

A review paper on Investigation of Box Type Solar Cooker Combined With Water Heater.

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Abstract- A practical and widely used heating gadget known as a solar cooker is out there. To increase the effectiveness of traditional sun cookers, these paper box type solar cookers incorporate copper tubes connected to water tanks. We evaluate the performance of a solar cooker with a copper tube and a water heater to the performance of a box-style solar cooker, and the difference is found to be significant. For cooking purposes, solar cookers offer renewable sources. Their biggest flaw is that they can't be used when there isn't enough sunlight.[6]The use of thermal energy storage (TEs) can significantly get around these restrictions. Solar energy is now used for a variety of purposes as a result of the reduction of fossil fuels and the rise in fuel prices. Flat reflectors are typically used in box-style solar cookers. The temperature within the solar cooker has been raised, and efforts have been made to improve the effectiveness of the water heater-heated box cooker. [11]However, the method of heat transfer into the storage medium affects the shape of the storage units. The power of the cookers was significantly influenced by the thermal diffusivity of the storage media and the design parameters of the cookers.

Key Words: Box Solar Cooker, Solar Energy

1. INTRODUCTION

One of the many options for domestic and institutional cooking is solar cooking. Environmental pollution is decreased and conventional fuel (firewood and fossil fuels) are saved, both of which have ecological advantages. In order to permit cooking indoors and away from the sun, several of these efforts included adding thermal energy storage (TES) to solar cookers. The purpose of this study was to determine how TES configurations and heat storage materials affected cooking performance. We are currently in a period when the global energy crisis is more widely recognized. Cooking is a routine activity all across the world. In order to make food safe, it is crucial to heat it to a high temperature that is sufficient to destroy microorganisms that can cause diseases. [5]According to the World Health Organization, diseases associated with indoor cooking cause around 4 million deaths annually. When placed in the sun, a cooker's interior temperature can rise from 100 degrees Celsius to 140 degrees Celsius in 2 to 3 hours. Therefore, only foods that require light

heating can be prepared with a solar cooker. Because the user has to go outside the kitchen to operate the typical solar cooker, it is not very user-friendly. Many professionals have modified the design of the solar cooker by employing a separate reflector in the outdoor field with focusing in the kitchen in order to overcome this drawback. Numerous professionals have additionally improved the inbox-type design for ease of use and more efficiency. Available solar cookers typically fall into two categories: box type and parabolic reflector focusing type.[9]

1.1 Box type Solar Cookers Features:

A Box the Solar Cooker is essentially a glass-covered, insulated box with a top lid and a mirror on the inside that allows sunlight to enter the box when the lid is left open. The box's interior is painted in a dark color. The box containing the food to be prepared is lined with up to four pots that have been painted black. Rice, lentils, and vegetables are among the things the cooker can prepare in between one and two hours. Simple cakes, roasted cashew nuts, dry grapes, and other foods have all been prepared with the cooker. With the exception of the monsoon and overcast days, most of the year, it is a perfect appliance for household cooking. However, it cannot be used to make chapattis or for frying..

1.2 Advantages:

- There are no ongoing fuel costs when using solar cooking. Solar power is completely cost-free.
- In a few years, the cost of the solar cooker can be readily recouped through fuel bill savings.
- If used frequently, a box solar cooker can save three to four LPG cylinders per year.
- Time is saved. While food cooks in the solar cooker, you are free to engage in other activities.
- There is no concern about burning the meal.
- Due to its slow cooking design, it ensures healthier and more nutrient-dense prepared food.
- It is easy to use and long-lasting.

- It conserves conventional energy and does not contaminate the environment.

2. LITERATURE REVIEW

The first solar cookers were created in the 19th century, when people recognize they needed an alternative energy source. And although it wasn't as effective as it is now, one of them, solar, could cook food. The invention of solar cookers was sparked by this requirement. Utilizing a solar cooker has the bizarre benefit of emitting no hazardous emissions and being quite environmentally beneficial. The fact that solar energy is a free and endless energy source is another benefit [1]. Solar cookers are easy to use, affordable, trouble-free, and efficient. De Saussure utilized a hot box-style oven and solar cookers as early as 1776. The effectiveness of the box type solar panel can be improved in a number of ways. Investigations were conducted on a solar cooker based on a parabolic dish collector with a phase change thermal storage unit. On the absorber plate of the parabolic dish collector in this experimental setup, a solar cooker with a phase-change thermal storage unit was placed. Acetanilide, a phase transition compound, stores solar energy during the day, and a solar cooker is stored inside an insulator box at night. The food is then heated by the phase change substance. In a study, a standard solar cooker was put up against a black-painted solar cooker and a solar cooker with a black-painted exterior and glazing; the temperatures obtained were, respectively, 119°C, 175.4°C, and 186.3°C [2]. Solar cookers are more, as was found through experimental testing and improved performance. When the horizontal surface of absorption was slanted, solar radiation uptake improved (by 33 percent). Here, two movable mirror boosters were employed to increase the absorption of solar light. This led to an increase in solar efficiency overall of 24.6%, which is on par with solar oven performance. However, it had a negligible impact on the price of this upgraded solar cooker, increasing it by about 10%. [3]. In the 1980s, scientists largely worked on the maximum optimization of the geometry of the solar cookers in order to simplify the geometry and hence reduce the overall cost. This helped to overcome defects in the sun cooker, notably in the box type solar cookers. It was stated that the amount of energy received for various angles of incidence significantly increased with the use of a single adjustable booster mirror to solar box. In addition, it was stated that the quantity of energy absorbed increased with increasing latitude position. Cooking in the evenings is made easier by the phase-changing material storage unit. Transparent insulation materials capture heat inside the solar box without creating a barrier that would block solar rays [4]. Solar parabolic cooker are alternative to box cookers, with better performance, the favorable conditions of cooking are from 1:30pm to 3:30 pm IST. Test procedures Box cookers can be replaced with solar parabolic cookers, which work better. The best time to

cook is between 1:30 and 3:30 IST. Heating and cooling test protocols were employed. They were carried out to assess the parabolic solar cooker's defining performance metrics. The only issue is that the parabola takes up a lot of room and is difficult to produce, which drives up the cost [5]. Research is being done on several solar cooking systems that can prepare food for a family of 4 to 5 people. This requirement was met by a model that was constructed. When the surrounding temperature was 30 degree C, the plate's greatest temperature that it could reach from sun radiation was 225 oC over a brief period of roughly 40 minutes [6]. An intriguing argument was made on the use of solar energy in the kitchen. The solar thermal energy source was used to supplement the LPG (liquefied petroleum gas). The main issue was the low temperature to which the water gets heated, so attempts are being made to increase the absorption capacity. Here, solar energy is used to heat water, which is then transmitted via a heat exchanger and used to prepare food.

3. METHODOLOGY OF SOLARCOOKERBOX

• Principle

Over 65 major designs and hundreds of variations exist for different types of solar cookers. The fundamental ideas guiding all solar cookers are:

• Concentrating sunlight:

To concentrate sunlight and heat into a tiny cooking area, commonly using a mirror or other reflecting material increases the energy's concentration and effectiveness. Converting light to heat any black on a solar cooker's inside, as well as specific materials used to make pots, will increase the efficiency of converting light into heat. The efficiency of the cooker will be greatly increased by the use of a black pan, which will absorb practically all of the sun's light and convert it into heat. Additionally, an oven will operate more quickly the better a pan transfer's heat.

• Trapping heat:

A significant difference is made by separating the air within and outside of the cooker. A plastic bag or a glass cover will let light through while used as a transparent solid, but after the light is absorbed and converted to heat, they will trap the heat inside. This enables the achievement of comparable temperatures on chilly and windy days in comparison to hot days.

3.1 Solar Cooker Specification

1. Size UV resistant model Aluminum body 480 x 480 x 170 MM (19.2x19.2x7Inch.)
2. Cooking Capacity: 4-6 Kg per day

3. Total weight: Approx.14Kg including cooking pots

4. Cooking pots:

Stainless steel, hard black coated cooking pots.

Size= All Boxes are 1Litres

5. Energy source: Solar

- Power consumption: Approximately 0.1 to 0.4 kWh Depending on food quantity and ambient length of time. A cooking pot that is placed on the cooker's focus point and a stand to support the cooking mechanism are the only components of a solar parabolic cooker.

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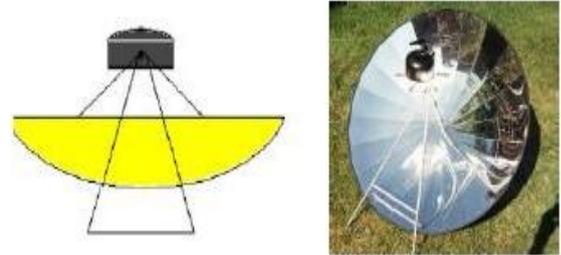


Fig-2: Solar Parabolic Cooker.

3.2 classification of solar cookers

A solar cooker is a device that pasteurizes cooks, or heats food or liquids using the energy of direct sunshine. The three main categories of solar cookers are as follows:

- Solar-powered cookers:
- Solar parabolic cookers
- Box solar cookers

i] Solar powered cookers

Due to their simplicity of construction and inexpensive materials, they might be regarded as the most basic variety available. Sunlight from above is concentrated in solar panel cookers. Flat panels are used in panel cookers to reflect and concentrate sunlight for heating and cooking. Due to its low cooking power, this solar cooking technique is not very appealing.

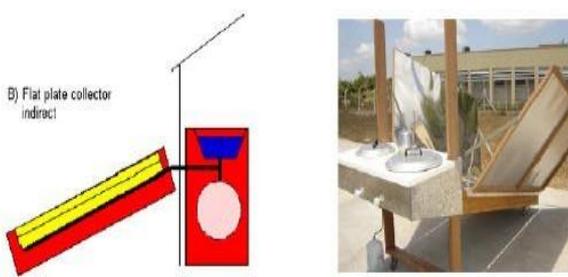


Fig-1: Solar Panel Cooker.

ii] Solar parabolic cookers

In contrast to panel cookers or box cookers, solar parabolic cookers can attain exceptionally high temperatures in a relatively short period of time and do not require a particular cooking vessel. However, due to the focused power used in a parabolic cooker, there is a chance that the food will burn if it is neglected for any length of time. A

iii] Box type solar cookers

The most popular and affordable variety of solar cookers is the box type. These inexpensive box cookers have a very basic design that primarily consists of a black-painted metallic trapezoidal tray (cooking tray) that is typically covered by a double glass window. It is protected by a metal or fiber-glass exterior casing, and insulation like glass wool is placed between the cooking tray and outside casing. The cooking tray and the blackened cooking pots are hit by the solar radiation when it strikes the double glass lid. While the glass covers transmit short-wavelength radiation, which makes up the majority of the sun spectrum, they are practically opaque to low-temperature radiation that is emitted inside the box. As a result, the box's temperature increases until a balance between the heat lost through exposed surfaces and the heat gained through glazing is reached (greenhouse effect). Additionally, to increase the amount of solar radiation hitting the aperture, a plane reflecting mirror (booster mirror) of almost the same size as the aperture area is utilized. The bottom and sides of the cooking tray are insulated. Cooking is facilitated by the heat being absorbed by the blackened surface and being transferred to the food inside the pots. The many solar cooker types are displayed in Figure 3.

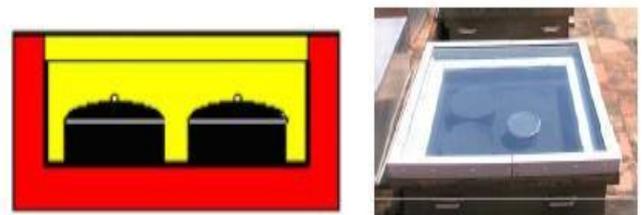


Fig-3: Box type Solar Cooker.

4. CONCLUSION

Thermal diffusivity of the storage medium and TESu Design parameter, namely cooker category, configuration of the cooking vessel in relation to the storage unit, and heat

transfer enhancement in the storage medium, have a significant impact on thermal storage unit design, heat storage material, and cooking performance of solar cookers with heat storage units. The efficiency of the cooker is significantly impacted by the ambient temperature. The efficiency of the cooker increases with increased air temperature. The cooker's efficiency is also influenced by the orientation angle of the insulating material and the reflector's degree of reflectivity. According to the experimental findings of the thermal performance test, a box-style solar cooker with a non-tracking solar concentrator could offer better heat collection and more effective cooking. Therefore, using solar energy and spreading awareness of it are essential, and solar cookers may make this feasible.

REFERENCES

- [1] Adil Ahmed.S., Dr. N.S.Prasanna Rao, Dr. P.L.Srinivas Murthy, Bheemarayappa.P.Terani, Detail Study of Parabolic Solar cooker SK-14, International Research Journal of Engineering and Technology (IRJET), Volume: 02 Issue: 04, page no. 24-27 July-2015.
- [2] Avinash Chaudhary, Amit Kumar, Avadhesh Yadav, Experimental investigation of a solar cooker based on parabolic dish collector with phase change thermal storage unit in Indian climatic conditions, Journal of renewable and sustainable energy, 5, 023107 (2013); doi: 10.1063/1.4794962.
- [3] Nahar N M, Performance and testing of an improved hot box solar cooker, Energy Conversion and Management, Volume 30, Issue 1, Page no. 9- 16, 1990.
- [4] Smita B. Joshi and A. R. Jani, Certain Analysis of Photovoltaic - Thermal Hybrid solar cooker with ionic liquids, ICIE-2013, SVNIT, Surat, 11/2013.
- [5] M. Ouannene, B. Chaouachi, S.Gabsi, Design and realization of a parabolic solar cooker, Int. Symp. On convective Heat and Mass Transfer in Sustainable Energy April 26- May 1, 2009, Tunisia.
- [6] Sonune AV, Philip SK. Development of a domestic concentrating cooker. Renew Energy 2003; 28:1225-34.
- [7] J.N.Shrestha and M.R.Byanjankar, "Thermal Performance Evaluation of Box Type Solar Cooker using Stone Pebbles for Thermal Energy Storage", International Journal of Renewable Energy, vol. 2, no.2, pp. 11-21, 2007.
- [8] S.A.Klein, et al., "TRNSYS16: A Transient System Simulation Program", University of Wisconsin Solar Energy Laboratory, Madison USA, 2006.
- [9] ASAES580JAN03 Testing and Reporting Solar Cooker Performance.
- [10] BIS 13429-3 (2000): Solar Cooker - Box Type, Part 3: Test Method.
- [11] <http://mypages.iit.edu/~maslanka/SolarGeo.pdf>.
- [12] <http://www.kaapeli.fi/~tep/man/manual.html>.
- [13] <http://www.google.co.in/imgres?sa=X&biw=1600&bih=687&tbn=isch&tbnid=ETzM>.
- [14] <http://www.powerfromthesun.net/Book/chapter02/chapter02.html>.
- [15] Ismail Isa Rikoto et al. (2013), "Comparative Analysis on Solar Cooking Using Box Type Solar Cooker with Finned Cooking Pot" International Journal of Modern Engineering Research (IJMER), Vol.3, Issue.3, May-June. 2013 pp-1290-1294.
- [16] Suhail Zaki Farooqui et al. (2013), "A gravity based tracking system for box type solar cookers", Solar Energy vol.92 (2013) 62-68.
- [17] S. Mahavar et al. (2012), "Design development and performance studies of a novel Single Family Solar Cooker", Renewable Energy vol.47 (2012) 67-76.
- [18] Abhishek Saxena et al. (2011), "A thermodynamic review on solar box type cookers", Renewable and Sustainable Energy Reviews vol.15 (2011) 3301-3318.
- [19] Prof. Viral K Pandya et al. (2011), "Assessment of Thermal Performance of Box Type Solar Cookers under Gujarat Climate Condition in Mid Summer", Vol.1, Issue 4, pp.1313-1316.
- [20] A.Saxena, Proceedings of International Conference on National Solar Mission on 4-6 March, 2010 PV+Solar India Expo-2010, World Trade Centre, Mumbai, India.
- [21] Nivayanadarajah, UC Berkeley, CE290 Spring 2009.
- [22] Kumar Naveen, Agravat Sagar, Chavda Tilak, and Mistry H. N. et al. (2008), "Design and development of efficient multipurpose domestic solar cooker/dryer". Renewable Energy, 2008, Vol.33, 2207-2211.
- [23] Arezki Harmimetal. (2008), "Experimental study of a double exposure solar cooker with finned cooking vessel", Solar Energy Vol.82 (2008) 287-289.
- [24] Klemens Schwarzer et al. (2008), "Characterisation and design methods of solar cookers" Solar Energy Vol.82 (2008) 157-163.