A Glance on Solar Cooking Technology in India

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Abstract— Energy consumption for cooking is unavoidable and it contributes a major part in sharing of total primary energy consumption in India. Hence it needs an alternative energy source for this purpose. The use of the fossil fuels such as kerosene and LPG for cooking is expensive therefore traditional cooking is replacing by solar cooker which utilizes the solar energy to cook the food. Solar energy is non consumptive and non-polluting fuel. Solar cookers have long been presented as an interesting solution to the world's problem of dwindling fuel. Solar cooker could reduce annual life cycle costs by up to 40% and environmental impacts by up to 65% including greenhouse emissions when compare with microwaves. The solar cooker have relevant place in the present fuel consumption pattern. The objective is to enhance the heat transfer rate and reduce the cooking timing. The performance and the parameters obtained from newly designed solar cooker are to be excellent than that obtained from previously known solar cooker. This performance of the solar cooker has been checked under the local climate conditions to observe its efficient satisfactory results.

Key words: Solar Energy, Cooker, Food

I. INTRODUCTION

Fuel based energy resources still predominate with the highest share in global energy consumption. Cooking is primary need of the people and a major household activity for different households. Energy consumption for cooking in developing countries is a major component of the total energy consumption including commercial and non-commercial energy sources. Solar energy is the cheapest, inexhaustible, environmental friendly and can be used for various domestic and agricultural requirements including cooking, drying, dehydration, heating, cooling and solar power generation. Among the thermal applications of solar energy, solar cooking is considered as one of the simplest, the most viable and attractive options in terms of the utilization of solar energy. Solar cooking is the process of heating food up to boiling temperature of water, and being kept at that temperature for a particular period of time depending upon the characteristics of the food. Solar cooker is a cooking device that cooks food by absorbing sun's thermal energy in the form of solar radiation. The solar cooking saves a significant amount of conventional fuels. Basically, there are 3 types of solar cookers, namely, solar panel cookers, solar parabolic cookers, and 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. Box type solar cookers are simple, easy to construct and operate, temperature around 100°C can be obtained. This cooker is the preferred option for individual family needs, because of its small size and simple handling and operational requirements. Concentrating types solar cookers operate at a higher temperature than box cookers. These cookers use a parabolic dish to concentrate solar radiation which focuses concentrated beam of solar radiation on the base of a blackened cooking pot used for cooking. In concentrating cookers all the light rays get focused to a single point where we place the cooking pot. Concentrating solar cookers need regular adjustments to track movement of sun for adjustment of focus for maximum reflection of solar energy onto absorber. Solar cookers use reflector which reflect maximum possible solar radiation on absorber plate thus it is very important to choose the correct reflector for cooker design. There are various types of reflectors that can be employed in the solar cookers like flat plate, compound concentrating collectors, cylindrical parabolic collectors. Thermal performance of the box type, panel type and parabolic-concentrating type solar cooker is rigorously reviewed and presented in this paper. The present work a review has been made to study conducted researches in the field of solar cooker.

II. LIGATURE REVIEW

A. *Elamin O. M. Akoy, Abdalla I. A. Ahmed [1]*

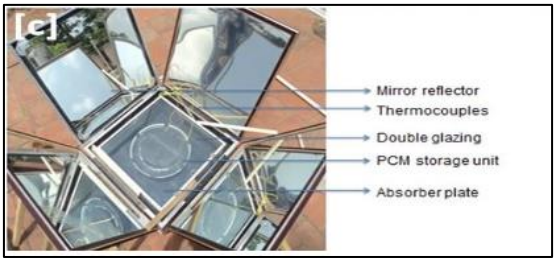
In this study, three different types of solar cookers namely; box-type, panel-type and parabolic solar cooker were designed and constructed using locally available materials. The main objective of the study was to investigate the thermal performance of the constructed solar cookers. The standard procedure for testing solar cookers was adopted to test the thermal performance of the constructed solar cookers. Several tests were conducted on the constructed cookers under Zalingei (Sudan) prevailing weather conditions during March 2011. In addition, a questionnaire was designed to evaluate the dissemination possibility of the constructed solar cookers in the study area which consisted of 50 respondents (males and females). Results of thermal performance showed that, the parabolic solar cooker attained a maximum temperature of 86.5^{0}C on average basis and was the best followed by the box-type solar cooker 52.36 ^{0}C and finally the panel-type 43.5 ^{0}C. Also the results of the solar cookers, efficiency for the parabolic cooker, box-type and panel-type

were found to be 31.53%, 77.4% and 67.4%, respectively. Finally the results of questionnaire indicated that 74% believe that solar cookers were economically feasible and could protect the environment.

B. Abhishek Saxena, Nitin Agarwal [2]

A new hybrid solar box cooker (SBC) has been developed and tested for thermal performance evaluation in climatic condition of western Uttar Pradesh, India. The uniqueness of new box cooker is an integrated trapezoidal duct and its other integrated elements. The objective of the study is to enhance the heat transfer rate and to reduce the cooking timings by consumption of minimum heat energy. For this purpose, a 200W halogen lamp has been placed inside the duct to enhance the heat transfer. Besides this, 450 of small hollow balls of copper have also been used to improve thermal performance of SBC especially on forced convection mode. The performances testing have been carried to evaluate the thermal efficiency, figures of merit (F1 and F2), cooking power, heat transfer and overall heat loss coefficient. After completion of experiments, thermal efficiency of SBC has been observed 45.11%, cooking power is estimated to be 60.20W and overall heat loss coefficient is obtained around 6.01 W/m2 . Results shows that the present design follow the BIS standards and can cook almost edibles in poor ambient conditions by consuming only 210 W. Discussion has also been made on the significance of the use of copper balls, fan and halogen lamp over the performance of SBC. The present solar cooker has been found as first kind of SBC which can efficiently perform on forced convection in any type of climatic conditions.

C. V S Vigneswaran et al [3]



In this work, an improved latent heat energy storage system was designed and fabricated to carry out experiments with conventional box type solar cooker for late evening cooking purposes. It was found that the efficiency of the solar cooker increased as the mass of the cooking substance increased when boosters were used. Moreover, the time taken to reach high temperature of fluid in the SBC also reduced when boosters were used. Oxalic acid dehydrate of 2.9 kg was used as phase change material. The results of the cooking experiment conducted at late evening hours showed that the selected PCM was able to supply heat energy effectively, with a discharge efficiency of 57%.

D. Yakoob Kolipak, A.M.K. Prasad [4]

Solar cookers with latent heat storage system using phase change materials (PCM) is carried out in the increasing order of the year of work development. As per the work carried out the Paraffin Wax which is having maximum temperature of 156oC will be very nearer to the other PCMs which are between 120oC to 180^{0}C. The Paraffin Wax at 20 ^{0}C, 60^{0}C and 110^{0}C the heat flow rates are 90mW, 140mW and 70 mW respectively. Hence it is confirmed that these heat flow rates can be useful for best daily cooking needs. By using Paraffin wax the night cooking also can be performed very smoothly as phase changing is appreciable. The less costly Paraffin Wax can be replaced in place of costly PCMs in the industry.

E. K.Kavitha and S.Arumugam [5]

An experimental investigation has been conducted in order to study the melting and solidification characteristics of paraffin as a phase change material. The obtained results give a good estimation of the phase change material melting and solidification processes. For the designed wax melting chamber the maximum efficiency of 8.56% was achieved for the load of mass 4kg paraffin wax. It can be concluded that presented work could provide guidelines for thermal performance and design optimization of the latent thermal energy storage unit.

F. I.L. Mohammed et al [6]

A truncated pyramid solar thermal cooker is presented in this paper together with its thermal performances, when booster reflector is covered with black cloth and when booster reflector is exposed to solar radiation. The cooker has proved, in both cases that it is capable of cooking domestic food items as it met the standard requirement set by BIS in terms of the First Figure of Merit (minimum of 0.120). The results and their analysis have shown that when the reflector of the cooker is exposed to solar radiation could be improved by 4.17%. Nominal time reduction of 5 and 6.3 minutes in heating and boiling times could be achieved, although in reality, these could be as high as 30.5 and 33.5 minutes respectively. Pot wall temperature could be increased by about 6 ^{0}C during sensible heating and at boiling point this could be up to 11.6 ^{0}C.

G. N.L.Panwar, S.C.Kaushik et al [7]

Review gives an overview that the solar cooking is the most direct and convenient application of solar energy. Solar energy is a promising option capable of being one of the leading energy sources for cooking. It is cheap compared with other forms of cooking, and is beneficial for areas with abundant sunshine. Various types of solar cookers are available; out of themo box type solar cooker is widely used all over the world. Solar cooker would help in conservation of conventional fuels in rural areas and LPG, kerosene, electricity and coal in the urban areas. Conservation of firewood would help in preserving the ecosystems, and animal dung cake could be used as fertilizer that could aid in increasing production of agricultural products. Moreover, the use of the solar cooker would result in the reduction of the release of CO2 to the environment. As far as exergy efficiency of both type of cooker is concerned it is even lower compared to energy efficiency, it may be due to large exergy of the escaping insolation and additionally due to the degradation of the insolation absorbed on the surfaces of the reflector and the cooking pot.

H. M. Balakrishnan, A. Claude et al [8]

A box type solar cooker was designed and developed indigenously using locally available materials. A parabolic solar concentrator was also designed to be included inside the solar cooker which was found to ultimately increase the retention ratio and quantum efficiency of the infra-red radiations collected. The solar cooker was tested for its efficiency with and without the parabolic concentrator whereby the results proved that the parabolic concentrator played a major part in increasing the collection ratio and thereby the ambient temperature inside the solar cooker.

I. Bihter Arabacigil, Numan Yuksel et al [9]

The potential use and effectiveness of paraffin wax in a new solar cooker was experimentally investigated during daylight and late evening hours. For these experiments, a cooker having an inner reflecting surface was designed, constructed by filling paraffin wax and metal shavings. The side- and sub-surface temperatures of the paraffin wax in the cooker were measured in the summer months of June and July. The thermal efficiency of the cooker was tested on different conditions. The results show that the optimum angle of the outer reflector is 30°. Here, the peak temperature of the paraffin wax in the solar cooker was 83.4 °C. The average solar radiation reflected makes a contribution of 9.26% to the temperature of paraffin wax with the outer reflector. The solar cooker with the outer reflector angle of 30° receives also reflected radiation from the inner reflectors. Besides, the heating time decreased to approximately one hour. The designed solar cooker can be effectively used with 30.3% daily thermal efficiency and paraffin wax due to the amount of energy stored.

J. Harish Ronge, Vyenkat Niture at al [10]

In this paper, study of different solar cooker for domestic use has been done. Also, explanation has given about working and construction of different type of solar cooker and their advantages and disadvantages. There are many aspect about solar cooker require development and that should be subject for working in future. Cookers are not working at night but by using thermal storage will be possible in future.

K. Avesahemad Husainy et al [11]

In this paper experimental set up is to be designed and fabricated for simultaneous cooking and drying purpose. In this experimentation we compared the performance of solar cooker with and without hexagonal reflector with blackening effect. After experimentation we found that due to reflector mechanism and blackening effect we can achieve higher temperature in cooking box. The main specialty of this set is running dryer with the help of excess heat of solar cooker. After experimentation it was found that we can achieve 5-6^{0}C more temperature with blackening effect and 9-10^{0}C more temperature with reflector mechanism. Also time required for cooking is reduced by one hour as compared with experimental set up without blacking effect and reflector mechanism.

L. Kassem, Talal K. et al [12]

Box-type solar cooker has been adopted for the present research due to its simplicity of handling and operation. This solar system is coupled with vacuum-tube collector and integrated with thermal storage material (copper) to overcome the problems associated with the conventional box-type solar cookers. Feasibility of using such type of cooker under climate and geographic location of Taif City, Saudi Arabia will be investigated in the second phase of this research project.

III. Conclusion

In this paper, study of different solar cooker for domestic use has been done. Solar energy is the most gifted energy source and solar cooking is one of the convenient and important techniques of harnessing solar energy. The use of solar energy in cooking is expected to protect environment and reduce health risks. There are many aspect about solar cooker require development and that should be subject for working in future. From this review on solar cooking technology, it may be concluded that solar cookers are beneficial to the community. Performance of box cooker was checked with reflector mechanism and blackening effect.

Further, with use of solar energy, the following objective can be accomplished for healthy environment.

- Costly hi h grade energy fuels: Kerosene, Coal, cooking gas and Electricity can be conserved.
- Deforestation caused for increasing firewood consumption can be minimized.

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