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Lecture 13

Solar Cooker

Alternate source of energy is always a green approach of energy consumption, in the time of crises of energy and global warming. Use of solar energy for cooking is better solution, but still not established as user friendliness and economic aspect. Food is the basic need of human being. Food can be cooked with conventional fuels like wood, cow-dung, kerosene, Liquid Petroleum Gas (LPG) and electricity. Solar cooker is clean and eco-friendly energy device for cooking. There are large number of solar cookers designed and developed by the scientists and researchers all over the world but still the utilization of solar cooker is not sufficient. There are many reasons for the insufficient uses of solar cooker like, its bulky size, heavy weight, lack of open place, slow cooking, fixed timing for cooking, less awareness etc.. In this paper different solar cookers like solar panel cooker, solar parabolic cooker, solar box type cooker and hybrid solar cooker etc. are discussed in detail. Still lot of modifications are required to make the solar cooker user friendly, lighter in weight, smaller in size and still economic. Development of a photovoltaic and thermal hybrid solar cooker has started a new horizon in the field of solar cookers as the cooking is faster than conventional box type solar cooker and can be used at users convenient time. The cooker was converted into solar dryer by small modification and was used for drying vegetables. Still lots of scopes are there for research in solar cooker especially for small size domestic solar cookers.

Key words: booster mirrors, Photovoltaic effect, solar cooker, solar dryer, sun basket

1. Introduction

A solar cooker is a device which utilizes solar energy to cook food. Solar cookers also enable some significant processes such as pasteurization and sterilization. It is a clear fact that there are countless styles of solar cookers in the world and they are continually improved by researchers and manufacturers. Therefore, classification of solar cookers is a hard work. However, it may be asserted that most of the solar cookers today fall within three main categories called solar panel cookers, solar box cookers and solar parabolic cookers as shown in Fig. 1.

Reflector Type solar cooker

Solar panel cookers may be considered the most common type available due to their ease of construction and low-cost material. In solar panel cookers, sunlight is concentrated from above [1]. This method of solar cooking is not very desirable since it provides a limited cooking power. On the other hand, this type of solar cookers is highly appreciated by people living or travelling alone.

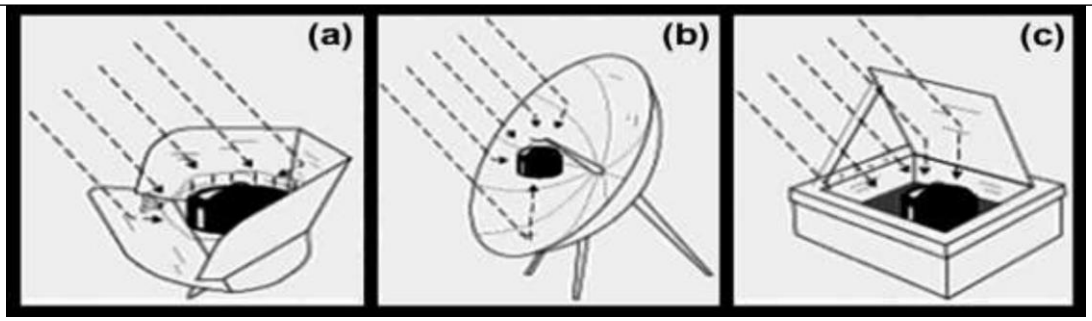

Fig. 1 (a) solar panel cooker; (b) solar parabolic cooker; and (c) Solar box cooker.[2]

Solar panel cookers utilize reflective equipment in order to direct sun- light to a cooking vessel which is enclosed in a clear plastic bag. Solar panel cooker of Dr. Roger Bernard (CooKit) is one of the most popular designs in this category [3]. Only cardboard and foil shaped was utilized to manufacture the CooKit. It was an affordable, convenient and effective solar cooker which enabled to preserve nutrients without burning or drying out. Bernard also investigated how the solar cooking technology is taken up by populations [4]. Performance of solar panel cookers highly depend on reflected radiation thus, they do not seem effective under cloudy conditions [5]

Another simple concentrating type solar cooker is known as sun basket. The sun basket is basically a parabolic mirror, made from paper mache, reinforced by a layer of jute fabric and held in place by a bamboo frame. The reflector lining is an aluminium foil which is glued on the inner side of the basket. This is also known as passive cooker.

For fabricating the sun basket a mound of cement concrete of parabolic shape is made on the ground. This is done with the help of a previously fabricated plywood frame of parabolic shape, which is revolved on the masonry work while still soft. A bamboo basket is woven in such a way that it fits exactly over the shape of parboiled mound. At the same time, paper mache is prepared from 5kg of shredded waste paper, 2kg of wheat flour, 1kg of fenugreek

flour and sufficient quantity of water to make a thick pulp. The ingredients are mixed well and heated to nearly boiling temperature. The mould is then covered with one layer of water-soaked newspapers so that the paper mache would not stick to the mould. The paper mache is then pasted in a layer of about 1.2 cm thick and well-pressed upon the paper covered mould. On top of this, the bamboo basket is then placed and pressed well onto the wet surface. The paper mache is then taken out. silver foil the inside of the paper mache is then pasted with for reflecting solar rays Nine sheets of (40*60 cm.) silver paper are necessary for a basket. For cooking purposes, the sun basket is focused towards the sun and the cooking pot is suspended from a tripod stand. It is claimed the sun basket under clear sky conditions can cook rice in 10 minutes and dal in 20 minutes. One liter of water can be brought to the boiling point in 5 minutes. The sun basket is estimated to be equivalent to 700 Watts electric cooker. [6]

Box Type Solar Cooker

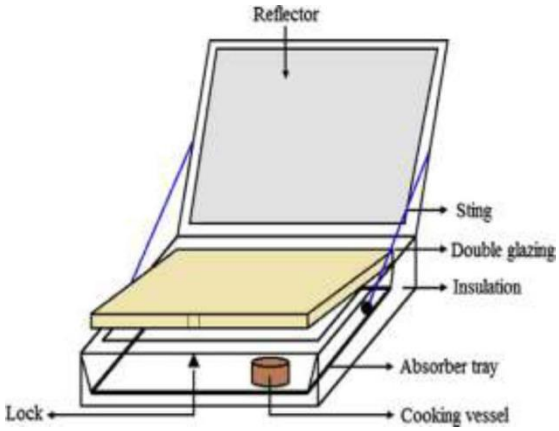

Fig. 2 Box Type Solar Cooker [7]

History of solar cooking technology started with the invention of box-type solar cookers. The first solar box cooker was invented by a French–Swiss naturalist named Horace de Saussure in 1767. Especially in the twentieth century, this solar cooker type demonstrated a considerable development in terms of design and performance parameters. A solar box cooker basically consists of an insulated box with a transparent glass cover and reflective surfaces to direct sunlight into the box [7]. The inner part of the box is painted black in order to maximize the sunlight absorption. Maximum 4 cooking vessels are placed inside the box [8, 9]. A detailed description of solar box cookers is illustrated in Fig. 2 Each

component of the box cooker has a significant influence on cooking power. Therefore optimization of these parameters is vital for obtaining maximum efficiency.

Advance Solar Cookers:

Cooker with Booster Mirrors:

After the 1980s, researchers especially focused on optimization of geometry parameters of solar box cookers since they have a dominant effect on performance. In this context, some researchers analysed the booster mirror effect on efficiency of box-type solar cookers. Dang [10] investigated the concentrators for flat plate collectors and explained that booster mirrors can be utilized in order to increase the efficiency of solar collectors since it provides extra solar radiation. The results indicated that the effectiveness of concentrators highly depends on the angle of mirrors. Garg and Hrishikesan [11] presented a comprehensive analysis of a system consisting of a flat plate collector integrated with two reflectors. They proposed a model which was numerically simulated for conditions prevailing in three different Indian stations for three different months. They found that the enhancement is maximum for the month of December in all the three stations for both horizontal and tilted surfaces. Narasimha et al. [12] comprehensively analyzed the solar cookers augmented with booster mirrors. They provided a single adjustable booster mirror to a solar box cooker and calculated the total energy falling on the cooking aperture for the latitude of 18 N (Warangal City, India) and for different declinations of the sun. Energy contribution by the booster mirror increase significantly with an increase in latitude of the location.

Uses of Phase changing materials (PCM):

Buddhi et al. [13] designed and analyzed a solar cooker augmented with three reflectors and a phase change material storage unit. The experimental results showed that late evening cooking is possible in the solar cooker proposed. Algifri and Al-Towaie [14] carried out a research in order to study the effect of the cooker orientation on its performance.

Uses of TIM (Transparent insulation material):

Insulation in a solar box cooker should not be limited to the walls of the frame box and absorber tray since a remarkable amount of heat loss occurs through the glazing. In this context, Nahar et al. [15] carried out some studies on utilization of transparent insulation material (TIM) in solar box

cookers. Under an indoor solar simulator, they tested a hot box solar cooker with glazing surface consisting 40 and 100 mm thick TIM. The stagnation temperature with the 40 mm TIM was found to be 158 C, compared with 117 C without the TIM. A double reflector hot box solar cooker with TIM was designed, constructed, tested and its performance was compared with a single reflector hot box solar cooker without TIM.[15]

Different designs of solar cooking systems

Sonune and Philip [16] developed a Fresnel type domestic SPRERI concentrating cooker. The cooker was found capable of cooking food for a family which consisted of 4 or 5 people. The highest plate bottom temperature was calculated 255 C in approximately 40 min while ambient temperature was 30 C and direct solar radiation was 859 W/m2.

Prasanna and Umanand [17] developed a hybrid solar cooking system as shown in Fig. 3 where the solar energy was transported to the kitchen. The thermal energy source was used to supplement the Liquefied Petroleum Gas (LPG) which was in common use in kitchens.

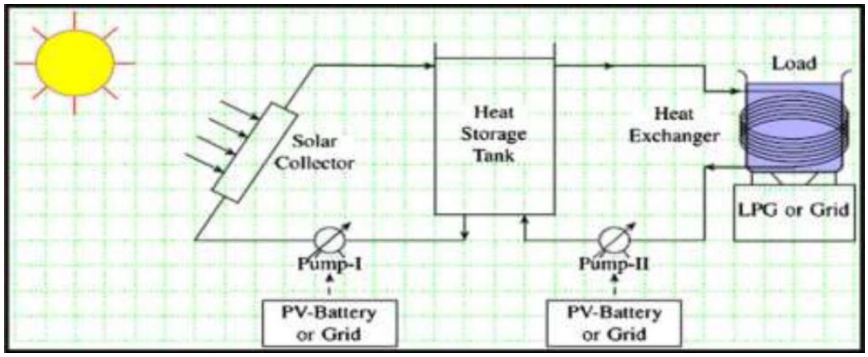

Fig.3 Heat storage material:

It is a clear fact from the literature that solar cookers are very promising devices in the upcoming future. However, there are some handicaps concerning the solar cooking technology. Perhaps, the most challenging point of solar cookers is that they are not able to serve when the sun goes down. Some researchers performed intensive efforts on solar box cookers in order to allow late evening cooking. PCMs were considered as a solution in most cases. Bushnell [18] designed, constructed and evaluated a solar energy storing heat exchanger as a step toward a solar cooking concept. The methods for describing the system performance were explained and applied to a test system containing a controllable replacement for the solar input power. This first stage of this research work followed by a heat

exchanger, which was connected to a concentrating array of CPC cylindrical troughs. Author also described the size of the solar collector area and mass of PCM mass needed in order to provide adequate energy for several family-sizes. Different researchers have studied ionic liquid for heat storage in solarenergy devices [19-21].

The small scale Photovoltaic and Thermal Hybridized (Casserole type) solar cooker as designed and developed was developed [22] tested for the performance with (a) Thermal Energy Storage materials (TES), sand (b) Ionic liquids (IL) BF4- and PF6- [23-25]. The cooker was modified and made users friendly all time working solar cooker and The maximum utilization of the solar cooker was studied by cooking different dishes in it [26,28]. The hybrid cooker was made more efficient by tracking the solar panel with dual axis solar tracker [29].The hybrid cooker was converted into solar dryer and was used for agricultural applications. [30, 31].

Conclusion

Scientists all over the world have made large number of efforts in developing different types of solar cookers for many decades. Although it can be one of the best alternative for cooking, it is hardly accepted by the society. There are many reasons for that like lake of awareness, large size, bulky models, slow cooking, highly dependent on weather conditions, fixed cooking time etc, The hybrid solar cooker which can work for all time and can cook faster than the conventional solar cooker has being designed and developed which if commercialized can become competent to the conventional solar cooker and can be proved as a boon to the society.

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