Potential of 2.7m2 Scheffler Reflector for Making Solar Powered Bricks in Indian Climatic Conditions

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***Abstract*- Renewable energy has been used in various forms for more than a century. Environmental issues like global warming, depletion of non-renewable energy sources marks the importance of pollution free renewable sources of energy. Scheffler Reflector, an alternative way to utilize solar energy in form of heat over conventional fuel. Scheffler Reflector receives solar radiation and constitutes a proven source of heat energy for various industrial and domestic applications. Various research works have been undertaken in the past to utilize solar radiation for different application using Scheffler Reflector and performed thermal analysis. However it seems that no work has been carried out by investigator to make the clay brick based on Scheffler Reflector in Indian climatic conditions.**

This paper has been focused on the various works done by the past investigators, to make the clay brick using solar energy as heat source and to point out the further future scope in the field of renewable energy. It was found from the present experimental investigation that compressive strength of brick increases from 1.3 MPa to 5.01 MPa. The maximum temperature of brick achieved with average solar radiations of 970 W/m2 was 351.3 °C. For this area of Scheffler Reflector change in compressive strength is remarkable.

***Index Terms*- Scheffler Reflector, Secondary Reflector, Receiver, Solar Radiation, Clay Brick.**

I. INTRODUCTION

Scheffler Reflector constitute a proven origin of thermal energy for industrial and domestic process heat and power generation, However their implementation has been powerfully influenced by economics. In recent years, environmental issues and other geopolitical factors have centered attention on renewable energy resources, improving the prospects for Scheffler Reflector deployment. The digested slurry of biogas plant is used as humus rich fertilizer for spice garden spread around the green kitchen to beautify the ambient [9] Further work is needed to increase the system efficiencies and active areas of research taking account of the testing rig design, development of advanced heat receiving elements and working fluid, optimization of reflector structures, thermal storage device and direct steam generation (DSG).

Solar energy has turn out to be one of the most auspicious alternative energy resources as it is free, environmental friendly and also it is available in abundance. A large part of industrial process heat lies from low to medium temperature range which can be supplied by solar energy [4]. From the last few years, solar energy is utilized in the field of moderate temperature applications using various types of collector such as, parabolic trough collector parabolic dish collector, and evacuated tube collector.

Wolfgang Scheffler set-up a parabolic reflector to use solar energy using low cost operation which can be used for domestic application India. A Scheffler fixed focus concentrator is used for the solar distillation system [4] Scheffler reflectors are part of lateral sections of paraboloids and provide permanent focus away from the path of incident solar radiations throughout the year. Tracking of Scheffler Reflector (primary reflector) is according to the movement of the Sun, concentrating sunlight on a fixed place. The focused area (receiver) get heated, which can be further used for heating, steam generation, baking breads, cooking and water heating. The Scheffler reflector can be used for the providing hot water for domestic purposes. One water storage tank can be used for these systems which perform dual function of preserving heat of water and absorbing solar radiation. Using the non-uniform distribution of solar radiation on the cylindrical absorber surface, Scheffler reflectors can result in effective water heating.

2. LITERATURE REVIEW

2.1 Ulrich Oelher and Wolfgang Scheffler [1994] presented two example uses of solar technology. First is solar cooker made of a polymer based insulated material and another one is solar hybrid kitchen using fixed focus concentrator. This system is easy to both install and to construct, which fulfill human needs. In recent years it is widely adopted due to its ecofriendly nature. He made the easiest type of solar cooker from a wooden box, metal reflector, some nails and with the help of carpentry tools. According to the design which he made, with in quarter of an hour temperature reached in solar cooker was 150 - 160°C and even 200°C under optimal weather condition i.e. clear sunny day, low wind.

As all we know that solar cooker is best suitable for a family, but for community of more than several hundred people hybrid kitchen was constructed by Oelher U. et al. using Scheffler Reflector of area 7m2. The experiment was conducted in Sudan and the technical data for solar kitchen was measured. The temperature, efficiency at focus with Scheffler Reflector of area 7m2, and the size of cooking pot was 200-350°C, 60% and 70-80litres respectively.

2.2 Michael Tyroller [2003] has experimentally studied the Development Test (in 2003) and installation of a Solar Steam Steriliser in Rural Hospitals. The area of Scheffler Reflector used in 761 sterilizer is10m2.The project was developed in 2003 and installed in 2004 in India. Thermal energy is stored in the core of a 230kg iron block. The iron block serves the function of steam generator. High efficiency, small hybrid system, easily availability and construction of iron block etc. were the benefits of this project. Clouds have no effect on the sterilization process, because thermal energy comes from storage. With 10 m2 Scheffler reflector temperature of iron block of 230 kg reached to 500 °C.

2.3 Jean-Claude Pulfer [2003] experimentally studied "CEDESOL Ingeniería" made for liquor factory "Hecho en Casa'' and small marmalade factory. The project is located in the Argentinean town of Clorinda. Scheffler Reflector (200 rectangular mirrors having thickness 2mm) with area 4.5m2 was used in the project with semiautomatic clockwise tracking system. The cooking pot having capacity of 50 litres with thermal insulation was used. Temperature readings were recorded in the interval of 20 min. Water temperature reached to 92ºC after 2 h 10 min. Then due cloud for some 5 min. the experiment was stopped. With focus diameter of 40cm on the receiver, thermal analysis was done. It was found that efficiency drop of the system was 52.7 to 46.1 %.

2.4 A. Munir [2009] studied and experimented the agro-based industries by innovative Scheffler Reflector which can open new bench mark in rural development especially in hot countries. Essential oils are extracted from herbs through distillation process, which are medium temperature agro-based industries. Using small scale distillation unit, laboratory experiments and field experiments with solar energy were conducted. Laboratory apparatus comprises of round glass boilers of capacity 2 litres, insulated electric heaters (0-500 W), glass still tubes Florentine flasks and condenser units.

Field experiment comprises of Pyranometer thermocouple to optimize and control the distillation processes. In order to separate the oil from water different glass Florentine flasks were used. For beam radiations range of 700-800 W/m2 receiver temperature range of 300-400°C technical data of field experiments with Scheffler Reflector was recorded. In the field experiment with 8m2 Scheffler reflector efficiency and temperature range was 43.25% and 23-250°C respectively with beam radiations 739W/m2.

2.5 Ajay Chandak et al. [2009] designed and experimented with multistage evaporation system for production of distilled water. With the help of Scheffler Reflector of 16 m2, each generating steam at 8 bar pressure in first stage and pressure is gradually brought to 1 bar, in four stage of distillation unit. It was observed that this system has great potential in food handling industry, for applications of sauces, juice thickening, salt concentrating systems, jams, and distilled water applications.

2.6 Christoph Müller et al. [2009] described the installations of solar bakery oven. The project of five solar community bakeries financed by BMZ project was installed in Argentinean Altiplano. It was found that own adobe oven is used more than one time by each family which consume 30 kg of tola each time. Due to the extreme barren land and sultry weather conditions and growing population, the effect of firewood collection is more and more noticeable. To protect the vegetation, a solar bakery oven was used with a fix focus Scheffler Reflector .The reflector area of Scheffler was 8 m².The capacity of oven was about 200 litres. The temperature reaches to 350 °C with an input power of around 3 KW. 22° south was the latitude of the site. The efficiency of the system was found to be 40% approximately. With the availability of around 6 hours in a day of Scheffler reflector about 60 kg bread can be baked. Solar Community Oven is remarkable example of the utilization of solar energy.

2.7 A.Munir et al. [2010] studied and developed Scheffler Reflector with fixed focus of 8m2 surface area for Extracting oil from plant material with the help of distillation process. He had conducted experiments in summer 2007 and 2008. System was altered according to the results found in 2007, at the beginning of 2008. He used various medicinal and aromatic plants. Some of them were Lavender, Melissa (leaves), Cloves (buds), Peppermint (leaves), Rosemary (leaves) and Cumin (seeds). For the particular experiment, the technical data recorded was within the beam radiation range of 700-800 w/m2.The system efficiency and power were found to be 33.21% and 1.548 kW respectively. The temperature at focus was between 300 -400° C.

2.8 Rupesh J Patil et al. [2011] has studied thermal analysis of Scheffler reflector of 8 m2 with the help of a drum of 20 litres capacity have been done. The performance of Scheffler reflector was examined in terms of system power and efficiency with water in the receiver. The experiments were carried out throughout the year which covers summer, winter and rainy seasons in India. The Parameters measured were solar radiation, water temperature, wind speed, ambient temperature and measuring instrument used were K-type thermocouple to measure ambient and water temperature, digital anemometer(having range of 0.3-30 m/s) for wind speed. To measure solar radiation Pyranometer is used. At the intervals of 5 min, all readings were taken. Within 1.5 hours, the maximum temperature reached to 98 °C on clear sunny day and with ambient temperature range and solar radiation of 28° C to 31° C, 700 – 780w/m2 respectively.

2.9 Sanjib Kumar Rout [2011] studied and described the cost analysis of solar energy equipment which can be used for hygienic food production with respect to conventional kitchen. Green kitchen involves the usage of solar parabolic reflectors, solar cookers, solar ovens, solar dryers, biogas plants, solar water heaters, Scheffler, biomass gasifiers, etc. It was found that for 500 people, the cost of green kitchen equipment was 892000 in Indian Rupees, whereas the cost of conventional kitchen for same no of people found to be about 25lakhs.This amount is thrice the green kitchen equipment. Green kitchen produce low and zero carbon food products. On the operation of six month in a year, with the help of green kitchen around 4.8 lakhs (INR) is saved than conventional Kitchen. Green kitchen is very much ecofriendly. The processed slurry of biogas plant is used as humus rich fertilizer. This technique may also be implemented in rural mass and community Centre for hygienic food production and cost effective.

2.10 Iris Chu et al. [2012] studied and developed special kind of solar cooker which can be used at night also. The Solar Cook Stove project seeks improvement in the method of food preparation in developing regions of India with the use of Phase Change Material (PCM) to solve the demand supply problems which are associated with solar cookers. Due to high thermal energy storage of PCM, it stores and releases a huge amount of energy during phase change from the solid to liquid phase and vice versa, at a particular temperature. Erythritol is used in this project as PCM because of its high melting point, low-cost, and easy availability. The Solar Cook Stove comprises of two major components. First is a cooking unit second is a solar reflector. The Phase Change Material (PCM) is contained by cooking unit. The PCM store and transfer energy to the cooking plate. The Scheffler reflector is a parabolic mirror which focus the sunlight onto the cooking part. This type of Solar Cook Stove has been designed to be useful for cooking before and after sunset.

2.11 Vishal R. Dafle et al. [2012] studied the Design, Fabrication and Thermal performance for 2 bar pressure and temperature 110 oC with 16 m2 Scheffler reflector. The system comprises of Scheffler Reflector with 16m2 and mild steel absorber plate having dimensions, 18 cm ø and 2.5 cm thickness. At composite climate zone thermal analysis was done in month of February 2012. During the experiment it was observed that with solar radiation range of 620 W/ m2 to 937 W/ m2, the thermal efficiency decreases with increase in radiation. The maximum and minimum absorber plate temperature was 235oC and 138oC respectively, while temperature of steam obtained was 107oC at the boiler outlet. During the testing and analysis, 4 Kg of steam was produced at 110 oC and 2 bar pressure which is equivalent to 3.5KW energy output per day. The overall efficiency evaluated was 57.41 %. This paper conclude the achievement of concentrating solar thermal equipment using Scheffler technology for low pressure, temperature steam generation, water heating.

3. EXPERIMENTAL SETUP

The objective of this paper is to produce solar powered clay brick, tile based on Scheffler Reflector (SR) under local weather conditions.In present work, there is no external work required to transfer the heat from parabolic dish collector to the receiver .The main components of the set up are Scheffler Reflector, receiver and secondary reflector and clay bricks/tiles.Scheffler reflector is a small lateral section of a much larger paraboloid and provides permanent focus away from the path of incident solar radiations throughout the year.Scheffler Reflector (SR) and thus tracks the sun. This tracking can be either manual or automatic.The solar radiation after reflecting from the reflector frame is focused at the receiver. The receiver may be different shapes and size depending upon the application.

Most of the rays coming after reflecting from Scheffler Reflector falls directly on the brick/tile and some part are lost. This lost part can be used again using secondary reflector. This secondary reflector again concentrates these rays falling on it, and reflects back to the clay brick/tile. The reflecting materials of the secondary reflector are highly reflecting aluminum sheets. Brick/tile sample used in the present work is ordinary building brick which is made of a mixture of clay, which is subjected to various processes, differing according to the nature of the material, the method of manufacture and the character of the finished product. After being properly prepared the clay is formed in moulds to the desired shape, then dried and burnt.

3.1 Measuring devices and instruments

Different parameters measured are brick or tile Surface temperature, ambient temperature, wind speed, solar radiation intensity weight of the sample and compressive strength. RTD PT 100 thermocouples and Infrared Temperature Sensor are used to measure the surface temperature of the clay brick; tile and ambient temperature. Anemometer is a small size instrument used to measure the wind speed of project site. It is light in weight and easy to carry.Anemometer is widely used in data collection for refrigeration industry, boiler, navigation measurement, solar energy field and weather forecast. The pyranometer (model CM11 Supplied by Zonen and Kipp, Holland) is used for the measurement of global solar radiation received on a horizontal surface.The weight of the Brick, tile and clay object (Diya) is measured with the help of weight machine.The compressive strength of the baked brick is measured at last. It is measured with help of Compressive Strength Test Machine having maximum load capa
city of 3000kN.

3.2 System Operation

The main objective this experimental setup is to make the solar powered brick and tile. In this experimental setup, Scheffler Reflector is connected with receiver (focus of Scheffler Reflector). During sunshine hours solar radiations which are falling on the Scheffler Reflector, made to focus on receiver. The focus at the receiver is fixed because sun is tracked by manual clock mechanism. These concentrated solar radiations at the focus have very high temperature and this available energy at the receiver is transferred to the brick/tile which is placed on it. As the concentrated heat falls continuously on the brick/tile, the surface temperature also increases accordingly. All the performance parameters such as solar radiation, surface temperature and weight of the sample are measured with measuring instruments with an interval of one hour. After sunshine hour setup is stopped and the sample placed on the focus is allowed to cool. After cooling of the sample the compressive strength is measured with the help of compressive strength testing machine.

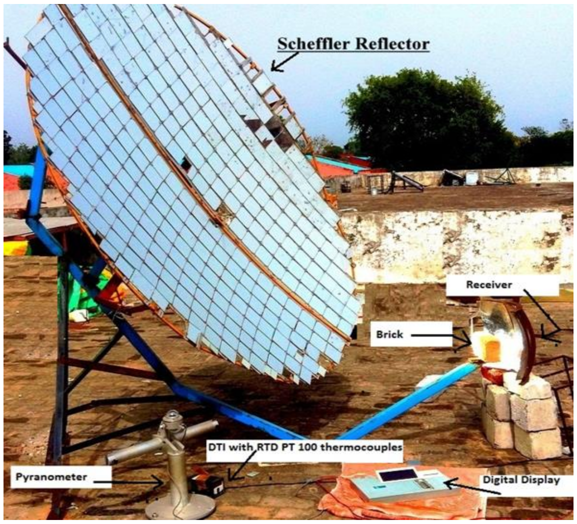

Figure 1.1 Photographic view of the experimental set up

4 EXPERIMENTAL RESULTS AND DISCUSSIONS

The experiments were conducted during the month of June 2017. Every day, solar collector was exposed to solar radiation at 9:30 hr. and readings were taken from 9:30 hr. at an every interval of 60 minutes up to 18:30 hr.

4.1 Variation of Brick Weight with Time

Figure 4.1 shows that with increase in time interval, the weight of the brick decreases. It shows that initially the brick weight is 3092.3 g at 9:30 hr. and it decreases at faster rate till 13:30hrthan after 13:30 hr. At 13:30 hr. brick weight is 2922.1 g. After that the decrease in weight of brick is very less almost constant .This is because the most of moisture in the brick has been removed before 13:30 hr. The weight is measured till 18:30 hr. which is 2898.2g.

Variation of brick weight with time is depicted in figure 4.1.

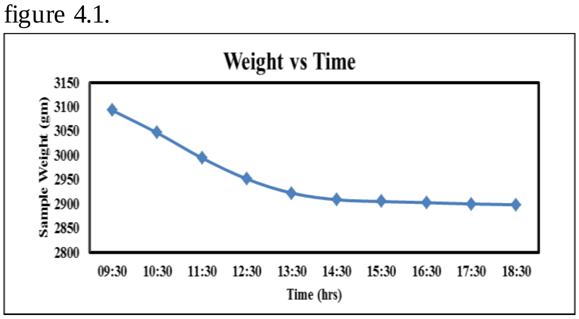

Figure 4.1 Variation of brick weight with time

4.2 Variation of Brick Drying Rate with Time

Figure 4.2 shows that first there is increase in drying rate for approximately one and half hour and then drying rate decreases with time. Drying rate of the brick is calculated with an interval of one hour from morning to evening. The drying rate after one hour (at 10:30hr) of experiment is 0.77 g/min and maximum at 11:30hr (0.8633 g/min). After 11:30 hr drying rate decreases uniformly till 15:30 hr. Again there is slightly increase for one hour and at last it reaches to its minimum value of 0.0266g/min at 18:30 hr.

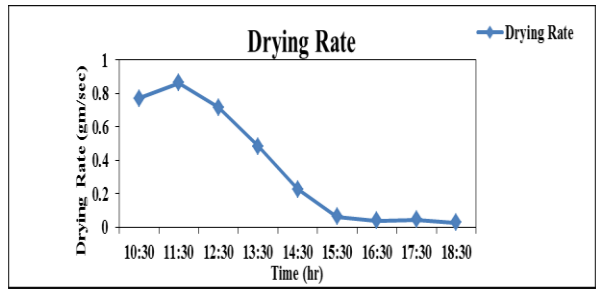

Figure 4.2 Variation of brick drying rate with time

4.3 Variation of Brick Surface Temperature, Solar Intensity, Ambient Temperature, Wind Speedwith Time.

Variation of brick surface temperature, solar intensity, ambient temperature, wind speed with time is depicted in figure 4.3.

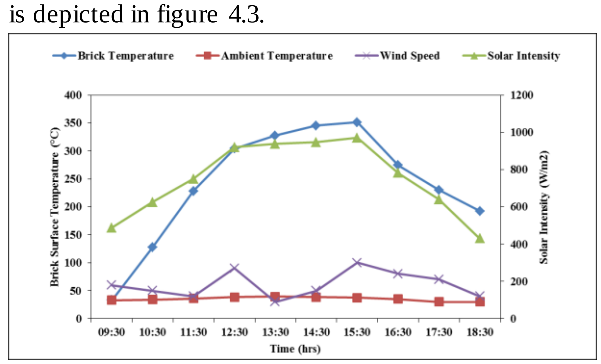

Figure 4.3 Variation of brick surface temperature, solar intensity, ambient temperature, wind speed with time.

The figure 4.3 shows the results obtained from 9:30 hr. to 18:30hrwhen the brick is placed on the focus of the Scheffler Reflector. Four parameters such as solar intensity, wind speed, brick surface temperature and ambient temperature are measured during experiment. It is clear from the figure 4.3 that ambient temperature variation is approximately 4°C. Initially, the ambient temperature was 33.1°C and then it starts increasing till it reaches maximum value (39.2 °C) corresponding to the time 13:30 hr. The influence of wind speed is very less on the brick surface temperature. The effect of solar radiation on brick surface temperature as compared with other parameters is quiet high. As the solar radiation increases, the brick surface temperature also increases till 15:30 hr. and after that of solar radiation decreases and brick surface temperature also starts decreasing. The maximum solar radiation and brick surface temperature obtained during sunshine hour during experimentwas 970 W/m2 and 351.3 °C respectively.

5 CONCLUSIONS

The main objective of the present research work was to explore the feasibility of baking bricks based on Scheffler Reflector in north region of India, as an alternative approach to the conventional method of baking brick. The main conclusions emerging from the present work is:

1. On clear sunny day the maximum temperatures of bricks achieved with average solar radiations of 970 W/m^2.
2. The weight of the brick decreased from 9:30 hr. to 18:30 hr. was 194.1 g.
3. The compressive strength of brick increases from 1.3 MPa to 5.01 Mpa.
4. The maximum amount of energy absorbed in one hour by brick is 424.03 kJ.
5. It concluded from the experimental investigation that, for this area of Scheffler Reflector increase in compressive strength of brick and tile is significant.

REFERENCES

[1] Chandak, A., Somani, S K., 2009. Design of Multistage Evaporators for Integrating With Scheffler Solar Concentrators For Food Processing Applications, International Solar Food Processing Conference.

[2] Munir, A., Hensel, O., 2009. Solar Distillation for Essential Oils Extraction - A Decentralised Approach for Rural Development, International Solar Food Processing Conference.

[3] Müller, C., 2009. Solar Community Bakeries on the Argentinean Altiplano, International Solar Food Processing Conference.

[4] Munir, A., Hensel, O., 2010 On-Farm Processing Of Medicinal and Aromatic Plants By Solar Distillation System." Elsevier, ISSN-15375110.

[5] PATIL, R., AWARI GK., 2011. Experimental Analysis of Scheffler Reflector Water Heater." THERMAL SCIENCE, Vol. 15, No. 3, pp. 599-604.

[6] Rout, SK., May2011. Development of Model Solar Kitchen with Green Energy For Demonstration And Application In Rural Areas, World Renewable Energy Congress 2011-Sweden

[7] Pulfer, JC, 2003. Small Marmalade Factory in Argentina Working With Scheffler Type Industrial Cooker, CEDESOL Ingeniería.

[8] T, Michael.,Brücke, S., 2003.Solar Steam Sterilizer For Rural Hospitals,G.v.Werdenbergstr.6 89344 Aislingen Germany.

[9] U, Oelher., W, Scheffler., 1994. Solar Energy Materials and Solar Cells 33(1994) 379-387.