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Comparative Thermal Performance Analysis of Circular and Triangular Embossed Trapezium Solar Cooker with and without Heat Storage Medium

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Abstract: ***Energy consumption, waste generation and greenhouse gas emissions will continue to grow as long as population and economic growth persists. These are serious challenges to the global community. The solar energy which is available in abundant amount can be used for cooking purpose with the help of solar cooker which reduces emission of greenhouse gases upto great extend. In the existing work, trapezium shaped solar cooker is fabricated with circular and triangular embossed inner surface with intention that to capture maximum incident solar energy and get converted into thermal energy can be utilized for cooking purpose by formation of radiation network and at the same time circular and triangular embossed behave like energy storage pockets. The main objective of present is to comparative thermal performance analysis of circular and triangular embossed trapezium solar cooker with and without using sand as heat storage medium.***

Keywords: Trapezium Solar Cooker, Circular and triangular embossed, Heat storage, Green house

1. Introduction

Solar energy is the energy from the sun. The sun generates energy in a process called nuclear fusion. During this process four hydrogen nuclei combine to become helium atom with the release of energy. This energy is emitted to the space as solar radiation. A small fraction of this energy reaches the earth. Today solar energy is used in various applications such solar heating, distillation, drying, cooking etc. To cook food for nourishment is fundamental to any society and these require the use of energy in some form. The use of solar energy to cook food presents a viable alternative to the use of fuel wood, kerosene, and other fuels traditionally used in developing countries for the purpose of preparing food. An affordable wooden box - style solar cooker was created by Harish Ronge et al. [1] focused on research work carried out by other researchers in the area of solar cooker also discussed about design of various cookers. N. Gayathri et al [2] focused on the design and fabrication of parabolic solar cookerand by varying the focal length and its effect on thermal performance. Yogesh R. Suple et al [3] developed a parabolic disc typed solar cooker and investigated thermal performance of this setup with a box type solar cooker. Clement A. Komolafe et al [4] fabricated solar cooker tracker system and introducing heat storage material and evaluate the thermal performance of the solar cooker.

Mahendra Singh Seveda et al [5] experimented on solar cooker at Sikkim from 6: 00 a. m. to 6 p. m. and obtained around 98 ^{0}C without load with cooker efficiency of 37 %. Sonali Kesarwaniet al [6] obtained results of box type solar cooker and carried out exergy analysis of same considering wind velocity and solar intensity. Arunachala U. C et al [7] concentrated on concentrated parabolic collector type of solar cookers which can also be used for night cooking purpose using oil to cook rise in which oil temperature reaches to 110 ^{0}C and drops by 35 ^{0}C only which is sufficient to cook 500 gm rise. The aim behind the design of circular and triangular embossed trapezium solar cooker compared to box type solar cooker is to enhance the rate of heat transfer which increases the possibility of faster cooking rate by maximum utilization of solar energy also one objective is to introduce sand as thermal reservoir. Thermal Energy Collector based applications similar to Solar Cooker are like solar water heater [8 - 13], Solar air heater [14 - 16] heat exchanger [17 - 19], biofuel related works [20 - 22] and many more. Solar cooker design optimization is performed in [23 - 33]. Solar Cooking current ongoing design review carried out in various demographic locations and various climate conditions [34 - 45]. Design, development and cooking performance for a unprecedented solar cooker design [46 - 58].

2. Experimental Set up

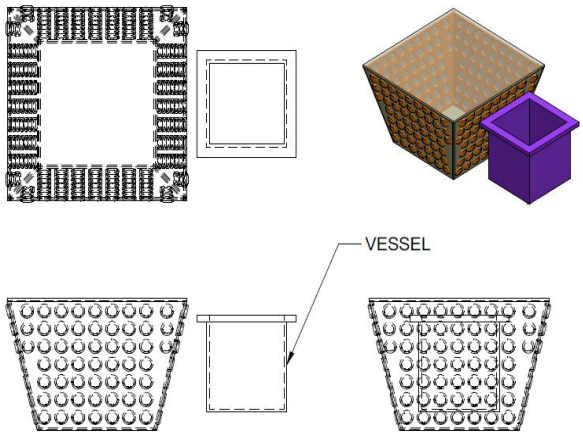

Figure 1: CAD model of Experimental Set up

Plate 1: Circular Die

Plate 2: Inner portion of circular Embossed Cooker

Plate 3: Inner portion of Triangular Embossed Cooker

Plate 4: Solar Cooker

Plate 5: Cooking Pan with the Thermocouple (Circular Emboss)

Plate 6: Comparative Thermal Performance of Solar Cookers

In the present work first of all the wood box of 1.25'X1.25'X 1.25' manufactured from 12 mm wooden sheet is manufactured and inside the wooden box four trapezium aluminum sheet with 1 mm thick and embossed the 2o mm circle with 1.25' upper face and 8" lower face with height 1' is placed at an angle such a way that so food pan/ vessel can be placed and the bottom of box and all sheets are painted with black color to enhance the rate of heat transfer. The transparent plain glass of 1.25'X 1.25" is placed of top of solar cooer as cover which not allows the radiation to reflected back to atmosphere. The temperature of the cooking pan is measured by the K typed thermocouples that are attached. The silicon glue is used to fill the gaps between the embossed sheets. Solar cookers with round embossed shapes are arranged in a north - south manner in the current work. Similarly triangular embossed solar cooker is fabricated and the dimension of triangular portion is such so that area of circular and triangular emboss portion are same.

During Experimentation the observation are taken for three times to check the consistency of results and the results are obtained with and without sand on separate days. For experimentation purpose Maggi is used.

3. Result and Discussion

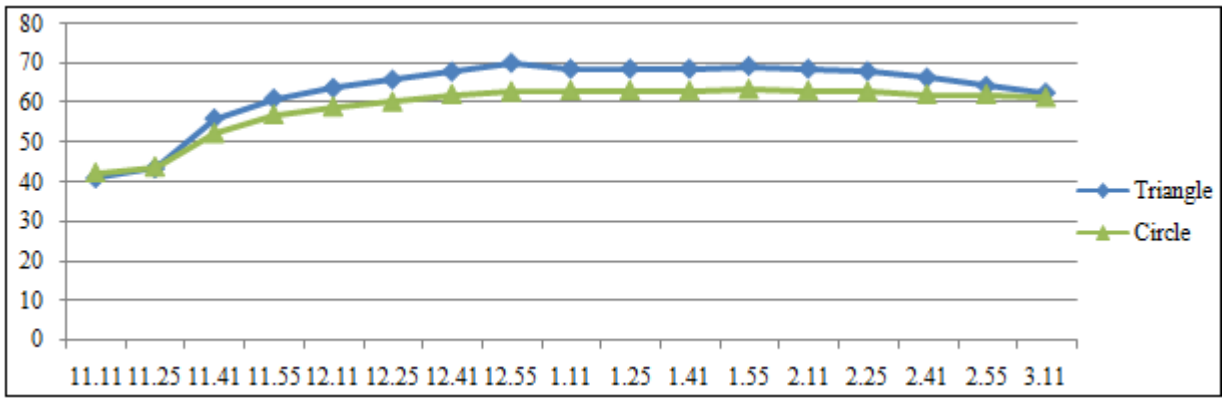

Figure 2: Cooking Pan with sand

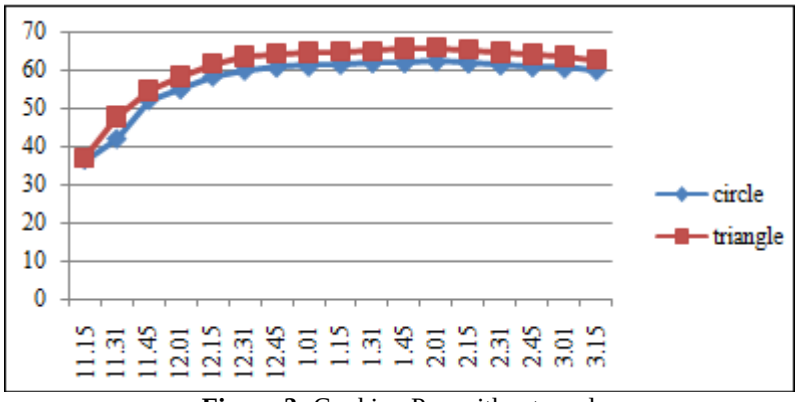

Figure 3: Cooking Pan without sand

In the present work the observation are taken after every interval of 15 minutes of temperature of Maggi water mixture using K type thermocouple. From Fig.2 and Fig.3 it is quite obvious that in case of solar cooker with sand having higher temperature than solar cooker without sand may be because sand behaves like additional heat source. In the present work only 100 g sand is used and it might be possible that by increase the quantity of sand better thermal performance may or may not be obtained because possibility would be sand absorb additional heat and so less heat may transfer to pan but one more passivity will be sand become source and so temperature of pan rise at faster rate too; but the most interesting observation is that in both cases means solar cooker with and without sand consistency in temperature value over entire span. In case of solar cooker the temperature values after 2: 00 p. m also when sun start falling the temperature is almost constant which may be because of less heat drop from the solar cooker and due to continuous reflection of solar radiation and inside the pockets there is storage of solar energy. The space available for pan/vessel is less in case of present solar cooker but constant temperature maintaining capacity can overcome such limitation. The combine effect of sand and embossed surface of solar cooker not only enhances the temperature above 60 ^{0}C inside the solar cooker but at the same time sand which behaves like heat storage medium too which helps to maintain temperature after falling of the sun in west. In comparison of circular embossed surface triangular surface gives better result and highest temperature very close to 70 ^{0}C and which is almost higher throughout time period of experimentation which may be because of triangularshape which creates better radiation network than the circular emboss

4. Conclusion

The major conclusion drawn from the present work is that in case of solar cooker with sand gives better results with consistency in temperature value. In case of trapezium solar cooker constantan temperature can be obtained for longer period in spite of change in solar position which helps to cook good quality food without environmental impact. Additionally triangular embossed surfaces provide better heat transfer inside the solar cooker than circular embossed solar cooker with almost 10 ^{0}C temperature rise.

5. Future Scope

The present work can be extended by changing the circular and triangular with square emboss surface shape and comparing the thermal performance results of the same. The additional work can be done by black color sand can be used instead of simple sand and also thermal performance can be evaluated. The work can also be extended by changing food placed inside the pan.

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