

Recent Developments in Solar Cookers: A Review

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ABSTRACT: Food delivers energy to Human beings; hence it is necessary that energy required for cooking the food is obtained from Alternate source of energy, instead of using the conventional energy sources such as wood, Cow-dung, Kerosene, Liquid Petroleum Gas (LPG) and Electricity as well. Solar energy is utilised in solar cooker which makes it ecofriendly and clean. There are various types of solar cookers available in the market, depending on the demand of customer, but still the utilization is not sufficient. Some of the factors are bulky size, heavy weight, working place and required cooking time and the most important is the awareness about using solar cooker. Hence to make solar cooker easy to use and smaller in size with minimum cost is major challenge. Use of photovoltaic and thermal hybrid solar cooker has boosted the cooking process with solar cookers. There is certainly scope for research in solar cookers. In this paper various types of solar cookers and latest trends in it are discussed in detail.

KEYWORDS: Solar Cookers, Phase change material (PCM), Hybrid solar cooker, Vacuum tube solar cooker.

I. INTRODUCTION

Solar cooker is a device which uses the energy of direct sunlight to heat and cook the food; however it can also be used for pasteurization of milk and water. According to Indian government survey as shown in the Figure 1, over 45% of rural households in the country were estimated to depend on firewood and chips for cooking. Over 5.5% used dung cake and 48% used LPG. This scenario changes substantially in urban areas where 86% people use LPG and only 5.6% masses use firewood and crop residue.

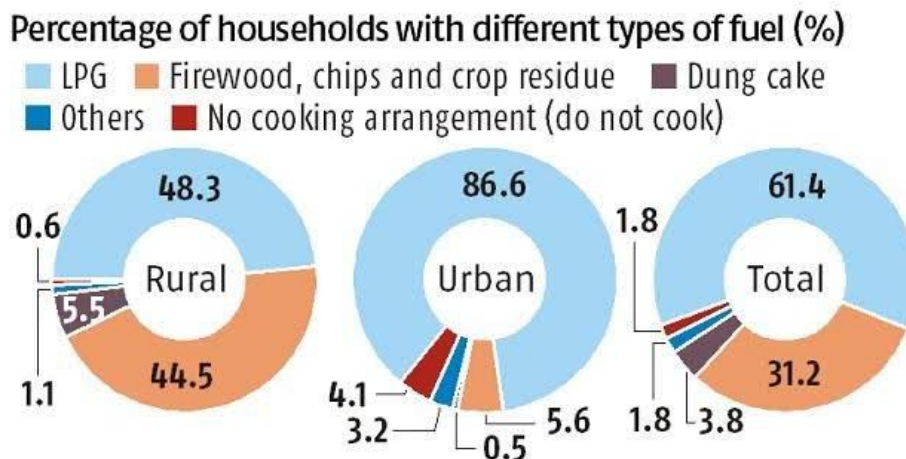


Figure-1 Percentage of household with different types of fuel in percentage.

Solar cooker was designed as far back in the 19th century, when humans realized the need for alternate source of energy. And solar was one of them, which could cook food, although it was not as efficient as of today. This need set a base for development of solar cookers. One of the surreal advantages of using solar cooker is that it emits no harmful gases, it is very environmental friendly. The other advantage being solar energy is freely available and inexhaustible energy source [1]. This work deals with the recent advancements in solar cookers as well as comparison of the popular

types of cookers available in the market is provided. Solar cookers today fall within three main categories called solar panel cookers, solar box cookers and solar parabolic cookers.

The problem with the energy in the 21st century is not with the generation but with the method to store it off the grid. The Renewable sources generate electric energy but that needs to be stored somewhere. The Energy requirement in the morning is less as compared to evening. While the requirement for electricity in the afternoon significantly decreases. The solar intensity is highest in the afternoon between 11:30 am to 3:00 pm [2]; hence it is not convenient to use solar Panels to generate electricity. On the other hand solar energy can be used for cooking in the afternoon.

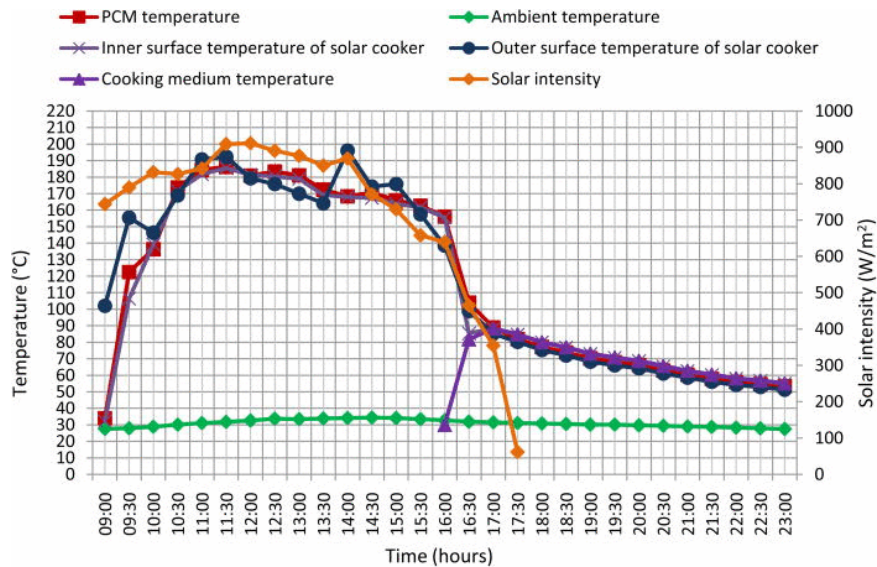


Figure-2 Temperature vs solar intensity

II. LITERATURE REVIEW

Solar cookers are simple, cheap, and trouble-free with good efficiency. Solar cookers were used as early as 1776 by De Saussure, who used a hot box-type oven. There are several ways by which the performance of the box type solar cooker can be increased.

Solar cooker based on parabolic dish collector with phase change thermal storage unit was investigated. In this experimental setup, solar cooker with phase change thermal storage unit was kept on absorber plate of parabolic dish collector. During day time, acetanilide (phase change material) stores solar heat and during evening, solar cooker is kept in the insulator box. Then, the phase change material delivers heat to the food. In a study an ordinary solar cooker was compared with the solar cooker painted black and solar cooker with outer surface painted black along with glazing, the temperatures obtained for each type is 119°C, 175.4°C, and 186.3°C, respectively[2].

Experimental testing and performance of improved solar cooker was carried out, in which it was observed that solar ovens are more efficient than solar cookers, but on the contrary solar ovens are more expensive and bulkier along with requirement of more tracking time. Hence simple box cookers with some modifications can overcome its demerits. It was observed that when the horizontal surface of absorption was tilted for better (33% more) solar radiation acceptance. Here two adjustable mirror boosters were used for improvement in solar radiation absorption. This resulted improvement in overall solar efficiency i.e 24.6% which is thus comparable with the solar oven. But it affected the cost of this improved solar cooker by a minute amount of 10%. [3]

Advancement in the solar cooker helps overcome flaws in it, especially in the box type solar cookers, in the 1980's scientists mainly focused on the maximum optimization of the geometry of the solar cookers in order to simplify the geometry, and thus to reduce the overall cost. It was mentioned that with use of single adjustable booster mirror to solar box, notable amount of energy received for various angles of incidences increased significantly; moreover with increase in the latitude position, energy absorbed increases. Phase changing materials storage unit is helpful for cooking in the evening. Transparent Insulation materials trap the heat in the solar box and since they are transparent, there is no barrier for solar radiation to pass by [4].

Solar parabolic cookers are alternative to box cookers, with better performance, the favorable conditions of cooking are from 1:30pm to 3:30 pm IST. Test procedures for heating and cooling were used. They were conducted to evaluate characteristic performance parameters of the parabolic solar cooker. The only problem is that the parabola requires a lot of space, and the construction is quite difficult, resulting in increment in the cost [5].

Various researches are being conducted on different solar cooking systems which can cook food for a family of about 4 to 5 members. A model developed was found to provide this need. The maximum temperature to which the plate absorbed the solar radiation was 225 °C in small time period of about 40 minutes, when the ambient temperature was 30 °C [6].

An interesting point was put forward where the solar energy was used in the kitchen. The LPG (liquified petroleum gas) was supplemented by the solar thermal energy source. Here the solar energy is used for heating water, then the heated water is passed through the an heat exchanger, where it is used to cook the food, the major problem encountered was the temperature to which the water gets heated is low, hence efforts are being made to increase the absorption capacity.

III. TYPES OF SOLAR COOKERS

III.I Solar panel cookers:

This is the simplest type of solar cooker, as far as the construction is considered. In solar panel cookers solar energy from the sun is concentrated by flat panels which then reflects the Sunlight and focuses for cooking purposes (Figure-3) [12]. Solar panel cookers incorporate elements of both parabolic and box solar cookers. It can attain a temperature range 95-120 degree C. This process has low capacity for cooking purposes, and hence is undesirable.



Figure-3 Solar panel cooker

III.II Solar Parabolic cookers:

These cookers focus a lot of solar energy onto a very small area where a cooking pot is placed, using parabolic shape reflectors. They can reach extremely high temperatures in very short time and do not require any separate box or cooking vessel (Figure-4). This cooker cooks as fast as conventional oven. But on the other hand the construction and the cost are high, along with the need to shift according the sun. Since the heating capacity is high, if the food is left unattended there is a possibility of burning of food.



Figure-4 Solar Parabolic cookers

III.III Box type solar cookers:

First Solar Cooker was invented by a French-Swiss Naturalist named Horance de Saussure in 1767 as shown in Figure-5 [13]. Since then many transformations have been made in it. A solar box type cooker basically consists of a box which is insulated. Topped with a transparent glass or plastic cover, this cover acts as solar energy trap. The solar radiation passes through the window, and is absorbed by the walls, the bottom of the cooker. The walls and outer side of the box are painted with black color. Temperatures inside the box can reach about 140-150 °C [7].

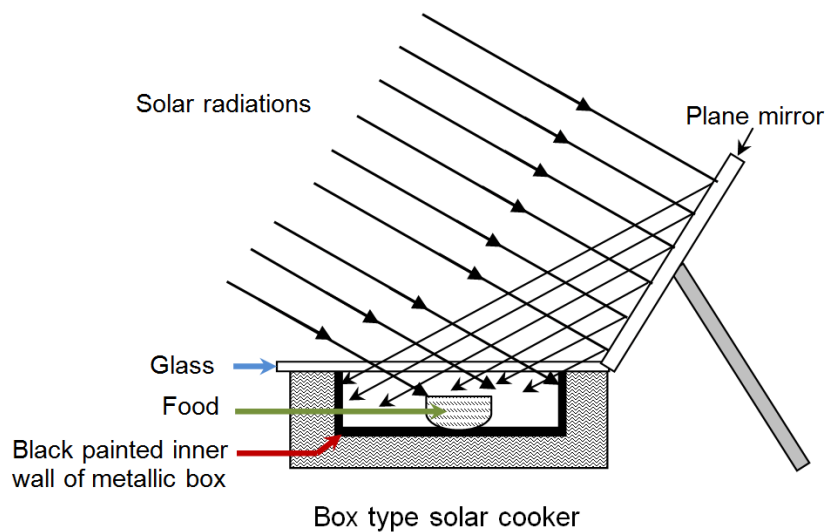


Figure-5 Box type solar cooker

III.IV Vacuum or Evacuated tube solar cooker:

This is one of the latest type of solar cooker which is now being included in the list of conventional solar cookers. It is simple in construction as no complicated parts are involved, but costly due to the Borosilicate type of glass, which has property of resistance to thermal shock; Along with this they are very strong and have high light transparency. There are two concentric tubes and vacuum is present between them hence the heat lost is negligible. The inner tube is coated with materials which absorb heat. A removable tray is provided in the inner tube for cooking food. Some innovations are being done to increase the performance and cooking capacity in this type of solar cookers; which include use of heat absorbing materials for making the vacuum tubes, which are transparent. Moreover alternate method to cook food in vacuum tube cooker is by using electric supply, especially when it is evening or night. Such cookers are available in market when it can cook food with solar energy in daytime and use small amount of power supply during night.



Figure-5 Vacuum tube solar cooker.

IV. CONCLUSION

Solar energy is free, environment friendly. Utilization of solar energy for various purposes is increasing day by day. Similarly the use of solar cookers is not sufficient. Hence Advancement in solar cookers is required to improve the performance and reduce the cost, so that it will be easily available for people at low prices. Solar cookers can fully replace the firewood use in rural areas, and clean energy can be obtained. Statistics has shown that many people die only because of unboiled food and inhaling dangerous gases produced due to burning of wood. This is definitely a serious issue. Hence to counter this problem many researches are in progress, which are mentioned in the above context. Vacuum tube solar cookers are very popular nowadays due to small size and portability. Solar cooking can be one of the best alternative for cooking, since in India sun shows up for about 9 months of the year. Hence more and more awareness camps should be organized in rural and urban areas, to make people understand the benefits of using solar cooker. The hybrid solar cookers can be considered as a boon, since it can cook faster, and can work for all time. If the hybrid cooker is commercialized then it can toughly compete with the other contenders in the market and prove its ability.

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