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EXPERIMENTALLY INVESTIGATE THE PERFORMANCE OF BAKED CLAY BRICK BASED ON PARABOLIC DISH COLLECTOR IN NORTHERN INDIAN CLIMATIC CONDITION

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ABSTRACT

In this article, baking of bricks was done by using parabolic reflector. The performance of baked brick is greatly affected by the surface temperature of bricks, but also depends upon the initial content in the brick.

The results shows that On clear sunny day the maximum temperatures of brick, tile and clay objects achieved with average solar radiations of 970 W/m^2 were 345.2° C. The weight of the brick decreased from 9:30 h to 18:30 h was 190.7g. The compressive strength of brick increases from 1.2 MPa to 4.80 MPa. It concluded from the experimental investigation that, for this area of Parabolic Reflector increase in compressive strength of brick and tile is significant

Keywords: Parabolic Dish Reflector, Receiver, Brick, Drying Rate, Numerical.

I INTRODUCTION

Energy for commercial and domestic purposes remains major concern of consumers and policy maker in India. Coal is a good source of energy and commonly used in industries like electricity power plant , brick, earthen lamp and tile manufacturing. But, coal plants are the nation's top source of carbon dioxide (CO2) emissions, the primary cause of global warming. Burning coal is also a leading cause of smog, acid rain, and toxic air pollution. Also, continuous depletion of these energy sources and increase in price of fuel indicates that there is urgent need to find the alternate way to save the environment and energy sources. Various sources of renewable energy can be utilized in and effective way for commercial and domestic use. The sun is one of the richest energy sources in this context and is almost everlasting. Solar technology and energy efficiency are essential elements to any building or community design.

A brick is building material which is utilized for different masonry construction. A brick can be composed of clay and brick baking is generally done by conventional approach. The bricks have extensive variety of utilizations e.g. building, homes, industries and pavements etc. The large amounts of coal used for bricks firing. The air pollution and bottom ash generated cause considerable health problems, especially related to respiratory health, while also

causing damage to property and crops. A new concentrating type solar cooker which may function as a cooker and/or water distiller. Designed parabolic square dish reflector, made of wooden matrix, covered with rectangular stainless steel strips. Such a cooker would have a short cooking time, this solar cooker not have condensation problems on the top glazing insulation (M.M. EL-Kassaby 1990). Good quality bricks can be produced from a slag-lime mixture and sand by pressing the mix at a pressure of 50 kg/cm2. Bricks of wet compressive strength in the range of 80-150 kg/cm2 have been obtained after 28 days of humid curing at ambient temperature (S.K. Malhotra and S.P. Tehri 1995).The performance analyses of community-size and domestic-size paraboloidal solar cooker based on energy and exergy analyses was done. The performance of community-size solar cooker (CSC) was found to be better than that of the domestic-size paraboloidal solar cooker (DSC). They also suggested that the exergy efficiency can be increased only up to some extent by increasing the reflectivity of the reflectors, proper designing of cooking place and using a suitable cooking pot (Kaushik and Gupta 2008).A parabolic dish/AMTEC solar thermal power system proposed and evaluated its overall thermal–electric conversion performance. Results show that the overall conversion efficiency of parabolic dish/ AMTEC system could reach up to 20.6% with a power output of 18.54 kW corresponding to an operating temperature of 1280 K . This study indicates that the parabolic dish/AMTEC solar power system exhibits a great potential and competitiveness over other solar dish/engine systems (Shuang-Ying Wu et al. 2009). Three experimental models with various geometrical sizes and diameter of about 0.5m of solar dish concentratorswas designed. These models are used to analyze the performance of parabolic concentrating collector's parameters such as reflector materials, aperture diameter, depth of concentrator, size of focal point and temperature at the focal point with different solar irradiations to increase the thermal efficiency Y. (Rafeeu et al. 2012). A recirculation type ICDC (Integrated Collector Drying Chamber) solar dryer for the purpose drying granular materials was designed. This type of continuous solar drying system has several advantages over the conventional solar drying system. First it used pneumatic conveying system where granular materials are transported in turbulent manner while performing the drying process. In this way the drying process will be conducted under high mass and heat transfer rates which make the process could be accomplished in a faster manner. 104 kg load of rough rice the solar dryer was capable to reduce the initial moisture content from 28.4%wb to final moisture content of 14.3%wb within 5 hrs. (Yefri Chan et al. 2014).A parabolic solar collector made of mild steel and its surface coated with an aluminum foil of thickness 10 micron was designed. Model tested for instant water heating and steam generation application. The system has an average temperature gradient of 35°C throughout the day with maximum temperature gradient of 43°C .The system has an average efficiency of 59.8% with mass flow rate of 0.011Kg/s. It has been seen that there is an average 20% heat loss per meter length of receiver. Average heat gained by water is 850W against average heat loss of 176W per meter (Atul A. Sagade et al. 2016)

Many researchers have used different design setups for the production of hot water, steam and cooking food with the help of Parabolic Collector. But no research has reported on production of heat energy based

II EXPERIMENTAL SETUP

The experiment is performed to investigate the performance of baked clay brick using parabolic dish. The

experimental setup consists of Parabolic Dish, receiver, as shown in figure1.

The experimental setup consists of the following two parts:

i. Parabolic dish collector

ii. Wire mesh receiver

2.1 Parabolic Dish Collector

The parabolic dish collector as shown in figure 2 refers to a point-focusing device. In this system 40 segments of the anodized aluminum are joined to form the concentrator. A flat surface works as the absorber, which absorbs the solar energy, concentrated on a point. The tracking is done manually and for that atracking screw is provided in such a way that shadow of that tracking screw is not visible during baking process. After setting this position, the parabolic dish collector is locked in that position by the holding screw. The specifications of the parabolic dish collector are shown in table 1.

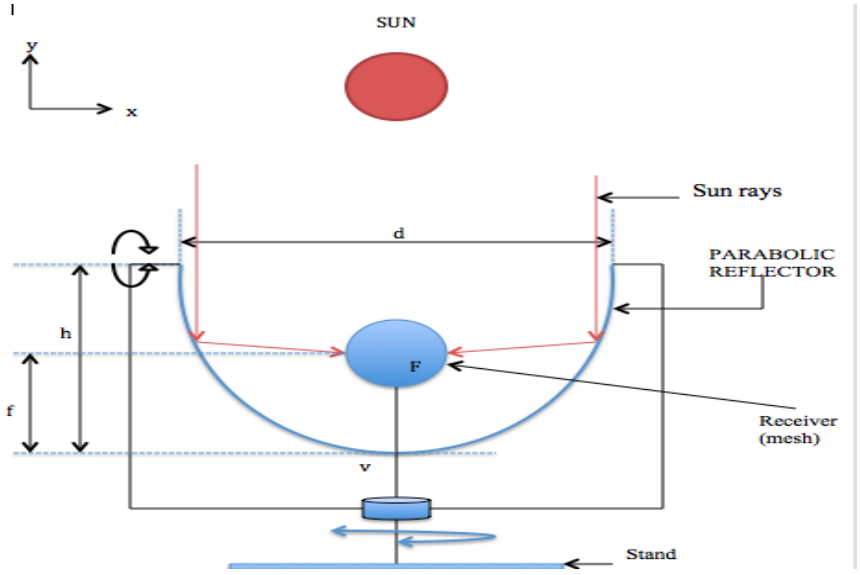

Figure 2Schematic diagram of Parabolic Dish Collector

Table 1 Specification of Parabolic Dish Collector

Diameter of outer ring	**1.4 m**
Focal length of dish	**0.24m**
Aperture area of dish	**1.54m^2**

2.2 Wire Mesh Receiver

A wire mesh receiver as shown in figure 3 is used to place brick at the focus of parabolic dish collector. The wire mesh receiver is made up of mild steel rods and wire mesh.

Figure 3 Photograph of Wire Mesh Container

III MEASURING DEVICES AND INSTRUMENTS

Surface temperature of brick was measured with an J type thermocouple connected with a digital temperature indicator that shows the temperature with a resolution of 0.1°C.

The solar radiation intensity was measured during the Baking process using a Pyranometer model CM11 (Kipp and Zonen, Holland).

Moisture content in brick during baking process was measured by using a digital weighing machine of 5 kg maximum capacity, 2 g minimum capacity, and with a resolution of 0.002 kg, model BOSS-30K2 (Boss appliances). The experiments for the baking process were performed during the daytime in the month of February 2017. The data for baking were recorded at an interval of every 30 minutes and 60 minutes, respectively.

Brick strength was measured by compression test machine

IV SYSTEM OPERATION

The main objective this experimental setup is to bake the brick. In this experimental setup, Parabolic Reflector is connected with receiver (focus of Parabolic Reflector). During sunshine hours solar radiations which are falling on the Parabolic 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 which is placed on it. As the concentrated heat falls

continuously on the brick, 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.

V ANALYSIS OF EXPERIMENTAL DATA

Drying rate of the brick, tile and clay mould object is given by:

$D_r = (W_1-W_2)/dt$

It is assumed that initially the sample to be analyzed is at ambient temperature.

5.1 Experimental Results and Discussion

In this experimental investigation, the main concern was on the baking of bricks by the parabolic dish collector and the drying rate. The experimental data were collected in clear sky days in February 2017.

5.1.1 Variation of Brick Waight With Time

Data of brick temperature, ambient temperature, wind speed, brick weight, drying rate, and solar intensity with time; 16/2/2017

Figure 4 shows that with increase in time interval, the weight of the brick decreases. It shows that initially the brick weight is 3088.1 g at 9:30 hr and it decreases at faster rate till 13:30 hr than after 13:30 hr. At 13:30 hr brick weight is 2922.3 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 that is 2898.0g.

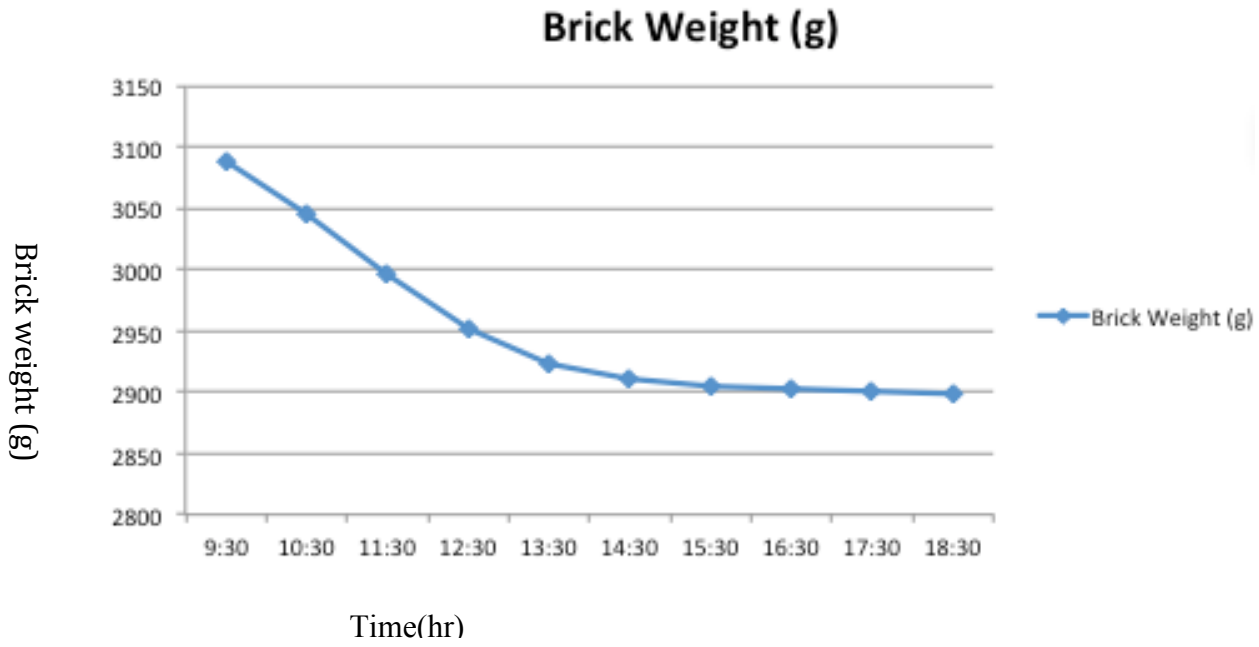

Figure 4 Variation of brick weight with time

5.1.2 Variation of Brick Drying Rate with Time

Variation of brick drying rate with time is shown in figure5

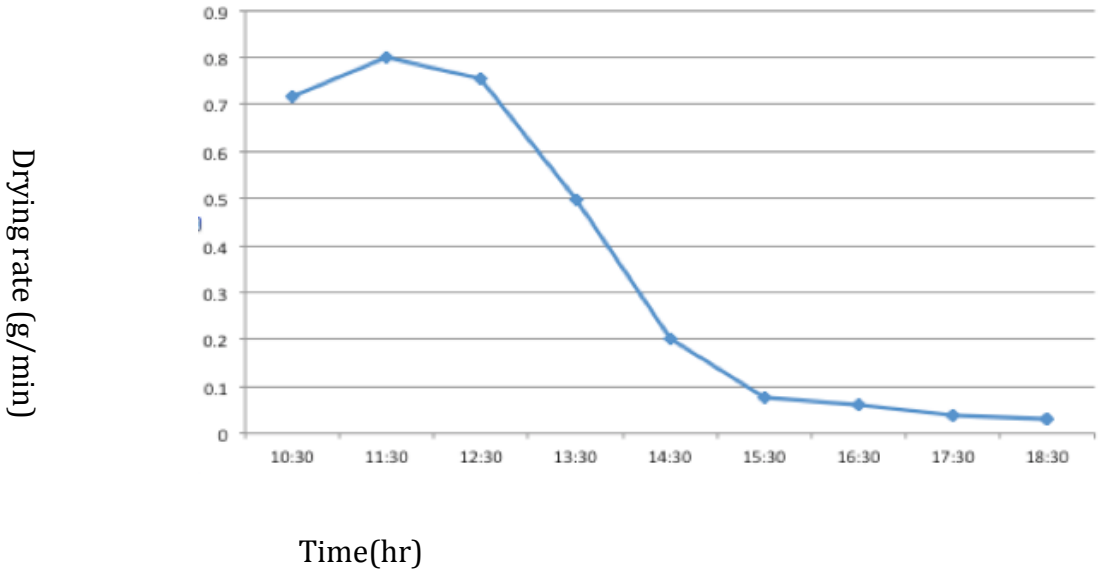

Figure 5 shows that first there is increase in drying rate for approximately one and half hour and then drying rate decreases with time. Drying rate of the brick is calculated with an interval of one hour from morning to evening. The drying rate after one hour (at 10:30 hr) of experiment is 0.715 g/min and maximum at 11:30 hr (0.798 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 0.03 g/min at 18:30 hr.

5.1.3 Parabolic Dish Based (Brick and Tile) And Conventional Approach Based (Red Brick And Tile).

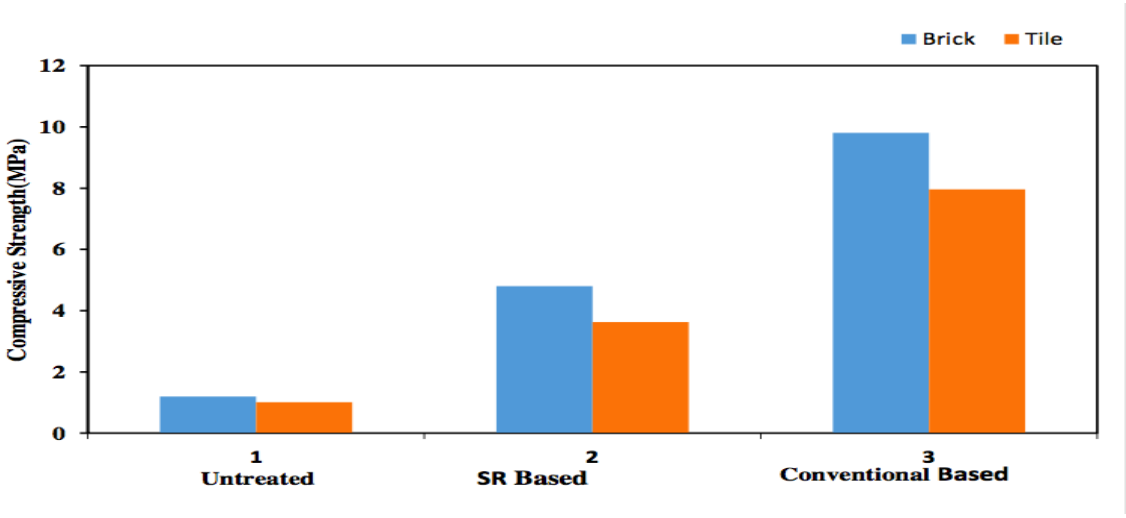

Figure 6 Relation between three different categories of brick and tile

Figure 6 shows the experimental analysis in terms of compressive strength of both tile and brick i.e. it shows the comparison of compressive strength of three different categories of both brick and tile. It is clear from the figure that brick and tile baked with conventional approach have maximum value of compressive strength (9.81 MPa and 7.96 MPa) and green brick and tile without any treatment have minimum value. Untreated green brick and tile have compressive strength of 1.2 MPa and 1.01 MPa respectively. Further compressive strength of Parabolic Reflector based brick and tile is 4.80 MPa and 3.63 MPa respectively.

VI CONCLUSIONS

The main objective of the present research work was to explore the feasibility of baking brick based on Parabolic Reflector in north region of India, as an alternative approach to the conventional method of baking brick. On clear sunny day the maximum temperatures of brick, tile and clay objects achieved with average solar radiations of 970 W/m^2 were 345.2°C. The weight of the brick decreased from 9:30 h to 18:30 h was 190.7g. The compressive strength of brick increases from 1.2 MPa to 4.80 MPa. It concluded from the experimental investigation that, for this area of Parabolic Reflector increase in compressive strength of brick and tile is significant.

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