Comparative Thermal Performance Analysis of Box Type and Hexagonal Solar Cooker

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***Abstract*- Energy is an important source for all sectors of any country's economy. It is a major input for socioeconomic development and poverty eradication. The standard of living of any country in the world is mostly dependent on per capita energy consumption. Due to rapid deterioration in the supply of fossil fuels, the solar energy can be the most appropriate option compared to other alternative energy resources due to availability in ample amount. In rural areas of developing countries almost 75% of the energy is used for cooking purpose. The solar cookers have a relevant place in the present fuel consumption pattern; but the position of the sun varies continuously throughout the daytime which affects the absorption rate. An advance design is to be proposed for the maximum utilization of solar radiation concentrated over solar cooker. In the proposed research work box type conventional solar cooker is compared with proposed hexagonal solar cooker with same surface area in both cases.**

***Index Terms*- Box type Solar Cooker, Hexagonal Solar Cooker, Sun, K-type thermocouple.**

I. INTRODUCTION

Out of all the alternative energy sources, solar energy is the easiest and simplest form of energy. It is widely available for free without much investment to extract it into a usable form. Solar energy is responsible for all light and most of the heat that we experience on Earth. The sun's heat can be harnessed by absorbing and conduction in solar collectors. It can be concentrated for mirror cooking and applied in rooms that need heating. The energy rays from the sun can even be converted into electricity using photovoltaic cells. Solar cookers focus sunlight into a collecting device such as a pan. The interaction between light energy and the receiving material converts light into heat. This conversion is maximized by using materials that conduct and retain heat. Most solar cookers convert sunlight into heat energy that is used for cooking. The solar cooker's ability to collect sunlight is directly related to the irradiation area of the solar collector perpendicular to the incident solar radiation.

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] studied the design and fabrication of parabolic solar cooker and 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 compared thermal performance of this setup with a box type solar cooker. Clement A. Komolafe et al [4] built a solar cooker monitoring system and introduced heat storage materials and evaluated the thermal efficiency of solar cookers. Mahendra Singh Seveda et al. [5] experienced a solar cooker in Sikkim from 6 am to 6 pm. and obtains about 98 0C at no load with a stove efficiency of 37%. Sonali Kesarwaniet al [6] obtained the results of the box solar cooker and conducted its allergenic analysis taking into account wind speed 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 0C and drops by 35 0C only which is sufficient to cook 500 gm rise. N. M. Nahar [8] Experimental testing, the performance of novel/improved box solar cooker and compared it with solar oven and hot box solar cooker. S. C. Mullick et. al.[9] experimentally presents some of the guidelines provided for the thermal evaluation of box solar cookers. Michael Grupp and. al.[10] focusing on an advanced version of the box solar cooker, Abdulla H. Algifri et. al.[11] was obtained experimentally the effect of the effective direction of the reflector of a box-type solar cooker.

O. V. Ekechu Kwu et. al. [12] discussed about the design philosophy, construction and measured performances of a plane-reflector augmented box-type solar cooker. Subodh Kumar [13] identified design parameters that help predict the thermal efficiency of box solar cookers. United States Mirdha et. Al. [14] presents the different possible designs of sloping kitchens with different positions of accent mirrors in the north-south direction as well as in the analyzed east-west direction, Naveen Kumar et. al.[15] presented a multipurpose solar device based on a truncated pyramid shape that can be used for household cooking as well as water heating. A. Harmim et. al. [16] focused on comparison between a finned absorber plate's box type cooker and a simple box-type cooker. Pranab J. Lahkar et. al. [17] proposed that the hob heat to photo ratio (COR) be proposed as a new general TPP for different types of stoves. Suhail Zaki Farooqui [18] proposed a one-way tracking mechanism for azimuth box-type solar cookers, which does not require any external power source and the tracking power is derived from Gravitational potential energy is stored in springs which are attached to the water tank.Gaur et al [19] proposed a cooking vessel supplied with a concave lid. Their experimental find out about confirmed a discount of 10-13% in cooking time in contrast to an normal cooking vessel beneath the identical conditions. Ammer [20] carried out research on the title, theoretical and experimental evaluation of double publicity photo voltaic cooker, respectively. D.Y Dasin [21] carried out an overall performance contrast of parabolic concentrator photo voltaic electricity cooker in tropical surroundings in Abubakar Tafawa Balewa University Bauchi Nigeria. Dr. Metcalf and Marshall Longuin [22] carried out water pasteurization using a solar box cooker. V.P. Sethi et.al [23] focused on optimally

inclined box type solar cooker with parallelepiped cooking vessel design S.B. Joshi et.al [24] studied on hybrid solar cooker. H. Zamani et.al [25] fabricated of parabolic solar cooker with three adjustable mirrors, which can be placed on the parabolic path according to the sun's position. S. Mahanvar et.al [26] developed box solar cooker with electric power back up. Yunsheng Zhao et.al [27] concentrated on novel portable solar cooker using a curved fresnel loss concentrator. A. Saxena et.al [28] studied hybrid solar cooker with air duct. John J. TODD et al [29] fabricated solar cooker from cardboard and evaluated its testing and performance. Muluken Biadgelegn Wollele [30] desined and fabricated solar cooker and studied the effect of thermal storage system. Schwarzer K, et al. [31] conducted a performance analysis of flat plate type solar cooker with vegetable oil as the TES material. Mussard M. [32] carried out a low cost small- scale solar concentric collector coupled with a thermal energy storage unit for higher temperature cooking. Senthil
R. et al. [33] proposed that the sensible heat transfer materials were found effective in the storage of heat as well as aiding conduction heat transfer during the cooking process. Sharma SD. et al. [34] had investigated a solar cooker based on an evacuated tube solar collector coupled with phase change material (PCM) commercial grade erythritol. Saxena A. et al. [35] studied several types of PCMs to check their suitability as heat storage for cooking purposes using a box type solar cooker. Rajendra C. Patil et al [36] reviewed different types of solar cooker on the basis of their thermal performance. A theoretical investigation on the performance of PCMs has also been conducted by Chen et al. [37]. The various application based on solar energy studies for thermal performance of heat transfer enhancement by variation in the solar collector geometries in [38-48] Patel Anand et al. for solar heater [49, 50] Anand Patel et al for-heat exchanger. [51] Nikul K Patel et al. [52] SK Singh et al. documents study of solar energy in biofuel applications. Solar Cooking current ongoing design review carried out in various demographic locations and various climate conditions [53- 64]. Design, development and cooking performance for a unprecedented solar cooker design [65-77].

II. EXPERIMENTAL SET UP

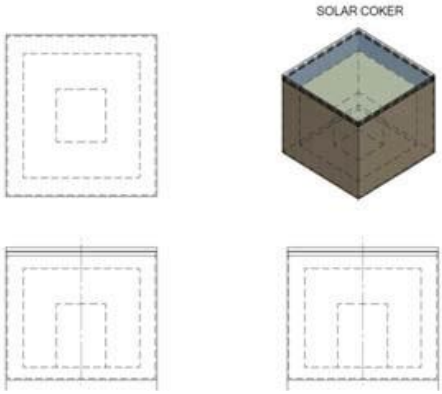

Fig 1 CAD Model of Box Solar Cooker

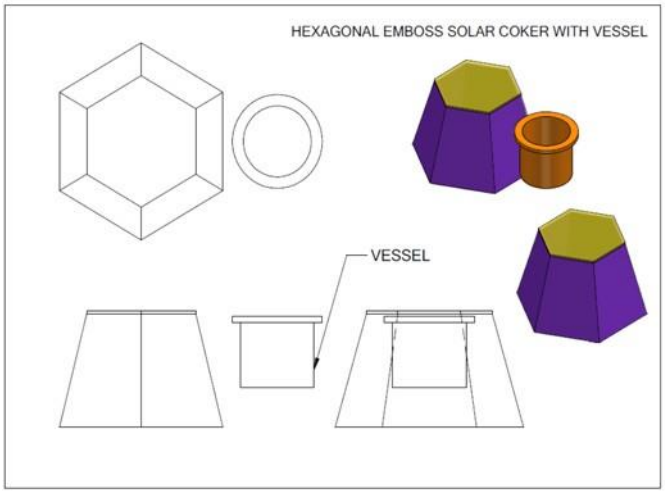

Fig 2 CAD Model of Hexagonal Solar Cooker

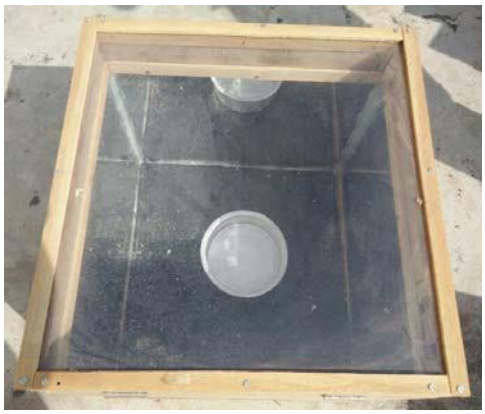

Plate 1 Box Solar Cooker

Plate 2 Hexagonal Solar Cooker

Plate 3 Box and Hexagonal Solar Cooker

Plate 4 Aluminum Vessels with Thermocouple

In this work using 12 mm sheet wooden the box of size 1'X 1"X 1' is fabricated and all four side of box from inside using mirror of 2 mm thick is stick with silicon glue on solar cooker. The top of the box is covered with 2 mm transparent glass sheet is hinged in wooden frame of 1'X 1'. With similar box dimensions the mirrors of 2 mm thick and six numbers in pieces are placed so that the top portion makes 12" diameter and at bottom of box 4."The base circle will formed on size of vessel. Aluminum vessel is painted with black color which is placed inside the cooker and K type thermocouple is placed in both set up two measure temperature inside the vessel.

III. RESULT AND DISCUSSION

In the first phase the experimental set up is placed in north south position with respect to sun's position in east and initially after interval of 15 minute measure the water outlet temperature with K type thermocouple after adjusting flow of water initially.

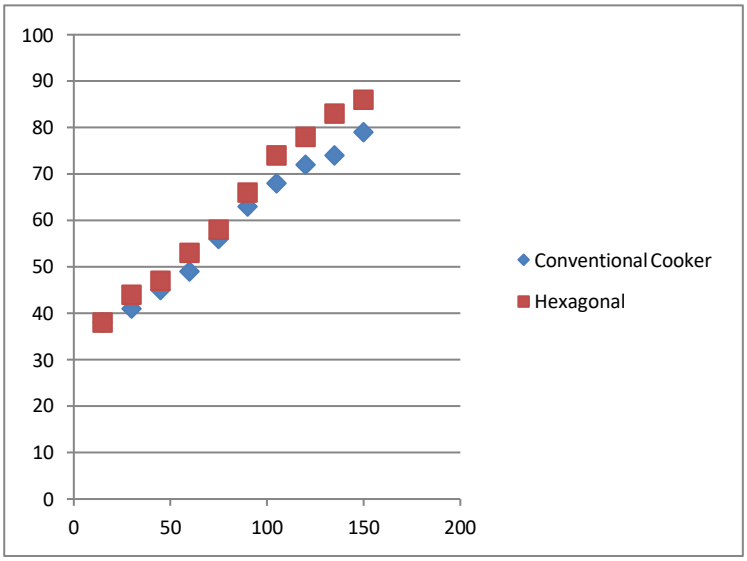

Fig 3 Temperature Variation with respect to time without vessel

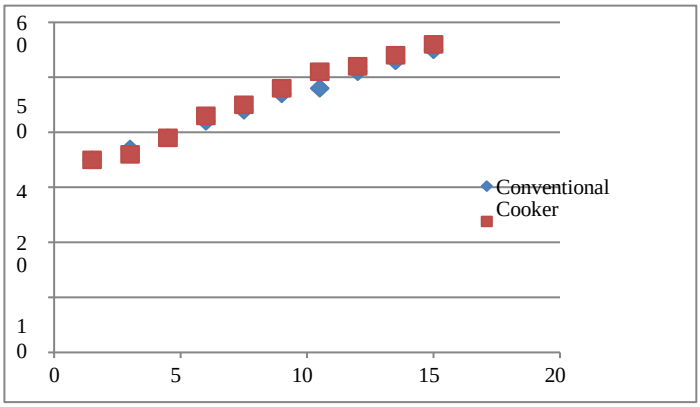

Fig 4 Temperature Variation with respect to time with vessel

Fig 3 and Fig 4 show temperature variation in case of box type and hexagonal type solar cooker in case of with and without vessel. As shown in Fig 3 and Fig 4 putting the vessel in the both solar cooker almost there drop in temperature with vessel by 25-30 ^{0}C may be because of in case of solar cooker with vessel some heat is utilized to increase the temperature of vessel or matter which is place inside the vessel In case of hexagonal solar cooker the rise in the temperature is high may be because of the geometric structure radiation energy incident upon solar cooker get reflected by several time and finally heat incident upon the vessel on empty space at the bottom of solar cooker.

IV. CONCLUSION

The major outcome of present work is that though the thermal performance of hexagonal solar cooker is better but the fabrication is somehow complicated.

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