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# Review on Phase Changing Material as the Energy Storage in Solar Cooker

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***Abstract :*** *The solar thermal energy is used for various application. The application of solar thermal energy include cooking, water heating, space heating, power generation and agriculture drying. This review include principle and classification, parameters influencing the performance of a solar cooker, and energy exergy analysis related to solar cooking system. The cooking in the evening or off Sunshine hours in solar devices is possible by operating the cooker on auxiliary power or by using different phase change materials in solar cookers. This study includes correct choice of phase change material that will be suitable for the cooking purpose. This demonstrate the feasibility of using a phase change material as the storage medium in solar cookers.*

***Keywords*** *-Phase changing material (PCM), space heating, energy exergy.*

## I. Introduction

The sun produces vast amounts of renewable solar energy that can be converted into heat and electricity, a solar cooker needed solar energy just a free fuel from the sky for operation having the concept to utilize this free fuel from the sun in the mind. Among all thermal energy storage systems, latent heat thermal energy storage is a particularly attractive technique because of the advantage of high energy storage density and isothermal characteristics of charging and discharging processes[16]. Solar thermal energy storage for solar cookers allows for cooking of food during periods when the sun is not available, thus enhancing their usefulness. The viable options of storing thermal energy for solar cookers are sensible heat thermal energy storage and latent-heat thermal energy storage[14]. The intensity of solar rays is unpredictable and often plays truant during rainy and winter season. The harnessed energy is transferred and poorly stored this redus the overall efficiency of the device the time required to cooking the food is increase because of lacking in heat storage. As solar energy is renewable and not associated with any environmental and health problems, it could be used as a source of thermal energy for cooking[12]. The use of phase change materials for storing the heat in the form of latent heat has been recognized as one of the areas to provide a compact and efficient storage system due to their high storage density and constant operating temperature[1]. PCM are promosing candidate for consideration as heat storage media due to their large energy storage capacity. A pcm storage system with small pcm size can be used for rapidly supplying a large amount of heat to the object .Hence,PCM is a good option to store the solar energy during sunshine hours and can be utilized for cooking in late evening or off sunshine hours.

## II. Literature Review

Lameck Nkhonjeraa, Tunde Bello-Ochende, Geoffrey John, Cecil K. King'ondu studied the cooking power is greatly influenced by thermal diffusivity of the storage medium and design parameters namely cooker category, configuration of the cooking vessel in relation to the storage unit, and heat transfer enhancement in the storage medium as well as from solar collector to the storage medium. [2]**.**Geoffrey John, Andreas Konig-Haagen, Cecil k.King' ondu, Dieter Bruggemann, Thermal diffusivities of fresh galactitol within a range of 20–240 were determined by a flash diffusivity instrument. The results show that the upper cycle temperature has a great influence on the attainable number of melting and freezing cycles, the degree of subcooling, the rate of change of degree of subcooling as well as the phase change enthalpy and temperature[3]. Sunil Geddam, G. Kumaravel Dinesh, Thirugnanasambandam Sivasankar (2015) results imply that ,The performance of box-type solar cookers was achieved with the largest cooker load. To increase the thermal energy storage capacity of the box type solar cooker using PCM (paraffin) as medium showed very beneficial for energy conservation. The food cooked in solar cooker can be kept hot for 3–4 h with the help of PCM medium[4].V.P. Sethi, D.S. Pal, K. Sumathy(2014) stated that an optically inclined box type solar cooker with single reflector is presented along

with the design and development of a novel parallele piped shaped cooking vessel design for efficient cooking. Results showed that the first and the second figures of merit (F1 and F2) for inclined cooker were 0.16 and 0.54 as compared to 0.14 and 0.43 for horizontally placed cooker. Time taken to boil the water boil and standard cooking power Pn was 37% less and 40% more respectively in parallelepiped shaped cooking vessel of inclined cooker as compared to conventional cylindrical vessel of horizontally placed cooker especially in winter conditions[5]. Maxime Mussard , Alexandre Gueno, Ole Jørgen Nydal(2013) Both boiling and frying are tested to estimate the cooking efficiency of the heat storage system. Following these experiments, simulations are conducted to optimize and improve the system. Cooking on a heat storage with optimized surface contact is proved to be competitive with standard solar cookers or other cooking devices[6]. S. Mahavar, P. Rajawat Marwal, R.C. Punia, P. Dashora, V.K. (2013) implies that As per the theoretical predication, its thermal performance is found satisfactory to cook 0.4 g rice twice, on a clear day. Reasonable cost, small size, light weight, short payback period and high NPV makes it suitable appliance for rice cooking[7] ]. Antonio Lecuona , Jose-Ignacio Nogueira , Ruben Ventas , Maria-del-Carmen Rodriguez-Hidalgo, Mathieu Legrand (2013) concluded that ,The ensemble is thermally simulated using 1-D finite differences. A lumped elements model with convective heat transfer correlations is used for the internal behavior of the utensil, subjected to external radiation. It is possible to cook the three meals for a family using the utensil prototype here proposed during sunny days in summer as well as in winter[8]. Abhishek Saxena, Varun, S.P. Pandey, G. Srivastav (2011) concluded that 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[9] C.R. Chena, Atul Sharmaa, S.K. Tyagib, D. Buddhi (2008) concluded that,The results also show that the effect of thickness of container material on the melt fraction is insignificant. The results obtained in this paper show that in a box-type solar cooker, acetamide and stearic acid should be used as a latent heat storage materials[12]. Yeliz Konuklu, Orkun Ersoy (2017) concluded that that paraffin/xonotlite composites were synthesized successfully and paraffin was the most suitable phase change material for preparation of phase change material/xonotlite composites. The melting and crystallization heats were determined to be 65.8 and −63.5 kJ/kg. We recommended that the fabricated nanocomposite-PCMs offer proper phase transition temperature range heat enthalpy values for thermal energy storage applications [16].

## III. Phase Change Material

PCM are heat storage media due to their large energy storage capacity. PCM is a good option to store the solar energy during sunshine hours and can be utilise for cooking in off sunshine hours, As the source temperature rises, the chemically bonds within the PCM break up as the material changes phase from to liquid[3]. Latent heat storage can be achieved through liquid to solid, solid to liquid, solid to gas and liquid to gas phase changes. However, only solid to liquid and liquid to solid phase changes are practical for PCMs. Although liquid to gas transitions gaunt has higher heat transformation(processing) than solid to liquid transitions, liquid to gas phase exchanges are impractical for thermal wide storage because golden volumes high press are required to blind the materials in their gas phase. Solid-solid phase exchanges typically very are slow dance and gaunt has relatively low heat transformation (processing)[4]. There are some different types of Phase change materials like stearic acid, acetanilide, parafine, wax, erythritol, magnesium nitrate hexahydrate,etc.

| No | Author | PCM material | Latent heat of fusion(KJ/Kg) | M.P. (º C) | Type of collector | PCM temperature achieved (º C) |
|---|---|---|---|---|---|---|
| 1 | Atul Sharma[1] | Stearic acid | 161 | 55 | Box | 80 |
| 2 | Buddhi And Sahoo[1] | Acetanilide | 222 | 118.9 | Box | 130 |
| 3 | S.D. Sharma[2] | Erythritol | 339.8 | 118 | Evacuated | 140 |
| 4 | A.Lecuona[7] | Paraffin | 140 | 100 | Parabolic | 164 |
| 5 | R.M. Muthusivagami[5] | Acetanilide | 222 | 118.9 | Parabolic | 186.3 |

**Table3.1Review of recent work on solar cooker using PCM**

## IV. Phase change process

Latent heat storage is the most efficient ways of storing thermal energy. Unlike the sensible heat storage method, the latent heat storage method provides much higher storage density, with smaller temperature difference between storing and releasing heat, every material absorb heat during a heating process while it's temperature is rising constantly. The heat store in the material is release into the environment through a reverse cooling process, the material temperature decreases continuously. During complete melting process, temperature

of PCM as well as its surrounding area remains nearly constant. When temperature increases PCM absorb heat and storing this energy in the liquefied phase change material, when the temperature falls the PCM release this stored energy and PCM solidify[5].

## V. Experimental Process

In the concentrating solar cookers the cooking jar is placed at the focus of has concentrating mirror. Concentrating type solar cooker is working on one or two axis tracking with a concentration ratio up to 50 and temperature up to 300º C, which is suitable for cooking[7]. Concentrating cooker utilize lenses parabolic concentrators to attain maximum temperatures they are popular among concentrating cookers because the focus is much better and sharper than that of other typical of reflectors drank at the same time it is very sensitive plant to even has slight exchange in the position of the sun and hence the use of such reflectors requires constant tracking This is the most effective type of the collecting the solar radiations[9].

Parabolic cooker reach higher temperature and cook more quickly than solar box type cooker, but are harder to make and use.

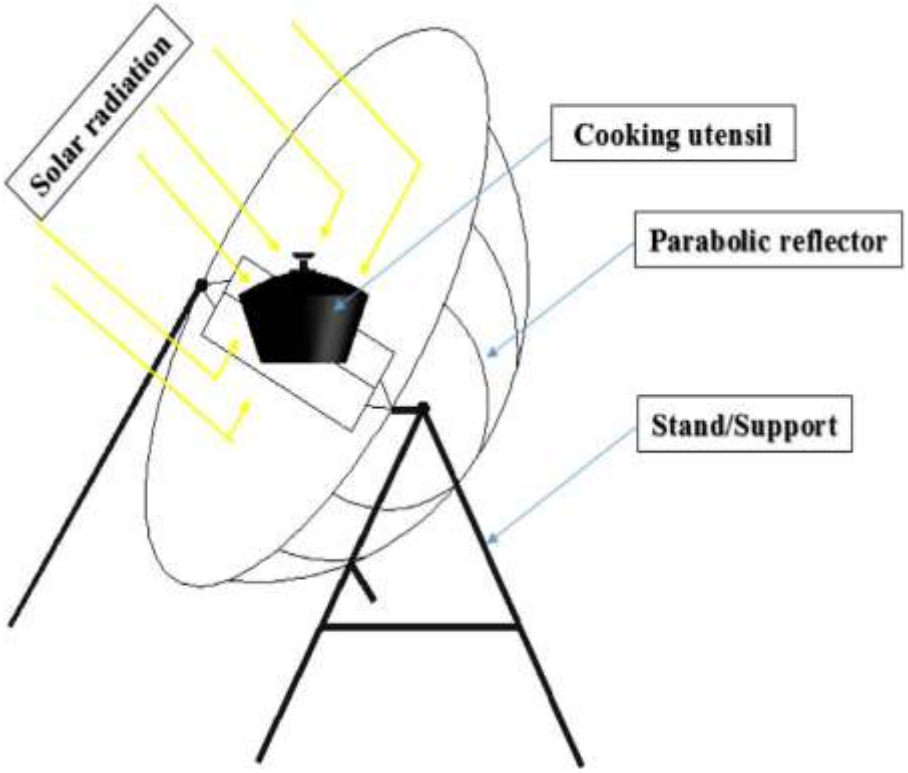


**Fig A- parabolic type solar cooker**

### 1. Parabolic Collector

In parabolic collector's is has type of solar thermal collector's that was curved have has parabola, lined with has polished metal to mirror. The energy of sunlight which enters the mirror parallel to its glides of symmetry is focused along the focal length, where objects are positioned that are intended to be heated. For example, food may be placed at the focal length, which causes the food to be cooked when the trough is aimed so the sun is in its plane[7]. The shape of a parabola means that incoming light rays which are parallel to the dish's axis will be reflected toward the focus, no matter where on the dish they arrive. Light from the sun arrives at the Earth's surface almost completely parallel, and the dish is aligned with its axis pointing at the sun, allowing almost all incoming radiation to be reflected towards the focal point of the dish. Most losses in such collectors are due to imperfections in the parabolic shape and imperfect reflection. Losses due to atmospheric scattering are generally minimal. However, on a hazy or foggy day, light is diffused in all directions through the atmosphere, which significantly reduces the efficiency of a parabolic dish[12].

**Fig.5.1 Parabolic type solar collector[13]**

**2. Cooking Equipment**

Cooking vessels are components of solar cooker that are indirect contact with the absorber plate. Both serves in receiving the absorbed useful energy and transmitting it to the food. Various shapes of cooking pots can be utilized, however, the rectangular and cylindrical shaped cooking utensils that are made up of aluminum or copper are recommended[2]. The cooking pot is painted black from outside and placed in the center of the absorber tray to rise the rate of heat transfer by conduction between them. In the vessels, cooking space is surrounded with PCM. For ease of operation and fast cooking proper design of solar cooker is important parameter[4].

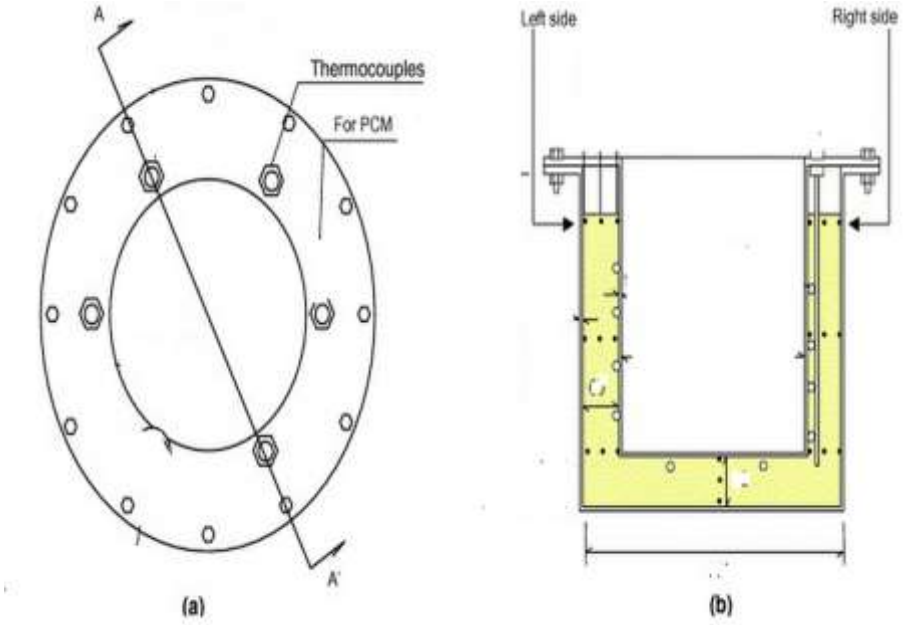


**Fig.5.2. Cooking Equipment [2]**

## VI. Conclusion

From the review it is concluded that, there are various options to meet the end user needs using both commercial and non-commercial energies. Traditional fuels like wood pellets, dung cakes and kerosene utilization must be minimized with the developed solar cooker. This will lead to a reduction in human drudgery. Such an effort will not only be useful in improving the quality of life but also in environmental protection. This paper focuses on several qualities of solar energy such as; a free fuel from the sky, environment friendly, huge availability of almost places, low or no running cost, good saving, minimization of the monthly electricity bill, accident free, less attention is required etc. Apart this, in the field of solar cooking the available thermal energy storage technology for solar cookers food can be cooked at late evening, while late evening cooking was not possible with simple solar cooker. Every element of solar cooker have great importance and direct effect on the performance of solar cooker in any climatic condition. Many of PCM's are under testing for solar cooking but Acetanilide is commonly used due to easy availability and economically suitable till now. it is more convenient for used in parabolic type solar collector.

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