver

2.3 Secondary reflector

Secondary reflector is placed inside the receiver. The rays coming after reflecting from scheffler reflector falls on the secondary reflector. The profile of Secondary reflector is such that all the rays falling on it are reflected upwards i.e. at the bottom of container. In this paper three secondary reflector with different reflecting materials are studied. Two different reflecting materials are as follows (Fig. 3):

- Galvanized iron sheets wrapped with aluminium foil.
- Highly reflecting aluminium sheet

(a)



(b)

Fig. 3: Secondary reflector with (a) Galvanized iron sheets wrapped withaluminium foil. (b) Highly reflecting aluminium sheet

Fig. 4: Secondary reflector placed inside receiver

2.4 Container

A container of aluminium is used to heat water of 1500 ml (Fig. 5).

Fig. 5: Photograph of container

3. MEASURING DEVICES AND INSTRUMENTS

Different parameters are measured, these are:

- water, vessel bottom and surface of secondary reflecting material temperature
- Ambient temperature
- Solar radiation intensity

The temperatures are measured with RTD PT100 thermocouples which are connected with a digital temperature indicator that shows the temperature with a resolution of 0.1℃.

Dry bulb temperature of ambient air is measured with sling Psychrometer.

The solar radiation intensity is measured during the day time with a Pyranometer-model CM11, supplied by Kipp and Zonen, Holland.

The experimental data is recorded at an interval of 10 minutes. The experiments were carried out in mostly clear sky days in the month of March 2015.

4. SYSTEM OPERATION

The main objective of this experimental setup is to study the thermal performance of secondary reflector using different types of reflecting materials. In the experimental setup, three different types of secondary reflecting materials were used to heat 1.5 litre quantity of water. Container is placed in the receiver and the system is exposed to solar radiation. Solar radiations after reflecting from scheffler reflector and the secondary reflector are made to concentrate at the bottom of container.

5. EXPERIMENTAL RESULTS AND DISCUSSION

In the experimental setup, cooking was conducted in the daytime as well as in the evening time at different cooking loads using a novel design of solar cooker with dual thermal storage unit based on the parabolic dish type collector. The performance of secondary reflector using different types of reflecting materials was studied at NIT Kurukshetra, India. The experiments were conducted during the month of March 2014. Every day, solar collector was exposed to solar radiation at 11:30 hr and readings were taken from 11:30 hr at an every interval of 10 minutesupto 12:30 hr. Two different cases were studied with different secondary reflector with reflecting material with

- Galvanized iron sheets wrapped with aluminium foil as secondary reflector
- Highly reflecting aluminium sheet as secondary reflector

5.1 Galvanized iron sheets wrapped with aluminium foil as secondary reflector

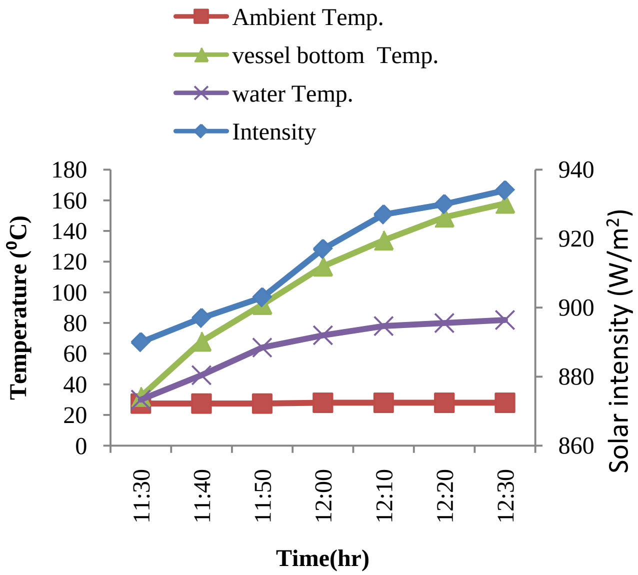


Fig. 6: Variation of temperature and solar radiation intensity with time in case of Galvanized iron sheets wrapped with aluminium foil as secondary reflector

During the day, the maximum intensity was 934W/m^2 at 12:30 and the ambient temperature was in the range of 27°C to 28°C. The Fig. 6 shows that the temperature of vessel bottom reched to 158 ⁰C while the temperature of water rises to 82 ⁰C in one hour.

5.2 Highly reflecting aluminium sheet as secondary reflector

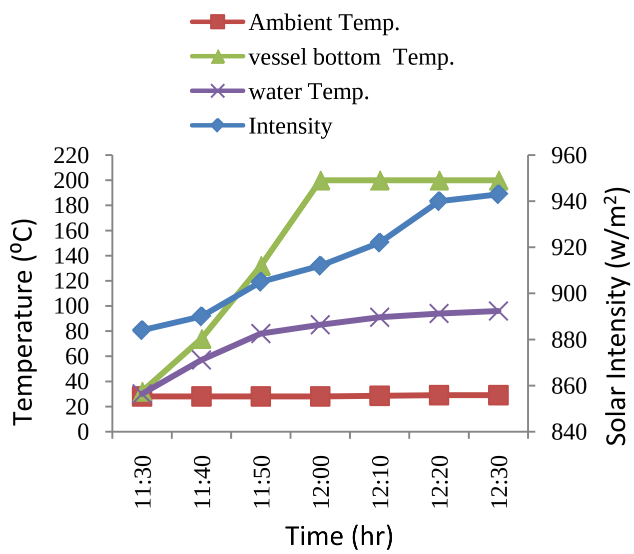


Fig. 7: Variation of temperature and solar radiation intensity with time in case of Highly reflecting aluminium sheet as secondary reflector

The ambient temperature was in the range of 28°C to 29°C and the intensity was in the range of 884 - 943 W/m^2. The Fig. 7 shows that the temperature of vessel bottom crossed 200 ⁰C in just half an hour. While the temperature of water rises to 96 ⁰C in one hour.

6. CONCLUSION

It was found that within a short period of half hour the temperature of water reaches 75 ⁰C. The temperature of water after one hour is 82 ⁰C and 96 ⁰C for case1 and case 2 respectively. It was also observed the temperature of bottom of vessel crossed 200 ⁰C for case 2 in just short span of 25-30 minutes. The large difference between the temperature of bottom of vessel and the water shows that there is heat loss. So there scope for improvement in receiver to prevent heat loss.

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