An Overview Study of Solar Cookers

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Abstract - *In the world, cooking is a major necessity for people. It makes up a sizable portion of the energy consumed in emerging nations. As a result, in these nations, residential use of solar cookers is quite prevalent. The benefits of using solar cookers would reduce the amount of CO2 released into the atmosphere. Because it accounts for 50% of all primary energy consumption in the household sector, cooking is the activity that consumes the most energy. Almost 77% of rural households in India are thought to rely on firewood and chips for cooking, according to a government poll. Compared to LPG, only 9% of people used dung cake. LPG was the main source of energy for roughly 62% of homes in urban areas. As a result, switching to solar energy for cooking can be seen as a solution to the current energy crisis. This essay provides a succinct overview of several solar cooker kinds.*

Key Words**:** Box Solar Cooker, Solar Energy

1. INTRODUCTION

Solar cooking is not a novel concept. The potential of the sun's energy to supply heat for cooking and other purposes was realised by designers as early as the 19th century, and the right equipment were created to harness it. It's possible that sun energy was utilised for cooking before that time.

Both for the user and the environment, solar cookers have a lot to offer. The fact that solar cookers lessen users' reliance on fuel sources for cooking is a benefit that is frequently mentioned. This decrease benefits the user economically by lowering their fuel costs, and it benefits the environment by lowering deforestation (in areas where wood is used as a cooking fuel) and the discharge of combustion byproducts into the atmosphere. Because a good deal of wood-based cooking is performed indoors with poor ventilation, solar cooking also has the potential to reduce smoke inhalation and related health difficulties

2. LITERRTURE SURVEY

C Z M Kimambo et al (2007) in their paper optimized various parameters and concluded that results obtained from this study show that under various conditions of insolation and wind, different types of solar cookers are superior to others. However, under best respective operating conditions, box solar cookers have lower performance compared to the reflector cookers. The reflector cooker with glass reflector achieved highest temperatures and accordingly shortest cooking times than any other cookers tested under sunny days with no cloud cover. It is recommended as being the most suitable type of cooker in areas with long durations of strong solar radiation with no cloud cover and low wind interference. However, special attention should be paid to protect the users from possible burns or eye damage that may occur due to the reflected radiation of the cooker.

The reflector cooker with polished aluminium reflectors has significantly lower performance than that of the reflector cooker glass mirror reflectors, under clear sky conditions. The reflector cooker with unpolished aluminium reflectors has the poorest performance of all the solar cookers even the box solar cookers under clear sky conditions. The ordinary unpolished aluminium should therefore never be used as reflector for solar cookers. Dissemination of such cookers would definitely end up in failure as the cookers would not be able to meet the cooking expectations of the intended users. The 'SunStove' box cooker was able to cook 2 kg of rice, which is sufficient for a moderate family in Tanzania. Both the 'SunStove' and the wooden box cooker can be used for cooking where the global insolation is high and wind effects are not pronounced. This work had shed some light on the status of solar cooking worldwide and provided a detailed account of activities taking place in Tanzania, in relation to solar cooking. Results obtained indicate that many of the cookers could be used to cook food for households in areas with medium and high insolation with appropriate selection of the type and specification of the cookers. The specification should be based on the measured insolation data of the location indicating the direct and diffuse components. This should go hand in hand with proper instruction and training of the users for successful dissemination. As a guiding tool, reflector cookers offer best comparative performance in areas with longest durations of clear sky (greatest direct beam), panel and collector cookers under moderate cloudy conditions and box cookers under very cloudy conditions. It should be noted here that all types of cookers offer best performance under clear sky conditions.

Prof. Viral K Pandya, Prof. Shailesh N Chaudhary, Prof. Bakul T Patel et al. (2011) started their study with the objective to analyze the performance of Box Type Solar Cookers under Gujarat Climate Condition in Mid Summer to improve the workability of cooker a small review on the box type solar cooker applications and its designs given here. Two designs of cookers were tested. The first type has a painted black base and second type has a pained black with coal. These designs were examined under two modes of operations: at fixed position and on tracking system. The cooker at a fixed position had recorded thermal efficiencies ranging from 25.2 % to a sharp peak of 53.8% at the maximum solar intensity of the day around 12-13 pm with an average overall efficiency around 32.3%. Whereas, cooker with black coal pained installed on a sun tracking system gave higher water and pot temperatures, and thermal efficiency ranged from 28% to 62.1% with an average overall efficiency around 43.8 %. Cookers installed on sun tracking system had the advantage of maintaining a higher as well as closer range of thermal efficiencies through the daylight than the ones at fixed positions.

S. D. Pohekar et al. (2005) This paper discusses cooking energy dissemination in the country with an objective of understanding the underlying socioeconomic factors governing the utilization of various fuels/energy carries in cooking. The diffusion of renewable energy devices is observed to be far better their estimated potential. Policy intervention required for better dissemination of renewable energy based devices is also discussed. In view of the above, it is necessary to follow certain principles which are true for any household energy technology in general and cooking devices in particular. The suggested that dissemination programmers should have an objective of assuring adequate supply of energy in environment friendly and socially acceptable manner. The benefits should occur at user level and not necessarily at national or regional level which are assured anyway by the effective implementation of the programme. It has been proved in many cases that wherever subsidies are offered, quality suffers as the main accent is to minimize the cost. Technology has to compete with conventional cooking energy technologies. Development and dissemination of cooking energy devices should address technical requirements and support, needs orientation, integration into socio-cultural setting, participatory approach by masses, social and environmental sustainability as a goal, training and learning from experience and intensive follow up.

B. Ahmad (2000), in their paper interviewed twenty-eight families in three urban sites in Gujarat, India. Direct discussions with families, who were using practical solar cooking, brought forward the practical issues. The study showed that many disusers of solar cookers do not have a suitable place for their solar cookers. Other disusers could not adjust their daily routines with what solar cooking requires, and some disused their solar cookers because they were not interested in using them. User want practical and objective technology, most of the user have problem in using the solar cooker, have maintenance problem, price issue and production problem. The paper stressed on the need of close

understanding between the user and the developer of technology so that it becomes user friendly ad there is no missing link.

Nivay anandarajah, et al. (2009), study on different types of solar cooker the main goal of their study was to help build the tools necessary to compare the performance and cost of solar box cooker (SBC) designs, which will then inform future prototypes. The models were based on a commercially produced solar box cooker manufactured by Fair Fabricators. Scenarios were chosen, altering only one major solar box component at a time to determine both performance and cost benefits of the changes. After reviewing the results, combination scenarios were created to test the performance and cost of altering multiple solar box components concurrently. This assessment focused on material costs and the following efficiency parameters: peak temperature, rise time for the temperature inside the SBC to reach pasteurization temperature (176 ºF), and length of time above the pasteurization point.

S. Mahaver et al. (2012) presents the design development and, thermal and cooking performance studies of a novel solar cooker; it is named as Single Family Solar Cooker (SFSC). Small size, convenient design, inexpensive lightweight hybrid insulation and specially designed lightweight polymeric glaze are the main features of this cooker. A complete theoretical consideration for the fabrication of SFSC had been presented. The thermal profiles of various components of SFSC on different days under different conditions have been measured. During testing, the highest plate stagnation temperature, under no-load condition, approached 144 _C. The two figures of merits F1 and F2 are found to be 0.116Cm^2/W and 0.466, respectively, which are according to the Bureau of Indian Standards. The cooking power regression curve is fairly linear with the regression coefficient R2 =0.948. Initial cooking power 103.5Wand the heat loss level 1.474 W/_C, place it in the region of small cooker with good insulation, as per International Standard. The thermal and cooking performance of SFSC (which is small in size and has been fabricated by using new efficient materials for glaze, insulation and casing) are found to satisfy Bureau of Indian Standards and International Standard. Calculated F1 and F2 values indicate that the cooker can be used for consecutive cooking on a sunny day. The values of the initial adjusted cooking power, heat loss coefficient and adjusted cooking power at a temperature difference of 50C are within the range of these parameters obtained by Funk (2000) for small size good insulation solar cookers. The cooking of different items ascertains its good cooking performance for cooking requirement of two persons for two meals. The stagnation temperature achieved by SFSC was 144C.

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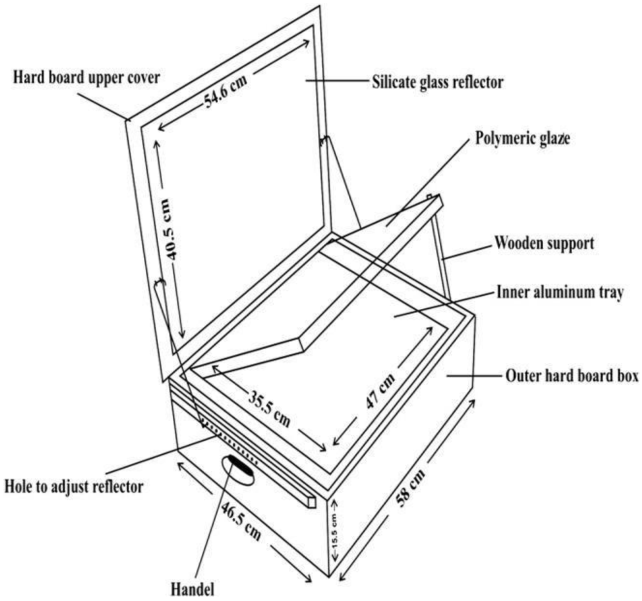

Fig -1: Schematic diagram of SFSC (S. Mahavar et al. /Renewable Energy 47 (2012) 67-76)

2. DESIGN OF SOLAR COOKER BOX

Principle

There are a variety of types of solar cookers: over 65 major designs and hundreds of variations of them. The basic principles of all solar cookers are:

Concentrating sunlight: Some device, usually a mirror or some type of reflective metal, is used to concentrate light and heat from the sun into a small cooking area, making the energy more concentrated and therefore more potent.

Converting light to heat: Any black on the inside of a solar cooker, as well as certain materials for pots, will improve the effectiveness of turning light into heat. A black pan will absorb almost all of the sun's light and turn it into heat, substantially improving the effectiveness of the cooker. Also, the better a pan conducts heat, the faster the oven willwork.

Trapping heat: Isolating the air inside the cooker from the air outside the cooker makes an important difference. Using a clear solid, like a plastic bag or a glass cover, will allow light to enter, but once the light is absorbed and converted to heat, a plastic bag or glass cover will trap the heat inside. This makes it possible to reach similar temperatures on cold and windy days as on hot days.

Box-type solar cooker

It consists of an insulated outer and inner box, metallic cooking tray sat inside the box, double glass lid on the cooking tray, and two reflecting mirrors fitted to the two sides of the lid of the box and an adjustable stand. The cooking tray is insulated on the sides and bottom. The cooker box consists of a top open black painted inner box kept inside of the box and the space between the two boxes is filled with glass wool insulation. The two reflecting mirrors are placed on the upper side of the box with a gap between them and are in hold by a hinge joint with the cooker box. This is a conventional type of cooker and its length is three times its width and depth is same as that of width. The cooker is to be placed facing sun, keeping longer side vertically inclined position and

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the inclination of the cooker box can easily be changed from 15 degree to 45 degrees with respect to the ground by the adjustable stand, attached at the back side of the box. The reflectors are set along the length of the cooker box cover, one in each side, by hinge and holding strip. So length of reflectors is equal to the length of the glass cover.

The widths are equal to the width of the glass cover .The reflectors are inclined at an angle of 115 degree with the face of the box cover. The face of the cooker is to be placed perpendicular to beam radiation to collect the maximum energy. This perpendicular position can be easily achieved simply by the rotation of the cooker towards the sun with the help of caster wheels ,suitably attached at the bottom side of the cooker and by changing the inclination of the cooker by adjustable stand of the back side .But the position of the reflectors remain unchanged throughout the working period. Black painted aluminium cooking pots are used and are placed side by side at the longer side of the cooker on cooking trays. For each cooking tray two bolts acted as hinge are fixed at both longer sides of the cooker inner box. The cooking tray is suspended from the end of the bolts through M.S strips. Length of these strips is equal to the cooking pot radius and these strips are fixed with the ends of tray aligned with the exact middle position of the tray as When the cooker box inclination is changed the cooking tray along with cooking pot, for its own weight, rotated around the bolts and always remained in horizontal position. To avoid the chance of tilting of pots, square shaped trays, length of which are kept equal to the diameter of pots are used and ends of the trays are folded upward

Advantages

- Solar Cooking involves no recurring expenses on fuel as the solar energy is absolutely free.
- Cost of the solar cooker gets recovered easily through savings on conventional fuel in few years. Regular use of a box type solar cooker may save 3-4 LPG cylinders per year.
- It saves time, as the cook need not be present during cooking in a solar cooker.
- There is no fear of scorching the food.
- It provides better and more nutritious food due to slow cooking.
- It is durable and simple to operate.
- It does not pollute the environment and conserves conventional energy.

BIS (Is 13429:2000) Box Type Solar Cooker

1. Size 550mmx550mmx170 mm ± 20 mm With four matt black coated cooking pots (with lid)(made of stainless steel IS 4536 Part-I, II/ IS 5522)
2. Solar cooker must have thermal performance (F1) not less than 0.12 (ie, Grade A)
3. The cover plate should be made of toughened glass with over all transmittance of not less than 65%.
4. The body of the solar cooker should be 1.00 mm thick UV resistant FRP.
5. The gaskets must be made of neoprene/EPDM on minimum 2 mm thickness
6. Mirror reflectivity should not be less than 75%.
7. Each solar cooker must be provided with four castor wheels as per BIS 13429
8. All parts of the cooker must be made of rust/ corrosion free materials.

3. CLASSIFICATION OF SOLAR COOKERS

A solar cooker is a device which uses the energy of direct sunlight to heat, cook or pasteurize food or drink. Basically, there are 3 types of solar cookers, namely:

1. Solar panel cookers:
2. Solar parabolic cookers
3. Solar box cookers

Solar panel cookers may be considered the simplest type available due to their ease of construction and low-cost material. In solar panel cookers, sunlight is concentrated from above. Panel cookers have a flat panel which reflects and focuses sunlight for cooking and heating. This method of solar cooking is not very desirable since it provides a limited cooking power.

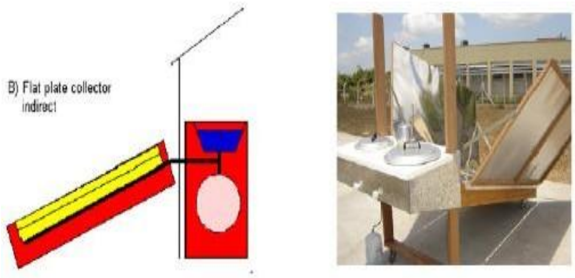

Fig -1: Solar Panel Cooker.

Solar parabolic cookers can reach extremely high temperatures in a very short time and unlike the panel cookers or box cookers; they do not need a special cooking vessel. However, a parabolic cooker includes risk of burning the food if left unattended for any length of time because of the concentrated power. A solar parabolic cooker simply consists of a parabolic reflector with a cooking pot which is

located on the focus point of the cooker and a stand to support the cooking system.

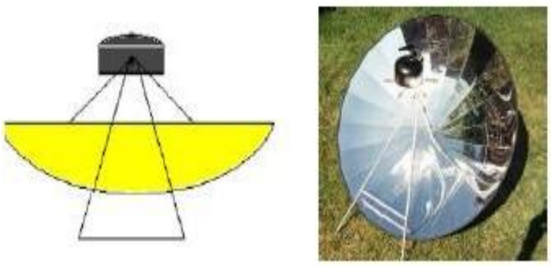

Fig -2: Solar Parabolic Cooker.

A box type solar cookers are the most common and inexpensive type of solar cookers. These box cookers have a very simple construction and they are made of low cost materials, which essentially consist of a black painted metallic trapezoidal tray (cooking tray) and is usually covered with a double glass window. It is kept in a metal or fibre-glass outer casing and the space between the cooking tray and outer casing is filled with the insulation like glass wool. The incoming solar radiation falls onto the double glass lid and passes through it to strike the blackened cooking pots and the cooking tray. The glass covers, while transmitting radiation of short wavelength which form major part of solar spectrum, is almost opaque to low temperature radiation emitted within the box. Thus, the temperature of the box rises until a balance is reached between the heat received through glazing and heat lost by exposed surface (greenhouse effect). In addition, a plane reflecting mirror (booster mirror) of about equal size as that the aperture area is used for augmentation of solar radiation on the aperture. The cooking tray is insulated on the sides and bottom. The heat is absorbed by the blackened surface and gets transferred to the food inside the pots to facilitate cooking. Figure 1 showsthe different types of solar cookers.

Fig -3: Box type Solar Cooker.

3. CONCLUSIONS

One of the most promising sources of alternative energy is solar energy because it is inexpensive and environmentally friendly. Solar cookers can completely or partially replace the use of firewood for cooking in many developing regions by giving the necessary energy. Solar cooking has frequently been criticised for being a technological panacea created without consideration for consumer needs. This

essay is a survey of the literature that is currently accessible on solar cookers. Some issues that plague our civilization on a global scale:

- To cook their meals, half the population of the globe must use firewood or decomposed manure.
- A fifth of the world's population, or nearly 1.2 billion people, lack access to clean drinking water.
- Every year, unboiled drinking water causes the deaths of over 1 million children.
- The annual loss of 16 million hectares of forest is a result of wood being cut for cooking.
- The burning of solid fuels for cooking and heating exposes half of the world's population to indoor air pollution.

Hence, using solar energy and being aware of it are essential, and solar cookers may make this feasible.

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