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Design and Fabrication of Parabolic Solar Cooker

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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 utilized in solar cooker which makes it eco-friendly 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 cookingtime and the most important is the awareness about using solar cooker. Hence to makesolar cooker easy to use and smaller in size with minimum cost is major challenge. Use of parabolic solar cooker has boosted the cooking process. There is certainly scope for research in solar cookers.

Keywords: Solar Cooker, Eco friendly Cooking, Rural Development.

1. Introduction

Cooking is a vital method used by human beings to prepare food for survival, and it isresponsible for a large amount of energy consumption in many countries. In developedcountries such as the United States of America, cooking accounts for about 37%–53%of total energy consumption. In developing countries located in Africa, Asia, and South America, a major part of the residential energy consumption is utilized for cooking. Astudy conducted by Karekezi showed that about 80% of Sub-Saharan African countriesstill utilize firewood, fossil fuels, biomass and electricity for cooking food, which results in huge amounts of greenhouse gas emissions and deforestation. This indicatesthat there is a need for alternative cooking methods that are environmentally friendly and use clean energy resources. Although only about 14% of the world's available renewable energy potentials is currently being utilized, the percentage utilization of renewables is projected to increase soon due to concerted global efforts to mitigate against global warming due to greenhouse gases emission. Solar energy has gained prominence over recent years as an alternative energy source for developing countries.It is estimated that the solar radiation flux in the sunniest region of the earth is about1 kW/m2, the total global solar radiation per day is about 7 kWh/m2, and the total amount of solar energy received on earth is approximately 1.8 × 1011 MW. This is about 10000 times larger than the present energy consumption rate from all other commercial energy sources. This indicates that solar energy can be exploited for a wide range of domestic energy requirements, especially cooking. Solar collectors can be regarded as devices that help to concentrate/collect solar radiation by capturing and converting radiant energy from the sun into thermal or electrical energy. Solar collectors can be categorized into two groups namely; non-concentrated collectors (flatplate collector, evacuated tube collector, etc.) and concentrated collectors (parabolic dish, parabolic trough, etc.). Some of these

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collectors can be modified easily for solarcooking. A solar cooker is a solar collecting device that uses the energy from thesun to cook food. Although solar cookers are not a recent novel idea, they have undergone several modifications over the years . However, there is still room for improvements in order to achieve higher efficiency, lower cost, greater portability, and further adaptability to different environmental conditions. The three main types of solar cookers are: solar box cookers, concentrated solar cookers, and indirect solar cookers. Solar cooker based on parabolic dish collector fabricated. 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 solarefficiency 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%. 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. Transparent Insulation materials trap the heat in the solar box and since they are transparent, thereis no barrier for solar radiation to pass by Solar parabolic cooker are alternative tobox 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. 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. An interesting point was put forward where the solar energy was used in the kitchen.

2. Literature Review

The literature review is carried out on the various fields of research on parabolic solardish collector which is aiming to improve the performance of parabolic solar dish collector.

El Ouederni et al. developed parabolic solar concentrator. Experimental measurements of solar flux and temperature distribution on the receiver have been carried out. The solar flux concentrated on receiver has been experimentally determined. The obtained results describe correctly the awaited physical phenomenon. The temperature in the center of the disc reaches a value whichis about 400 °C. So that, a good quality of industrial high temperature equipment's, can be obtained using this technology of solar energy concentration. The second result was the good efficiency of the studied solar concentrator which can be increased by different interventions. In another term, using this solar equipment we can extract eventually 27 percent of direct solar

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energy and convert it into thermal energy that can be used directly for several applications such as water heating, electricity generation using Stirling engine, vapour production, etc.

Lifang Li et al. developed a new conceptfor designing and fabricating large parabolic dish. The dish mirror was formed from several optimal-shaped thin flat metal petals with highly reflective surfaces. Attachedto the rear surface of the mirror petals were several thin layer whose shapes optimizedto reflective petals form into a parabola when their ends were pulled toward each otherby cables or rods.

Ibrahim et al. reported the design and development of a parabolic dish solar water heater for domestic hot water application. He found that the heateris providing 40 litres of hot water a day for a family of four members, assuming that each member of the family requires10 liters of hot water per day. Initially he expected the thermal efficiencies of 50 percent by the design but he obtained thermal efficiencies of 52 percent - 56 percent and this range of efficiencies is higher thanthe expected designed value.

Fareed. M. Mohamed et. al studied Portable Solar Dish Concentrator and reported design and fabrication of solar dish concentration with diameters 1.6 meters for water heating application and solar steam was achieved.

The dish was fabricated using metal of galvanized steel, and its interior surface is covered by a reflecting layer with reflectivity up to (76%), and equipped with a receiver(boiler) located in the focal position. The dish equipped with tracking system and measurement of the temperature and solar power .Water temperature increasedup to 80°C, and the system efficiency increased by30 percent at mid noon time.

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. Policyintervention 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 devicesin 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 nationalor 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 competewith 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.

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

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cooker manufactured by Fair Fabricators. Scenarios were chosen, altering only one major solar box component at a time to determine both performance and cost benefitsof 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 pasteurizationtemperature (176 ºF), and length of time above the pasteurization point.

S. Mahaveret 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 completetheoretical 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 144C. The two figures of merits F1 and F2 are found tobe 0.116Cm2/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. CalculatedF1 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.

3. PARABOLIC SOLAR COOKER

Parabolic type solar cooker developed by National Physical Laboratory (NPL) of Indiaat New Delhi. Focus a lot of sun energy onto a very small space, using parabolic shapes. Reach temperature up to 450 C. Works on the principle that when a 3D parabola is aimed at sun, the rays are reflected on to the focus. Consistsof a large parabolic and cooking pot holder. When the reflector surface is aimed at thesun, the rays falling on the parabolic surface converges to the focus of the parabola. The cooking pot is placed at the focus of the reflector. The pot surface are blacked to improve the absorption. In parabolic solar cooker the sun rays are used to generate heatat a point which is further used for cooking. The incoming rays from sun incident on theparabolic reflector having larger diameter of 1.5m which is made up of mild steel sheetat base and aluminum foil on it, after the reflection from reflector the reflected rays areconverges at a point called focal point, at that point a white glass box is fixed and theinside of the glass box the aluminum material cooking pot having black coated is keep. purpose of use of white glass box is to create greenhouse gas effect and the purposeof coating black on outer surface of cooking pot is to absorb more heat because blackbody absorbs heat by which the heat generation is

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more and the efficiency of solar cooker will increase. The converged ray incident on glass box and the rays transmits into the glass box and generate heat at that point where the cooking pot placed and absorb heat and increase the temperature of the cooking pot and the material inside init.

Procedure for heating test Heating test is conducted to determine optical efficiency factor of the parabolic concentrator solar cooker. For this test, the cooking pot with a predefined amount of the water (as the cooking load) is mounted at the focus of the parabola. The solar cooker is exposed to unobstructed solar radiation and is adjusted in a manner that the bright spot of the concentrated solar radiation falls on the centre of the bottom of the cooking pot.

Fig. 1. Parabolic Solar Cooker

4. CONCLUSION

Fabrication of parabolic solar cooker is completed and successfully tested.

Parabolic Solar cooker is having following advantages:

- Sustainable solution for rural development to solve costly fuel problem.
- Easy to use. Rural women can easily operate it.
- Low cost. One time investment. No Maintenance cost.
- Safe in operation.
- It can be installed at any location.
- It can be used for agriculture applications also.
- It can generate up to 450°C temperature in sunny days.

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