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RESIDENTIAL SOLAR COOKER WITH ENHANCED HEAT SUPPLY

Priyanka Wasudeo Phirke[1], Wasudeo D Phirke[2]

Final Year Mechanical Engg., Late Sau K.B. Jain COE Chandwad (India)

ABSTRACT

Energy has become the utmost necessity of our life. It is required from dawn to dusk to fuel the world. Energy is scattered everywhere around the Earth. Man has always desired to capture it and use it for mankind. One of the most important sources of energy is solar energy. Several methods of capturing solar energy and its usage are practised. The intensity of solar rays is immense and ways are still being discovered to harness the full potential of the rays. Focussing the rays to a point will cause generation of heat. Transferring the energy towards cooking is one such method. Usually a solar cooker is a device that is placed in the open ground under direct sunlight. This causes inconvenience to the users. Recent developments are in progress to make it possible to cook under shelter harnessing energy from the solar rays.

There is extensive potential in the solar rays yet to be harnessed. The existing methods, apart from being inefficient in transferring energy, it fails to store the heat effectively. Introduction of Phase Change Materials (PCM) has done the trick of harnessing sun's energy to cook. By doing so the heat energy storing efficiency is increased and thereby effectively increases the process of cooking. With prices of LPG elevating, using this method proves to be cost effective and energy conserving. Unlike induction stoves, the residential solar cooker uses energy from the solar rays and is cost effective. In the absence of sunlight, the PCM setup still increases the efficiency of heating the utensils.

Index Terms- Solar Cooker, Phase Change Material, Wax, Solar Mini Pond, Parabolic Point Solar Collector

I. INTRODUCTION

He present day solar cooking promises in our expense.It could promise future technology when it comes user friendly.the usage of solar cooker is not predominantly found everywhere because of its seasonal changes.The intensity of the solar rays is unpredictableand often plays truant during rainy and winter seasons. Theharnessed energy is transferred and poorly stored. This reducesthe overall efficiency of the device. The time required to cookthe food is increased because of lacking in heat storage.To overcome these major problems, a new design has beendevised to heat efficiently using the sunny days and as well as theother dusky situations. This device not only transfers energyefficiently and stores it for continuous usage. The PCM materiallayered around the vessel stores heat effectively and heats up thevessel. This helps in reducing the fuel consumption to a greater extent during non-sunny days. The harnessed energy is notliberated thus assuring fast heating process.

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II. EXISTING SYSTEMS

A. Box Cookers

Box cookers are the most common type made for personaluse. They consist of an enclosed inner box covered with clearglass or plastic, a reflector, and insulation. There is a widevariety of patterns and plans that can be adapted to workwith available materials. While they do not heat quickly,they provide slow, even cooking. Box cookers are very easyand safe to use, and fairly easy to construct.

B. Panel Cookers

Panel cookers are flat reflective panels which focus thesunlight on a cooking vessel without the inner box commonin box cookers. Panel cookers are the easiest and leastcostly to make, requiring just four reflective panels and acooking vessel, but they are unstable in high winds and donot retain as much heat when the sun is hidden behind clouds.

C. Parabolic Cookers

Parabolic cookers reach higher temperatures and cookmore quickly than solar box cookers, but are harder to makeand use. Parabolic cookers require more precision to focus thesunlight on the cooking vessel. If the sunlight is not focusedexactly on the cooking vessel, the food will not cook.Whenthe parabolic oven is used, the temperature must be watchedso the vessel does not overheat, burning the food. The risk ofburns and eye injury is greater with homemade parabolicdesigns. While they provide excellent results when usedcorrectly, they are not easy to build at home and require greatcare to use.phase change material is calculated. According to the pondered

III. DESCRIPTION

Cooking is vital and it has to be done in all places. Energyrequired for this operation is only from either LPG or electricity.Troubles will be faced in the production of both LPG andelectricity. The effective cooking is also done by the alternativeresources like solar energy which is explained below. The intactunit consists of vacuum tubes, phase change materials, cookersurrounded by the jacket, small tank, insulated tubes andparabolic collector. The system is designed with theassumptions of 5 persons in a domestic house.vaccum cube istaken and copper tubings is done inside it.The intent for choosingPCM is that it has superior latent heat storage. The volume ofvolume, phase change materials are crammed into insulatedcubical box. The cubical box is chosen as it has lower value ofsurface area to volume (SA/V) ratio compared to other standardshapes. Hence heat loss will be minimum at the night time. Thecopper tubes are placed inside the vacuum tube which is bentfor greater surface contact and to enhance the better heattransfer and water is promulgated inside the copper tube. Thisentire setup is positioned in the point focus of the paraboliccollector.

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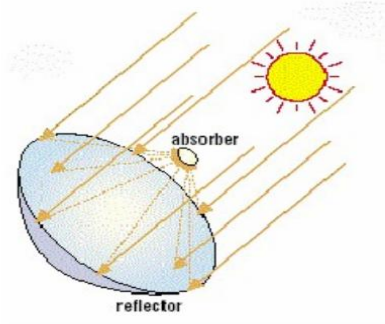

Figure 1:parabolic point collector

The area of parabolic collector is calculated by consideringavailable solar irradiation per unit area and the energy required.Seven coils of copper tube are to be found for better surface areacontact in the cube of phase change material located in thecentre.since 57kg of PCM is required ,so two parabolic pointsolar collectors are used. The small tank is sited next to thecooker for condensation of the wet mixture. A pump is also built-in for the circulation of water and it completes one cycle. Thetemperature of water increases aggressively and it cooks the foodin the cooker. If this system is erected in the universe, we caneasily face the LPG and electrical power demand. By eliminatingthe usage of LPG, we can control the carbon emissions in largequantity.

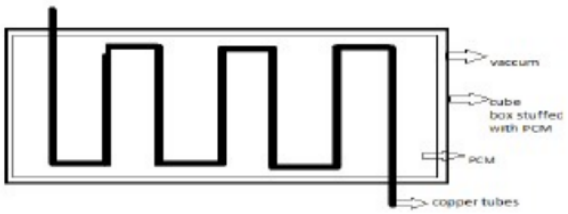

Figure 2: Cube box sectional view placed in parabolic trough

IV. WORKING

The entire arrangement works by utilizing heat from the solarirradiation and the efficiency relies upon the effective wayswhich harness the full potential of the sun. The paraboliccollector is selected for the rationale of obtaining point focus init. The parabolic collector reflects sun rays and converge it into apoint where the vacuum tube packed with phase change materialis positioned. Copper tubes are mounted inside the phase changematerial. The water as a working substance is circulated insidethe copper tube which absorbs the heat extracted by the vacuumtube. In between the vacuum tube, cube of PCM is located whichis well insulated from the surroundings which also playseffective role in heat transfer. Hot water is transferred to thecooker by insulated pipes to eliminate transmission heat loss.

Due to the solar irradiation, water gets heated up in step by stepprocess.since preheating is done in the first parabolic point solarcollector,its is passed through non radiating pipes towards the

second parabolic point collector to acquire required temperatureas shown in layout Figure[3]. This hot

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water is made circulatedthrough the jacket in the cooker. The small tank is sited next tothe cooker for the condensation of the wet mixture of watervapour. A pump is used to drive the system of fluids. A valve isfitted for the adjusting of mass flow rate of water. This massflowrate will controls the cooking temperature. If the mass flowrate is higher, it obtains lower cooking temperature and viceversa. This system surely meets the demand of LPG and powerconsumption and it also reduces pollution.The process isexplained in Figure[3]

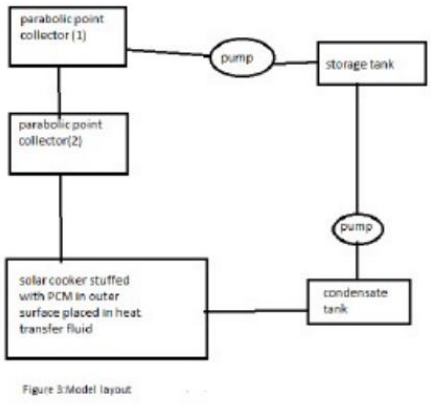

Figure 3:Model layout

V. CALCULATION

ASSUMPTIONS

1) It is assumed that 7L cooker is suited for 5 people in a house
2) The cooking food is considered to be water
3) The location for cooking is chosen to be Madurai, Tamilnadu,India
4) It is assumed that maximum final temperature of the food is130-150C
5) Parabolic collector to be designed for PCM to attainmaximum temperature of 160C
6) Optimum melting point of PCM is 120C
7) Time required to cook food during night time is assumed to be1½ hours

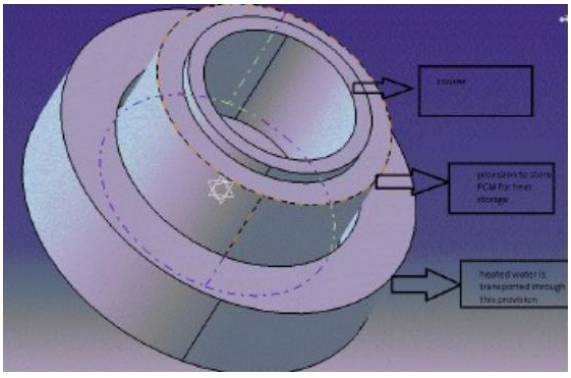

Figure 4:CAD MODEL OF COOKER

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5.1 Energy Required to Cook food

Volume of the Cooker V = 0.007 m

For water,

Density = 1000 kg/m^3

Mass m = 7 kg

Specific heat (at constant pressure) C= 4.187 kJ/kg K

Initial temperature of food Ta = 30C (room temperature)

Maximum final temperature of food Tb=130C

Temperature difference dT = 100C

Required heat energy Q = m * C

dT= 7 * 4.187 *100

Q = 2930.9 kJ

5.2 Time for Backup

Due to absence of sunlight during night time cooking,let maximum time required to cook during night time = 1 ½ h

5.3 Temperature

Maximum Cooking temperature T1 = 150C

Maximum temperature of PCM T2 = 160C

5.4 PCM Selection

Required melting point of PCM = 120C

Name = S117

Melting point = 117C

Density = 1450 kg/m^3

Latent heat L = 160 kJ/kg

Specific heat capacity Cp = 2.61 kJ/kgK

Thermal conductivity k = 0.7 W/mK

5.5 Mass of PCM Required

Heat energy required to boil 1L q = 291.14kJ

By experiment,

Time taken to reach boiling point of water = 20 min

For 20 min energy supplied = 291.14 kJ

Let us assume backup time t = 1 ½ h

For 1 ½ h energy required Q = 1310.13 kJ/L

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For 7 Litre,

m=57kg

Total energy required Q = 9170.91 kJ

Q=m*L

m = Q/L

5.6 57kg of PCM can be filled in 77.11cm side of cube .but we haveused two parabolic point collector troughs, so two evacuvated cubes with copper pipings is made. eventually a cube has a side of36 cm(approx).two cuboids are used because of getting PCM toobtain its phase change temperature quickly .

5.7 Design of Coil Assumptions

* Copper pipe diameter d = 12 mm

*Coil diameter D = 150 mm

* Free gap G = 10 mm

*No. of turns n = 7

*Secondary Length of the coil l = 100 mm

* Total length of the coil,

L = n * ((2 * p * r) + G) + (2 * l)

L = 53 cm

5.8 Mass of CO2 Emission by LPG

LPG contains 70% propane and 30%butane

The chemical reactions are:

Propane :

C3H8 +5O2 ->3CO2+4H2O

Butane:

2C4H10+13O2->8CO2+10H2O

By atomic weight calculation,it is found 1 ton of LPG emits 3.04ton(approx)

VI FURTHER WORK

Since cooker is covered with PCM for cookingat night time with enhanced heat supply system. We can make it tokeep fresh to serve by incorporating PCM inside cooker,atsurface where it is supposed to ignited.CAD drawings of proposed further work is shown here in Figure [5].PCM is filledin some extended surface which doesn't affect the cookingmethods helps to utilize the waste energy and make it Go Green.

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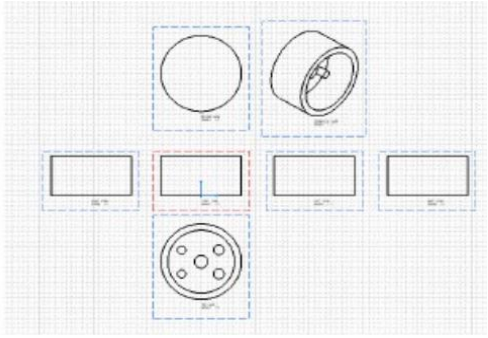

Figure 5: Proposed work draft model

VII RESULTS AND DISCUSSION

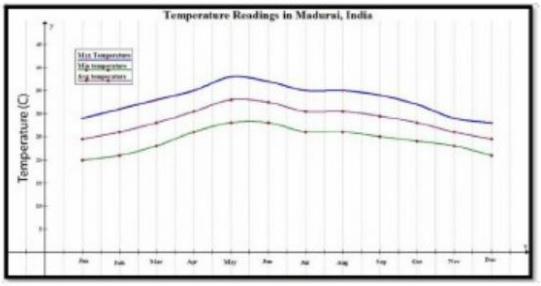

Figure 6: Temperature reading in Madurai

The above graphs shows the temperature readings inMadurai with average day time temperature as maximum temperature and minimumtemperature to be a night time temperature.

This graph shows that there will be enough solar irradiationin the tropical regions especially in Indiato implement the steam cooking which is more suitable forhouses and also hotels.

VI. CONCLUSION

The calculation is performed for above all assumptions andthe total system is designed forthe domestic house. From the graph, it is found that theaverage day temperature of Madurai is 35degree celcius.

Hence it meet the cooking requirements by adopting theabove design. The drawbacks in this systemwill be little more investment than other systems. But thepayback period will be few yearswhich total cost of cooking will be only the maintenancecost of the system. By improving the designof vacuum tubes, PCM selection, tracking mechanismcollector shapes etc., will have a great scope in market.

As our demand for LPG and electrical energy areescalating day by day, the amount of fossilfuel will become scarce on one day. By implementing thissystem, it eradicate for cooking in night time. The overallsystem will work only during the daytime then it will notbe compact and there will be cooker in each and everyhouse will replace LPG and electric stove. Installation ofthis system in India reduces more than millions oftemperature can be greatly reduced in the future.to thishectic world. The effects of thermo physical properties ofPCM,

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installation methodology, location of PCM are scopeof future work.

ACKNOWLEDGEMENT

We hereby declare that the paper above is our ownthoughts developed into a model and working for future works.

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