# Concentrated Solar Cooker By Integrating Pcm Material

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**Abstract:** In India for the cooking purposes the conventional fuels are likely consumed more than the non-conventional fuels, and the household conventional fuels increase air pollution. By switching to the non-conventional way of cooking it is a way of reducing the household air pollution caused by conventional fuels. Solar is the one of the efficient way of cooking and heating purposes without pollution .The way of cooking is with the parabolic dishes, the concentrated solar rays is made to be focussed on the vessel placed nearby it, which in turn heats and cooks the meal placed in it. But the problem in solar cooking system is that the cooking is cannot be performed after the sunshine hours and people hesitates to adopt it for the fulltime cooking. The problem can be overcome by employing the phase change materials additionally when the vessel subjected to the sunrays the phase change materials which were surrounded to the vessel is also subjected to sunrays which melts the phase change materials and in turn absorbs heat up to maximum temperature of 372.5℃. The absorbed heat can be used after the sunshine hours particularly for evening cooking purposes, the heat absorbed during the sunshine hours is now liberated to cook the meal. Finally solar cooking is made flexible for the cooking purposes.

## 1 INTRODUCTION

India is in one of the most populous countries in the world with about 136.23 crores people in it. The food grain production has increased as high as 284.83 MT (million tonnes).The annual per capita consumption of food grains alone reaches to about 209.08 kg. The increasing population requires a better, cheaper and cleaner way of cooking. The most popularly used fuels for cooking are LPG, Kerosene and Firewood. Nearly 80% of Indian households now have access to LPG. Firewood and Kerosene are the main source of cooking fuel in towns and villages.On an average LPG costs about Rs.18,656 per household annually. With the continuous rise in the prices of basic commodities and the increasing threat posed by the use of fossil fuel, the need to harness free and renewable energy has gained much prominence. A very promising source of such energy is the sun which virtually cost nothing and pollution-free. One of the best technologies derived from the utilization of solar energy is the solar cooker.

## 2. LITERATURE REVIEW

Vassilis Daioglou et. al. [1] First of all, residential energy use represents about 35% of global energy use and it therefore plays a key role in global energy-related environmental problems such as climate change and resource scarcity.It portrays vitality interest for a few end-use capacities dependent on a lot of physical drivers. Karimatu L. Abdullahi et. al. [2] portrays that It has for quite some time been realized that cooking can make high groupings of airborne inside. Progressively, it is currently being accounted for that cooking vaporized is additionally a noteworthy segment of open air particulate issue.

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Up 'til now, the wellbeing outcomes are unquantified, however the nearness of surely understood substance cancer-causing agents is an unmistakable sign that cooking airborne can't be kind. It is discovered that cooking can produce both apparent masses of vaporized at any rate inside the region where the cooking happens, that molecule sizes are to a great extent inside the respirable size range and that significant gatherings of substance mixes which have been utilized to describe cooking airbone.R.M.Muthusivagami et. al. [3] onsidered that the constant increment in the degree of ozone harming substance outflows and the expansion in fuel costs are the principle main impetuses behind endeavors to all the more viably use different wellsprings of sustainable power source. In numerous pieces of the world, direct sun based radiation is viewed as one of the most planned wellsprings of vitality. Warm vitality stockpiling is basic at whatever point there is a jumble between the inventory and utilization of vitality. Inert warmth stockpiling in a stage change material is exceptionally appealing a direct result of its high stockpiling thickness with little temperature swing.The decision of PCM assumes a significant job notwithstanding heat move component in the PCM. Murat Kensisarin et. al. [4] depicts that the nonstop increment in the degree of ozone harming substance discharges and the move in fuel costs are the principle main impetuses behind endeavors to all the more viably use different wellsprings of sustainable power source. In numerous pieces of the world, direct sun based radiation is viewed as one of the most planned wellsprings of vitality. Be that as it may, the huge scale use of this type of vitality is conceivable just if the powerful innovation for its stockpiling can be created with worthy capital and running expenses. One of imminent systems of putting away sun based vitality is the use of stage change materials (PCMs). Lamentably, preceding the huge scale reasonable utilization of this innovation, it is important to determine various issues at the innovative work arrange. It takes a gander at the ebb and flow condition of research in this specific field, with the primary spotlight being on the evaluation of the warm properties of different PCMs, strategies for heat move upgrade and structure designs of warmth storerooms to be utilized as a piece of sun powered uninvolved and dynamic space warming frameworks, nurseries and sunlight based cooking. Antonio Leucona et. al. [5] tells about the pertinent issues on sun based cooking so as to characterize and assess an inventive format of a convenient sun powered cooker of the standard concentrating explanatory

sort that joins an every day warm stockpiling utensil. This utensil is framed by two ordinary coaxial round and hollow cooking pots, an interior one and a bigger outer one. The void space between the two coaxial pots is loaded up with a stage change material (PCM) shaping a middle coat. The group is thermally recreated utilizing 1-D limited contrasts. A lumped components model with convective warmth move connections is utilized for the interior conduct of the utensil, exposed to outer radiation. Two alternatives have been checked as conceivable PCMs: specialized evaluation paraffin and erythritol. Sun oriented cookers can have various groupings relying upon how they are being considered. In view of how warm vitality from the sun is moved to the cooking vessel, they can be partitioned into two principle classes: immediate and circuitous. On the other hand, while thinking about the setup of the gadget, there are three principle classifications: box cooker, concentrating cooker, and board cooker. The regular sorts of sunlight based cookers can be seen in Solar cookers can have a warm stockpiling segment in their structure. The cookers furnished with this segment can be characterized into two sorts: dormant warmth and reasonable warmth. Mohamad Aramesh et. al. [6] learned about the kinds of sun based focusing cookers have been generally utilized, yet they are not as well known as the container type, which are less expensive and simpler to develop Some various structures of concentrating cookers. solar concentrating cookers are generally classified into two categories: parabolic and trough although other special designs have been introduced. Parabolic cookers are normally indirect cookers. Lecuona et. al. used technical grade paraffin and erythritol as PCMs in a parabolic solar cooker. The PCMs were placed in the cooking vessel and divided between two pots. The authors' experiments revealed that simultaneous cooking and heat storing were possible with this method. They also used an insulated box to maintain the thermal energy of the PCMs. By applying insulation, the cooker could be used for cooking both breakfast and dinner .In a progressively point by point work, Mussard and Nydal built an aberrant illustrative sun powered cooker furnished with a sun following framework and a PCM. In their structure, a warm oil (Duratherm 630) streamed inside a safeguard tube. Two methods of vacuum tube-molded safeguards were tried ie., with insulation and without insulation. Insulation reduced system efficiency at low temperatures but increased it drastically at high temperatures (200 to 220°C). Cooking was done by the PCM after charging. This design can boil water in 38 minutes and fry meat in 20 minutes.

## 3 MATERIALS AND METHODOLOGY

### MATERIALS

| S.NO | COMPONENTS | MATERIAL |
|---|---|---|
| 1 | Parabolic Solar Collector | Steel |
| 2 | Receiver Cup | Stainless Steel |
| 3 | Phase Change Material | Erythritol |
| 4 | Tubes | Stainless Steel |
| 5 | Frame Bars | Steel |
| 6 | Reflecting Mirrors | Glass Mirrors |

### METHODOLOGY

Planning of the project. Selection of the materials. Designing the parts and assembly. Fabrication of the parts. Assembling the parts. Final Experimental setup.

### FABRICATION PROCEDURE

As the problems were discussed early before, the existing problem in the solar cooking is the no proper way to transmit or store the energy emitted during the sunshine times. The vessel which is subjected to the sunrays from the parabolic trough is subjected to some important changes that the vessel is surrounded by vertical steel tubes additionally and the phase change materials were filled into it. Phase change materials was employed here as a latent heat storage unit. The latent heat storage preserves the heat for evening cooking.The following flow chart represents the methodology of the project The receiver is surrounded by stainless steel tubes.Inside the stainless steel tubes the PCM materials are filled.Inside the receiver a vessel is kept which acts as an cooking medium.The upper surface of the receiver is with aluminium foil paper with prevents the heat loss. Diameter of the dish = 694mm
Centre height of the dish = 45mm

### DESIGN CALCULATION

Glass Dish
Diameter of the dish = 694mm
Centre height of the dish = 45mm
1 .Focal Length

$$f = \frac{D^2}{16h}$$

$$= \frac{694^2}{16\times45}$$

$$= 668.9 \approx 670\ mm$$

2. Rim Angle:

$$\Phi = 2\,tan^{-1}\left(\frac{694}{4\times670}\right)$$

$$\Phi = 29.04°$$

3. Half acceptance angle:

$$\Phi_A = \frac{90-\Phi}{2}$$

$$= \frac{90-29.04}{2}$$

$$\Phi_A = 30.48º$$

## 4. MAXIMUM RADIUS OF DISH:

$$P = \frac{2(670)}{1+\cos(29.04)}$$

$$P = 715\ mm$$

## 5. SURFACE AREA (OUTER):

$$A_s = \frac{8\pi f^2}{3}\left\{\left[\left(\frac{D}{4f}\right)^2+1\right]^{3/2}-1\right\}$$

$$= \frac{8\pi\times 670^2}{3}\left\{\left[\left(\frac{694}{4(67)}\right)^2+1\right]^{3/2}-1\right\}$$

$$=3843.5\times 10^2 mm^2$$

## 6. APERTURE AREA:

$$A_a = \frac{\pi}{4}(2P\ sin\ \Phi\ )^2$$

$$= \frac{\pi}{4}(2(715)\sin 29.4)^2$$

$$=3782.5\times 10^4 mm^2$$

## 7. DIAMETER OF FOCAL POINT:

$$D_{fo} = 2P\ sin\ \Phi A$$

$$= 2(715)\ sin\ 30.48$$

$$=72.5mm$$

## 8. AREA OF FOCAL POINT:

$$A_{fo} = \frac{\pi}{4}\left(D_{fo}\right)^2$$

$$= \frac{\pi}{4}(72.5)^2$$

$$= 41.28\times 10^2 mm^2$$

**Experimental Setup**

The experiment is performed in two steps by keeping the 10kg mass of receiver or cooking pot at the focus of the parabolic dish. Water heating test and cooling test were performed in both the steps of the experiment. In the first step, the receiver is filled with 2 l of water inside the pot and both heat transfer layer and PCM tubes are also filled with water. Temperature of the water in all the layers of receiver is recorded for every 5min time interval. After water inside the receiver reaches final temperature, the receiver is covered from the solar radiation for the cooling test. The temperature of the water inside the receiver is recorded again from the final value till it reaches 60℃. The time constants s are calculated for the temperature rise from 60℃ to boiling point and s0 is calculated from fall of temperature till the water temperature reaches to 60℃ from the boiling point of water. In the second step, the PCM tubes of the receiver are filled with PCM material. Heat transfer layer is filled with palm oil and 2 l of water is filled in the cooking layer of the receiver. The temperature in all layers of the receiver was recorded for every 5min. After water reaches boiling point, the receiver is covered from the solar radiation and cooling test was performed. Temperature of the water is recorded for every 5min till the water reaches from boiling temperature to 40℃. Again, the time constants were calculated by following the same procedures as mentioned in the first step.

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## 9. CONCLUSION

Thus the solar cooker using phase change materials is being designed and fabricated. Thus the problem in existing solar cooking method is studied and the appropriate solution is provided by using the phase change material as latent heat storage in the solar unit. Thus the heat stored in it can be restored for cooking in evening times The solar cooking unit can be used with different phase change materials in future for increasing the thermal conductivity in further to improve the efficiency of cooking in evening times. The solar cooking unit can be fitted with sun tracker to improve the overall efficiency in cooking.

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