A Review on Thermal Performance of Parabolic Solar Cooker with Phase Change Materials

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Abstract **-** Solar thermal energy refers to the technologies that utilize the sun energy for cookery, for heating water and alternative heat transfer fluids for a range of residential, industrial and utility applications. Solar cooker based on parabolic dish type collector with integrated latent and sensible heat storage unit was investigated for different load. In this experimental setup, solar cooker with integrated latent heat storage and sensible heat storage unit as heat storage units were used. During day time, the thermal storage system stores heat and meanwhile transfer it to the cooking pot. During evening, solar cooker is kept in the insulator box; the thermal storage system delivers heat to the food. It was found that the temperature of food was high even at late evening. The solar cooker was able to cook food two time (noon and evening) a day. Suitable thermal tests have been identified for performance evaluation of a concentrating solar cooker. These tests provide parameters that characterize the performance of the solar cooker, and are more or less independent of the climatic variables. The performance characteristic curve for the solar cooker will be obtains and discuss. The study indicates that the no load test, which is useful in the case of a box type solar cooker, is not appropriate in the case of concentrator type cookers.

Keywords **-** *Solar cooker, parabolic dish collector, phase change material, latent heat, Sensible heat.*

I. INTRODUCTION

Cooking is a prime necessity for all people across the world. About 75% of people living in rural India fulfill their cooking energy needs from noncommercial fuels like wood from the forest which contributes to deforestation and greenhouse effect. On the other hand price of LPG, which is another major source of energy for cooking, is rising day by day. Due to this cooking by using renewable energy sources is a burning issue. Fortunately, India is blessed with ample amount of solar radiation. This offers solar cooking as one of the most attractive options. Successful application of solar energy depends to a large extent on the method of energy storage. Energy storage not only provides bridge between supply and demand, but also improves the performance and reliability of the system. Different types of thermal energy storage system may involve only sensible heat storage (storing of energy by heating or cooling), latent heat storage (by melting or vaporizing or solidifying or liquefying) or a combination of both. If solar cookers are provided with the thermal storage unit, then there is possibility of cooking food during the off sunshine hours. Solar cookers employing paraboloid reflectors were developed during the fifties and the sixties and R&D work on similar designs has been described in several models of these have been fabricated and tested in many countries. The box type solar cooker has been commercialized in several states in India and many researchers are actively engaged in exploring the possibility of using concentrating solar cookers. The type that has received the most attention so far is the paraboloid concentrator cooker. The present work is aimed at providing suitable guidelines for thermal evaluation of the concentrating type cookers in general and paraboloid type cookers in particular. Maxime Mussard, Ole Jørgen Nydal, two charging experiments of a solar heat storage area unit conferred. The warmth storage is plus a self-circulating solar parabolic trough crammed with thermal oil (Duratherm 630). The insulated with a glass tube throughout the second check (the air Layer insulating the absorbent is seven millimeter thick, embowered between 2 glass cylinders. Associate degree electronic system tracks the sun throughout the experiments. The storage is principally oil based mostly however contains a big a part of nitrate salts so as to store energy with heat energy (melting temperatures: 210–220˚C). The results show that at low temperatures, the absorbent while not insulation is far simpler. However once the storage temperature approaches 200˚C, the glass tube becomes a plus and a necessity for the any heat assortment at higher temperatures. Higher than 200˚C, it becomes troublesome to gather while not insulation round the receiver. Chee Woh Foong et al., this paper reports on the testing of a little scale double-reflector star concentrating system with heat storage. The most advantage of thermal heat storage is that the thermal energy is on the market conjointly throughout times once there's very little or no sun- shine. Well-insulated heat storage ought to keep the warmth for concerning twenty four hrs. Several solar heat assortment systems area unit supported transportation of warmth from the put concentration to the storage by a current heat transfer fluid. With a double-reflector arrangement, the storage is heated directly, and no heat transport fluid is required during this system. Globally there is profuse literature on the continuous developments of box type solar cookers and solar ovens. A lot of research work

has been carried out in recent passed years in the world which clearly Shown the utilization of solar energy towards the greatest needs of mankind obviously solar cooking, fuel saving, non-polluting environment and to save and produce electricity. In the present literature the efforts have been made to focus on diverse developments of box type solar cooker till now. An attempt has been made to optimize the various major parameters such as geometries of box-cooker, glazing system, cooking vessels design, heat storage, insulation, mirror boosters and financial feasibility of solar cooker box. All the discussed factors have been taken into account in the fabrication of a simple solar box cooker and a good improvement has been found in the performance of box cooker with efficient working in low ambient temperatures. A wiper type mechanism to remove vapor droplets from the bottom of glazing, during the cooking process has been introduced and discussed with a new designed cooking vessel. The investigational testing of the fabricated box cooker has been carried out under the climate conditions of Moradabad Uttar Pradesh.

In this paper, a thorough review of the available literature on solar cookers is presented. The review is performed in a thematic way in order to allow an easier comparison, discussion and evaluation of the findings obtained by researchers, especially on parameters affecting the performance of solar cookers. The review covers a historic overview of solar cooking technology, detailed description of various types of solar cookers, geometry parameters affecting performance of solar cookers such as booster mirrors, glazing, absorber plate, cooking pots, heat storage materials and insulation. Moreover, thermodynamic assessment of solar cooking systems and qualitative evaluation of thermal output offered by solar cookers are analyzed in detail. Complex designs of solar cookers/ovens with and without heat storage material are illustrated and furthermore possible methods to be able to enhance the power outputs of solar Cooking systems are presented. Feasibility analysis, environmental impacts and future potential of solar cookers are also considered in the study.

II. EXPERIMENTAL SETUP

The experiment was performed to investigate the thermal performance of solar Cooker with dual thermal storage unit. The test section of solar cooker is based on parabolic dish collector. This system consists of parabolic dish collector, solar cooker. The experimental setup consists of following components:

1. Parabolic solar dish collector
2. Solar cooker
3. Latent heat storage unit
4. Sensible heat storage unit
5. Insulator box

A. Parabolic solar dish collector

The solar parabolic dish collector is a point focusing device which includes concentrator, plate for placing the cooker and frame. In this system, 40 segments of the anodized aluminum are joined to form the concentrator.

B. Solar cooker

Solar cooker is made up of three hollow concentric cylindrical vessels of aluminum. The cooker is painted black so that it can absorb maximum solar radiations. The inner vessel is used for cooking and a lid is also provided over it.

C. Latent heat storage unit

The selection of phase change material depends upon its properties such as melting temperature, latent heat of fusion, toxicity etc.

D. Sensible heat storage unit

Sand is used as a sensible heat storage unit which is filled in the outer space of the solar cooker. High melting point and availability in abundance made sand a good option for sensible heat storage unit

E. Insulator box

A box made up of wood is used for insulation. The box is filled with glass wool for better insulation

III. MEASURING DEVICES AND INSTRUMENTS

Different parameters are measured, these are:

1. PCM, wind and cooking medium
2. Temperature
3. Pyranometer
4. Ambient temperature
5. Solar radiation intensity
6. The cooling curve and heating Curve
7. Cooker performance characteristics

IV. METHODS TO ENHANCE SOLAR COOKING PERFORMANCE

There are many opportunities in order to improve the performance of solar cookers. First of all, amount of absorbed solar energy may be increased via a concentrating system. Fresnel lens is a good choice to achieve this purpose. Especially in recent years, many applications of Fresnel lens have been recorded in not only solar cookers but also other solar energy technologies [209–214]. However, if a photovoltaic cell is considered, when the PV cell is supported with a Fresnel lens it definitely should be cooled by an efficient cooling system for a desired increment in power output. Otherwise, as reported by Wu et al. [215] efficiency of the cell dramatically decreases depending on the huge temperature increase of the cell. Amount of solar energy falling on the surface of a solar cooker can also be enhanced with reflecting mirrors or surfaces. Secondly, thermo physical properties of the absorber tray play an important role on the performance parameters of solar box cookers. Absorber trays should be selected from materials with high thermal

conductivity and painted black. It is also possible to develop new materials with higher absorptivity coefficients. As recommended by Harmim et al. [67], absorber plate can be constructed with extended surfaces in order to enhance the heat transfer from absorber tray to food in the cooking vessels. Saxena et al. [20] reported a cooking vessel modified to reduce the cooking time for a solar box cooker. The cooking vessel had a trapezoidal shape which absorbs a good amount of solar radiation due to its exposed surface area and made of aluminium with a 150 mm bottom end diameter and 180 mm top end diameter. A series of lugs in a curvature form at the bottom of vessel was provided as to enhance the heat transfer. The lid became hot and generated a current of hot air, which circulated inside the box cooker. The heat carrying by this hot air circulation, reached to the food via the most sides of the vessel. A heat transfer between food and the lid took place by means of convection in the air layer between the food and the lid. The air convection was effective in transferring heat from the food to the lid and vice versa. The total depth of the cooking vessel was 600 mm + 40 mm. The radius of curvature of a lug was 2.5 mm. To measure the temperature of cooking fluid stored in the modified cooking vessel during the testing a lid holder openable knob (screw threaded) was provided on the top of cooking vessel. There was also a locking system of lid to the cooking vessel for proper closing. The testing was performed to determine the cooking power. Thirdly, an efficient and low cost insulation should be provided in order to avoid heat loss from the walls of the cooker to the ambient. Transparent insulation materials (TIMs) are highly recommended by many researchers for the insulation of glazing [105,106]. Finally, solar cookers should be used with thermal energy storage materials (water, rock, pebble, PCMs, etc.) to enable late evening cooking.

V. POTENTIAL OF SOLAR COOKERS

As reported by Panwar et al. [4], renewable energy resources will play an important role in the world's future. According to the global renewable energy scenario, proportion of the solar thermal applications will be about 480 million tons oil equivalent by 2040 . Average cost of solar cookers decreases day by day on the contrary their power output and efficiency considerably increases. In the upcoming future, widespread use of this technology is expected hopefully not only in developing countries but also throughout the world. Nowadays, solar cookers are also available to use in the areas with limited solar radiation depending on the developments in solar power concentrating systems and material technology. In addition, the most challenging point of solar cookers, unavailable to use when sun goes away, is overcome with thermal energy storage techniques. Briefly, it is anticipated that solar cooking technology will be demanded by a huge group of people in the near future because of its outstanding features.

VI. CONCLUSION

Cooking plays a very important role in property energy management in Indian households likewise as worldwide. My work is concentrated on the offered thermal energy storage technology for solar cook. In this study, a comprehensive review of the available literature on solar cookers is presented. The review covers a historic overview of solar cooking technology, detailed description of various types of solar cookers, performance analysis and thermodynamic assessment of solar cookers, novel designs on solar cooking technology, key items to enhance solar cooking efficiency and also ecological aspects of solar cooker and Improve efficiency cooker performance characteristics.

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