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SOLAR COOKER WITH HEAT STORAGE SYSTEM : A REVIEW

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ABSTRACT-

In most of the developing countries, the urban and rural population depends on non commercial fuels to meet the energy demand for cooking. The use of solar energy is one of the possible solutions for the cooking the food, but its reliability is less due to intermittent nature of solar energy. The intensity of solar energy varies throughout the day and also varies with the months. The reliability of solar energy may be improved to some extent by designing the heat storage system for solar based cooking system. The attempt has been taken in this paper to summarize the research work on solar cooking system with heat storage system.

KEYWORDS: ***Phase change materials (PCMs), solar cooking, heat storage, Heat transfer.***

1. INTRODUCTION

India has good potential of solar energy. Major portion in India receive mean daily solar radiation in the range of 5–7 kWh/m^2 and approximately 275 sunny days in a year [1]. There are two main type of solar cooker used in the country: Box type solar cooker, parabolic solar cooker. The cooking through solar energy is one of the cost effective solution for cooking of food as well as it also protect the environment. Therefore, solar cooking has high potential of diffusion in the domestic sector for cooking. There is some shortcoming associated with solar cooking first it depends on intensity and availability of solar energy. These shortcomings can be overcome to some extend by integrating heat storage system with solar cookers. Different designs of solar cooker have been proposed by different researchers in the literature. Therefore, in this paper, an attempt has been taken to summarize the investigation of the solar cooking system incorporating with heat storage material.

2. CLASSIFICATION OF HEAT STORAGE MATERIALS

Thermal energy storage materials can be classified as sensible and latent heat storage materials. Sensible heat storage further classified as liquid and solid sensible material. Classification of energy storage materials is shown in Fig 1.

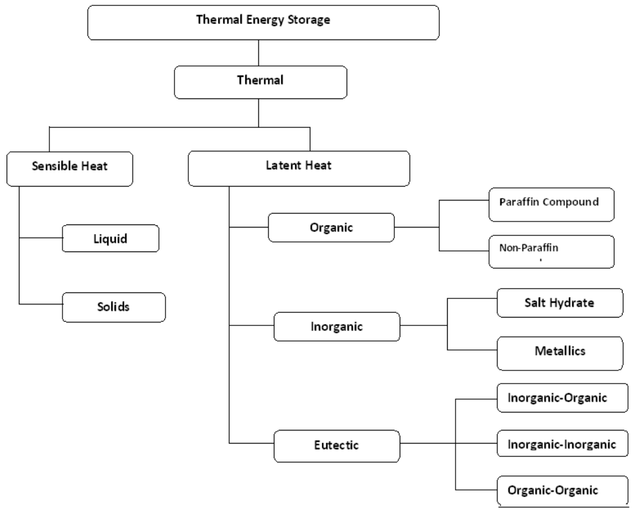

Fig 1 Classifications of Energy storage materials

Water, rock, brick, concrete and engine oil are some of the material which generally used in sensible heat storage [2] . Water appears to be the most promising sensible heat storage material due to its high specific heat and it is inexpensive for mid temperature range. However liquid metals, oils and molten salts are used for storage of thermal energy above 100^{o}C. Rock bed type storage materials are used for air heating application [2]. Latent heat storage (LHS) is based on the absorption or release of the latent heat at constant temperature when a storage material undergoes a change of phase from solid to liquid or liquid to gas or vice versa. Materials used in latent heat storage are the phase change materials (PCMs).

3. SOLAR COOKER WITH HEAT STORAGE SYSTEM

Fig. 2 Box type solar cooker with engine oil as heat storage developed by Nahar [3]

Fig. 2 shows the schematic of a hot box cooker with used engine oil as a storage material developed by Nahar [3]. The space between the inner trays is filled with 5.0 kg of used engine oil and it is completely sealed. The space between the outer tray and the outer box is filled with glass wool insulation and separated by a wooden frame. The maximum stagnation temperature attainable inside the cooking chambers of the hot box solar cooker with storage material is the same as that of the hot box solar cooker without storage during the daytime, but it is 23.8°C more in the storage solar cooker from 17.00 to 24.00 h.

Fig. 3 shows the schematic of flat-plate solar cooker developed by Schwarzer and Silva [4] using vegetable oil as storage medium. The system consists of one or more flat plate collectors with a coated absorber and double glazed covering, cooking pots and a storage tank to store thermal energy. Vegetable oil is used as them heat transfer fluid. The oil is heated up in the collectors and moves by natural flow to the cooking unit, where it transfers part of its sensible energy to the double-walled cooking pots.The major advantages are the possibility of indoor cooking, the use of a thermal storage tank to keep the food warm for longer periods of time or night cooking and the reach of high temperatures of the working fluid in a short period of time.

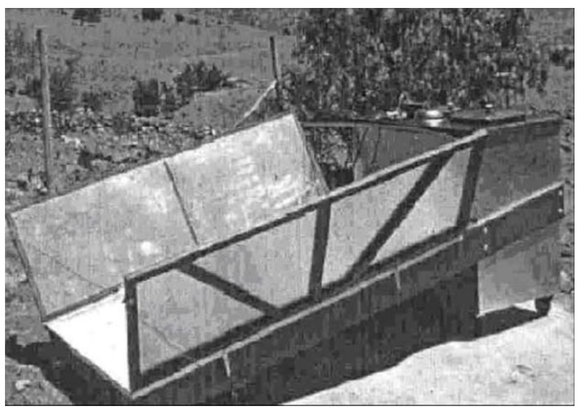

Fig 3. flat-plate solar cooker developed by Schwarzer and Silva [4]

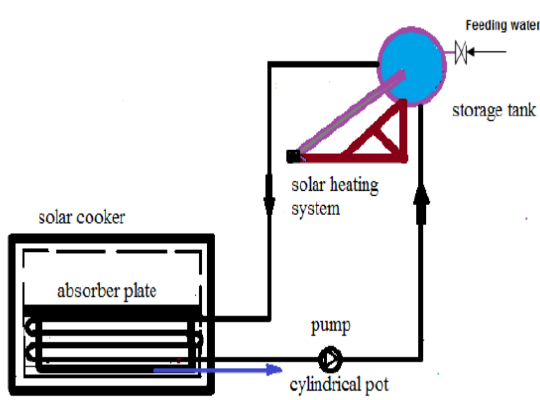

Fig 4. Schematic diagram of solar cooker designed by Kassem [5]

Kassem [5] designed, developed and evaluated the performance of box type solar cooker with paraffin wax as heat storage material (Fig. 4). The cooker is connected to solar water heating system compound of evacuated tubes solar collectors and a storage tank of hot water. The base of this box (the absorber plate) is incorporated by welding with a spiral copper tubes heat exchanger and cylindrical pot inside it filled with paraffin as a PCM. The heat storage accelerate the cooking process which can be started at 12:00 PM. At the same time, the solar heating system decreases the falling of the internal temperature of the cooker.

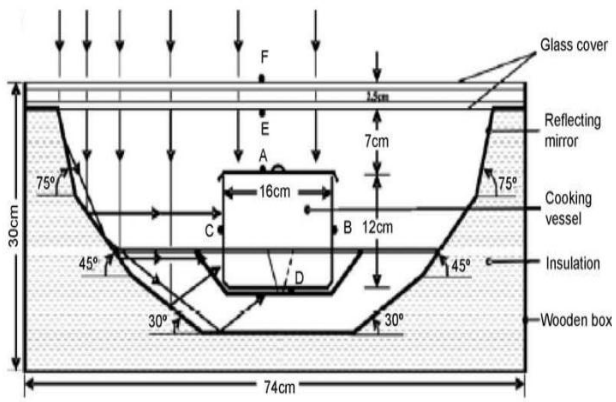

Fig. 5 Box type solar cooker developed by Domanski et al. [6]

Fig.5 shows the schematic of solar cooker with PCM cooking container developed by Domanski et al. [6]. He investigated the possibility of cooking during non-sunshine hours using phase change materials (PCMs) as storage media. For this purpose, two concentric cylindrical vessels (0.0015 m thick), made from aluminum are connected together at their tops using four screws to form a double-walled vessel with a gap between the outer and inner walls. The gap between the outer and the inner vessels is filled with 1.1 kg of stearic acid (melting temperature 69.8^{o}C) or 2 kg of magnesium nitrate hexahydrate (melting temperature 89.8^{o}C) which leaves sufficient space for expansion of the PCMs on melting. The cooker performance was evaluated in terms of charging and discharging times of the PCMs under different conditions. The overall efficiency of the cooker during discharging of the PCM was found to be 3–4 times greater than that for steam and heat-pipe solar cookers, which can be used for indoor cooking.

Sharma et al. [7] designed and developed a cylindrical PCM storage unit for a box type solar cooker to cook food in the late evening (Fig.6). Since this unit surrounds the cooking vessel, the rate of heat transfer between the PCM and the food is higher, and cooking can be faster. They reported that by using 2 kg of Acetamide (melting point 82 ^{o}C) as a latent heat storage material, a second batch of food could be cooked if it is loaded before 3:30 PM during winter.

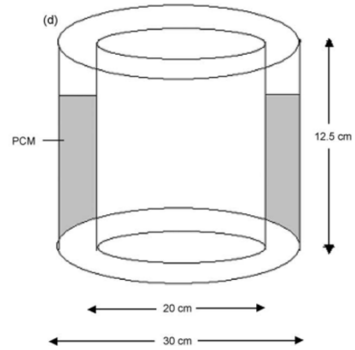

Fig. 6 cylindrical PCM storage unit for a box type solar cooker developed by Buddhi and Sharma [7].

Ramadan et al. [8] designed a simple flat-plate solar cooker with focusing plane mirrors and energy storage capabilities constructed by the locally available materials in Tanta University. The temperature distributions during the test periods through the absorbing plate, the glass covers, the cooking pot, the cooking fluid, the storagemedium and the ambient were determined. The diurnal variations of incident global solar insolation were presented. The utilization of sensible heat storage medium such as sand was investigated thoroughly.A jacket of sand (1/2 cm thick) around the cooking pot has improved the cooker performance tremendously. The temperature differences between the heat source and the heat sink during the test time were determined and the results were discussed. Six hour per day of cooking time has been recorded. Approximately 3 h/day of indoor cooking has been achieved. Overall energy conversion efficiency up to 28.4% has been obtained which was considered the best among other solar cookers in the literature. The possibility of using a phase change material as a storage medium to obtain longer cooking periods was studied. A thin layer of the salt hydrate $Ba(OH)_2 8H_2O$ as a jacket around the cooking pot was suggested.

4. CONCLUSION

Different designs of solar cooking system with heat storage system have been discussed in this paper. Box type solar cooker, solar cooker with flate plate collector has been discussed in this paper. The integration of heat storage system, improved the effectiveness and working duration of solar cooker.The late evening cooking is possible with the integration of heat storage system. Box type solar cooker is commonly used in India, so more research is required to enhance the heat transfer in box type solar cooker with heat storage and to compact the design of heat storage system.

REFERENCE

[1] Arjunan, T. V., H. S. Aybar, and N. Nedunchezhian. 2009. “Status of Solar Desalination in India.” Renewable and Sustainable Energy Reviews 13 (9): 2408–2418.

[2] Agrawal, A., Sarviya, R. M. 2016. A review of research and development work on solar dryers with heat storage. International Journal of Sustainable Energy, 35(6), 583-605.

[3] Nahar NM. Performance and testing of a hot box storage solar cooker. Energy Conversion and Management 2003;44:1323–31.

[4] Schwartzer K, Silva MEV. Solar cooking system with or without heat storage for families and institutions. Solar Energy 2003;75:35–41.
[5] Talal K. Kassem, Investigation Of Solar Cooker With Pcm Heat Storage For High Altitude places (Taif City), International Journal of Mechanical Engineering and Technology ,2012;3(3):555-564.
[6] Domanski R, El-Sebaii AA, Jaworski M. Cooking during off-sunshine hours using PCMs as storage media. Energy 1995;20(7):607–16.
[7] Sharma SD, Buddhi D, Sawhney RL, Sharma A. Design, development and performance evaluation of a latent heat storage unit for evening cooking in a solar cooker. Energy Conversion and Management 2000;41:1497–508.
[8] Ramadan MRI, Aboul-Enein S, El-Sebaii AA. A model of an improved low cost indoor solar cooker in Tanta. Solar and Wind Technology 1998;5:387–93.