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Solar Cooker Thermal Energy Storage System Using Acetamide

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Abstract : The solar energy is an important part of the renewable energies. Their abundance and low cost are two great strategic advantages, that they turn it an excellent energy alternative for developed and developing countries. PCM storage unit for a solar cooker is proposed for the this project work .The storage materials for temperatures applicable for food cooking range is required to be selected .There is need to design the system by quantifying the storage materials ,type, technical parameters and its incorporation in to the solar cookers or new device of the solar cookers. Acetamide is used as specific heat storage material.The project work is planned accordingly, but literature is reviewed in every aspects of the components of the solar thermal cooking system.

Keywords: Solar cooker, PCM, Acetamide, Thermocouples.

I. INTRODUCTION

A solar cooker, or solar oven, is a device which uses the energy of sunlight to heat food or drink to cook it or sterilize it. High-tech versions, for example electric ovens powered by solar cells, are possible, and have some advantages such as being able to work in diffuse light. However at present they are very unusual because they are expensive. The vast majority of the solar cookers presently in use are relatively cheap, low-tech devices. The current worldwide trend is towards finding alternative energy sources. Looming difficulties in securing fossil fuels, their climbing costs together with their detrimental environmental impact, all make it important to find viable alternatives, such as energy derived from biofuels, wind farms, wave and tide, nuclear, and solar. The solar energy is an important part of the renewable energies. Their abundance and low cost are two great strategic advantages, that they turn it an excellent energy alternative for developed and developing countries. Solar thermal technology is concerned principally with the utilization of solar energy by converting it to heat. In the concentrating type of solar collector, solar energy is collected and concentrated so that higher temperatures can be obtained. Energy for cooking is the basic requirement of mankind all across the world. In developing countries like India, energy requirement for cooking is 36% of the primary energy consumption (Sharma *et al.*, 2009). In India, 70% of population is living in rural areas. More than 80% of this population is dependent on firewood, dung-cake and agricultural waste for fulfilling their energy requirements. While in urban area, people are dependent on firewood, LPG, Kerosene oil and electricity. In rural areas, the dung-cake, firewood, agricultural waste are available at free of cost but it requires a lot of effort in gathering these fuels and in urban areas the fuel is available at high cost. The fuel used by the population of India in rural or urban area is leading to

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deforestation and continuously polluting the environment. Considering the need of storage at extended periods ,this project deals with design and development and analysis of solar thermal system for cooking i.e domestic applications

II. PROBLEM DEFINITION

In innovation theory there are two approaches: Technology-push and Demand-pull. Solar cookers belong to the first category. In India they were promoted by the government mainly for targets rather than for a long-term goal with reliability. It has been proved in many cases (solar cookers are no exception) that wherever subsidies are offered the quality suffers as the main accent will be to minimize the cost. Any device/gadget should meet the user's needs. Nobody uses useless things. Bicycles costing three times that of a solar cooker were never subsidized but millions of them are in use in India today. As such, solar cookers should meet the user's needs . Also, the report in *Rural Energy Journal* presents interesting reading; "A majority of the half-million solar cookers sold are in cities, almost none in rural areas where women suffer most from indoor air pollution from cooking. They estimate only 10% are being used or are in working order. Unless the cookers are available in several sizes and price ranges, are lighter and sturdier, they are unlikely to be seen under the sun where they belong.

The main reasons for slow progress of solar cookers in India are:

- For most Indians, cooking and eating are private affairs. Nobody wants to stand in the hot sun to cook food in the open.
- Assuming that progressive women adopt solar cooking, most of the working women go to the office/workplace from 9
  AM to 5 PM.
- There is no provision for frying in the box-type solar cookers. No meal is served without fried curries in South India.
- Nobody wants to use two cooking systems, one for frying and another for boiling.

III. OBJECTIVES

Following are the main objectives which have to be covered in this work.

- To Study of solar thermal energy storage system in all respect.
- To Study of different types of phase change materials.
- ToDesign cooker thermal storage system for family.
- To Test, data collection and analysis of storage system.
- To study Performance evaluation of storage system.

IV. PROJECT DESIGN METHODOLOGY

Considering the aspects and following objectives of the project the project work is planned with following methodology

1. Collection

The goal of collection is to direct solar rays towards an absorber surface. The process begins when solar rays fall on a collector. The average solar irradiation is a physical constant (1300 W/m^2). Therefore, the

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gross amount of energy collected is directly proportional to the surface area used for collection.

2. Absorption

Once sunlight from the collector reaches the absorber, the light energy must be converted to heat. The ratio of radiated light energy to absorbed heat energy is the absorption efficiency. The two factors that govern this efficiency are the emittance ratio and the absorptance ratio

3. Heat transfer and storage

Various mechanisms exist to store heat and transmit it to the food, so that heat losses are minimized. The mechanism used is governed by the spatial and temporal position of the food in relation to the absorber

Module construction

(a) Fabrication

The weight of the aluminum modules can be reduced by using (rolled or drawn) aluminum sheets, instead of machined aluminum. This would possibly cut the weight, and cost. Casting can be used for production

(b) Joining and sealing

Mechanical fasteners (in conjunction with sealants) are easy to assemble and disassemble. However, welding and brazing have the advantage of being much more accessible.

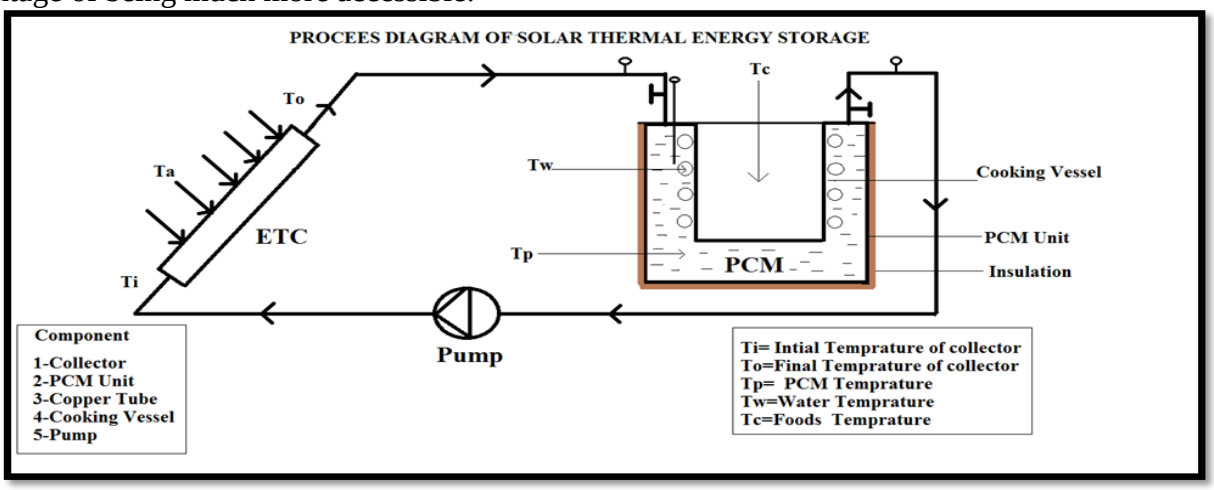


Fig. 1 Experimentation Set Up

Solar heat absorbed by Evacuated Tube Collector and gives this heat to water which is used as heat transfer fluid. Water having specific heat of 4.187kJ/kgK is used as Heat transfer fluid to PCM during Sun shine hours. During sun shine hours, water asheat transferring fluid gets heated and circulates in the system due to convection. This water transfers heat to phase changing material, placed around solar cooker. Phase changing material (PCM) absorbs heat by changing its phase from solid to liquid. During the non-sunshine hours this stored heat in PCM is used to heat the food stuff in solar cooker. Heat transferred is enough to cook the food stuff in cooking vessel.

Heat-storage-material-Acetamide

Acetamide is likely candidates because they melt at desirable temperatures (such as 79-81℃) and had been used previously to

store thermal energy in solar applications.

Heat Storage Material -Acetamide Properties (C2H5No)

Melting Temperature (℃) = 79

Latent Heat Of Fusion KJ/Kg = 241

Density(Kg/M^3) 1) Solid = 1159

2) Liquid = 998

Specific Heat 1) Solid = 1.94

2) Liquid = 1.94

Thermal Conductivity (W/m℃) = 0.5

Efficiency Vs Solar Radiation:

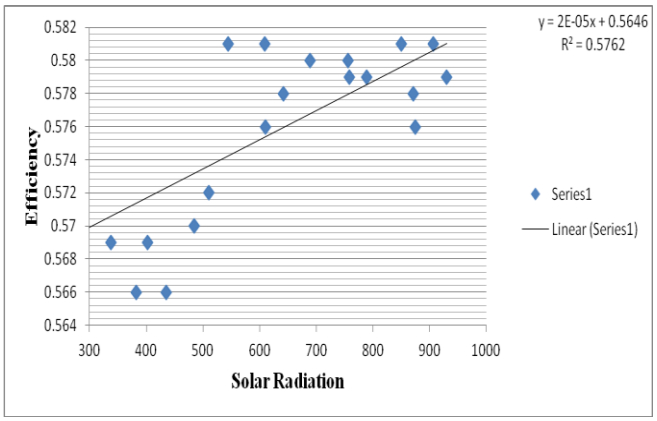
Theere are three efficiencies

1.Efficiency of PCM –Heating

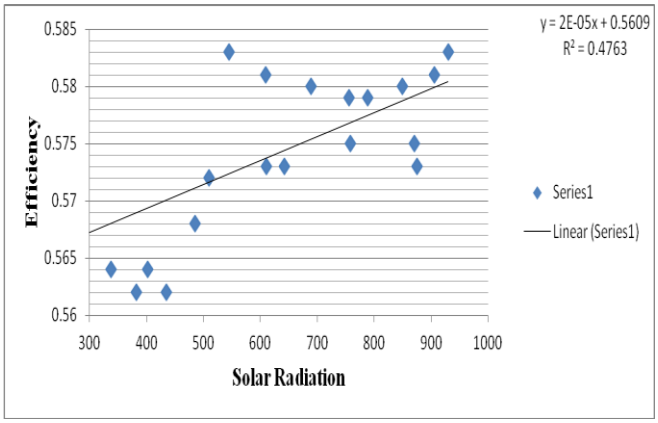
2.Efficiency of food – Cooling Efficiency

3.Efficiency of Collector – Water Heater Efficiency

Graph 1 Efficiency (cooking) Vs Solar Radiation without PCM PCM (Readings taken as on 16.06.2018)



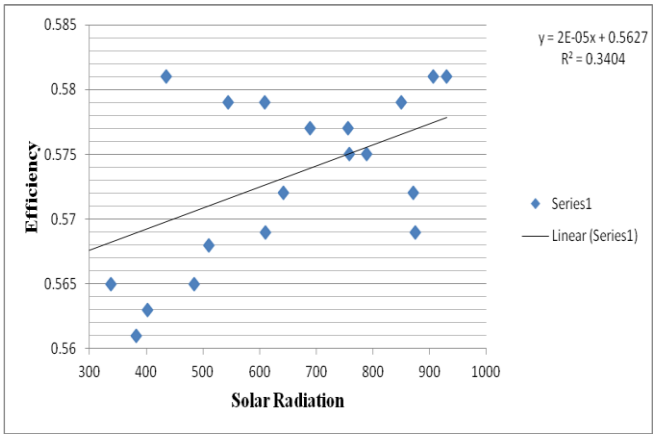
Graph 2 Efficiency (cooking) Vs Solar Radiation without (Readings taken on 17.06.2018)



Graph 3 Efficiency (cooking) Vs Solar Radiation without PCM

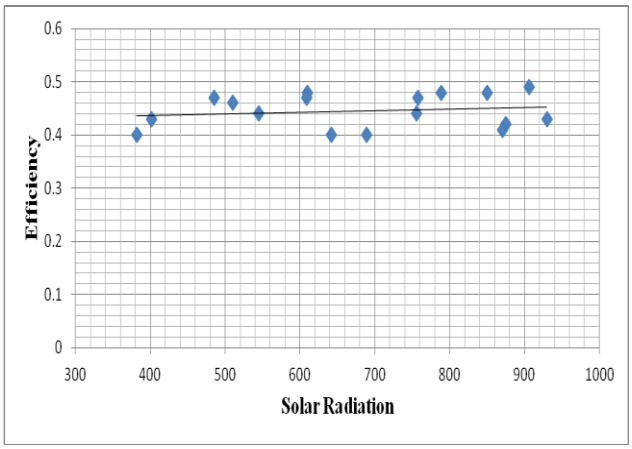
Graph 4 Efficiency (cooking) Vs Solar Radiation

(Readings taken on 19.06.2018)



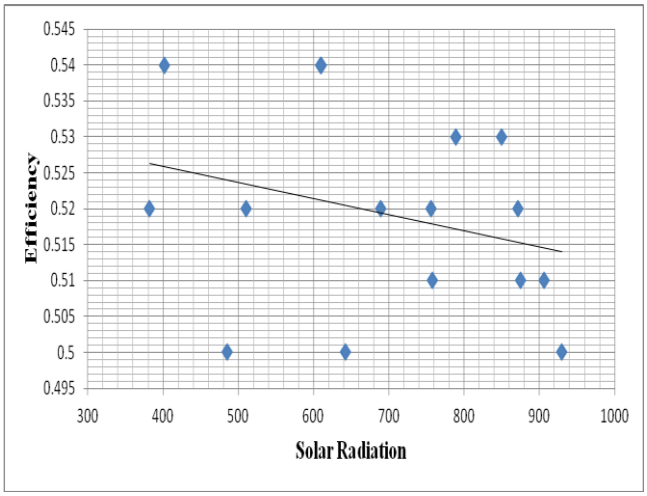
Graph 5 Efficiency (PCM) Vs Solar Radiation Graph

(Readings taken on 16.06.2018)



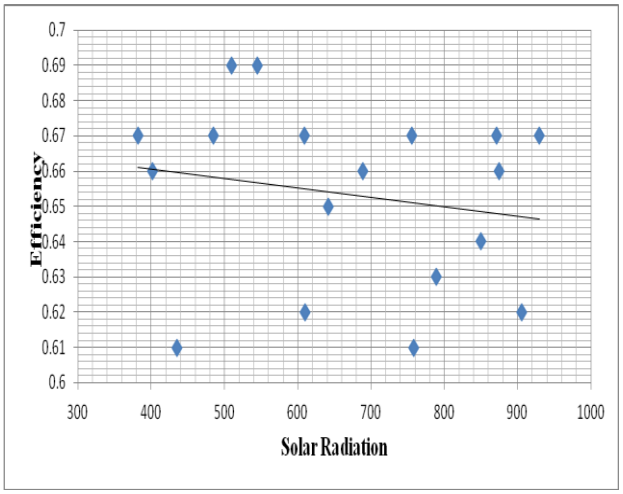
6 Efficiency (collector) Vs Solar Radiation

(Readings taken on 16.06.2018)



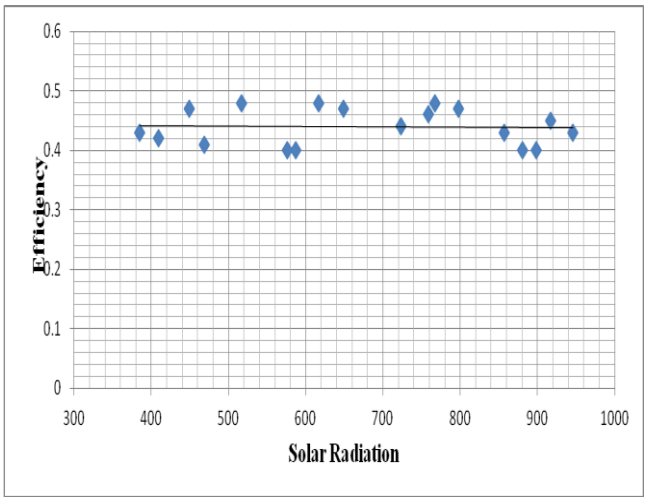
Graph 7 Efficiency (Cooking) Vs Solar Radiation

(Readings taken on 17.06.2018)

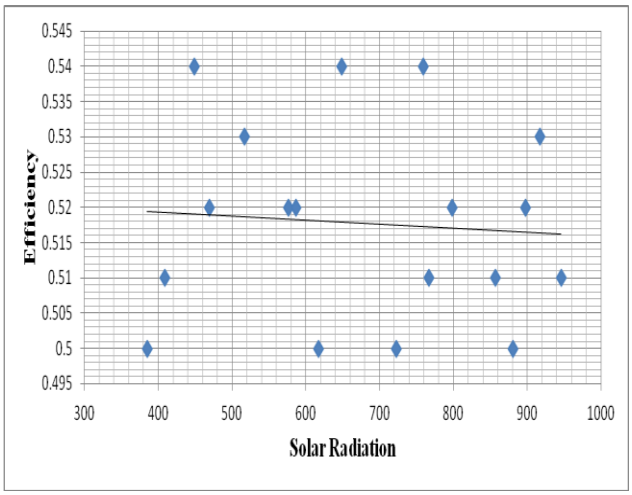


Graph 8 Efficiency (PCM) Vs Solar Radiation

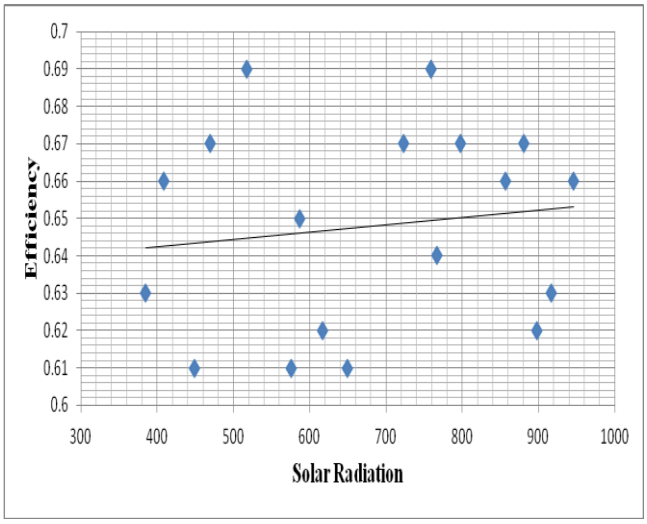
(Readings taken on 17.06.2018)



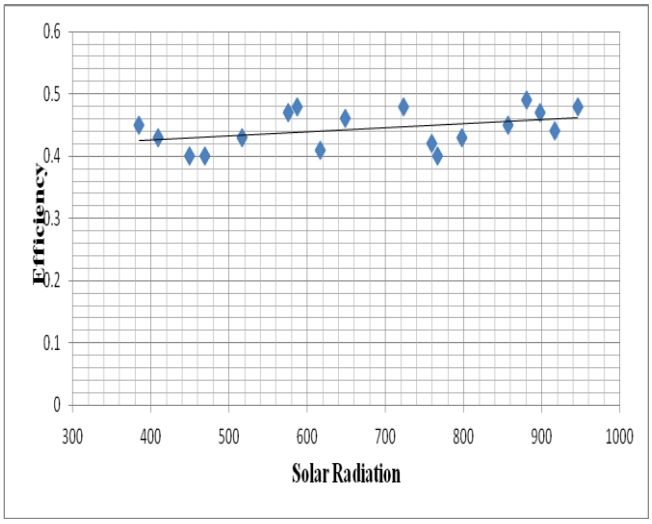
Graph 9 Efficiency (collector) Vs Solar Radiation
(Readings taken on 17.06.2018)



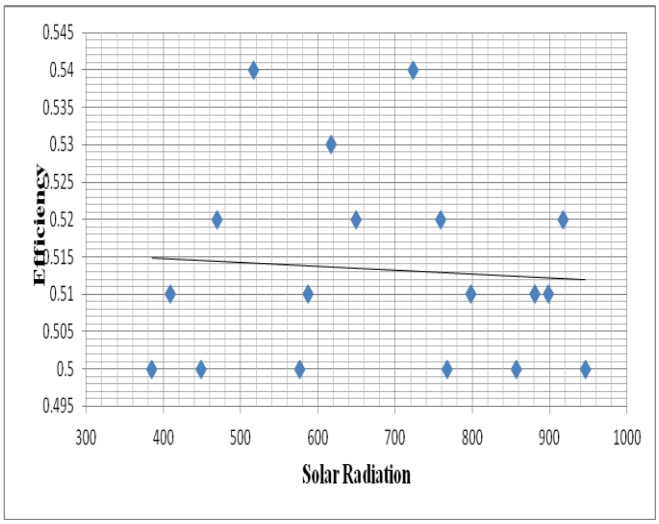
Graph 10 Efficiency (Cooking) Vs Solar Radiation
(Readings taken on 18.06.2018)

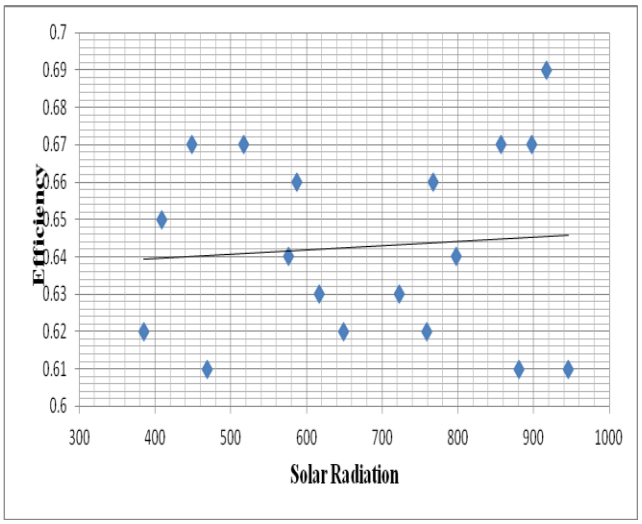


Graph 11 Efficiency (PCM) Vs Solar Radiation
(Readings taken on 18.06.2018)



Graph 12 Efficiency (Collector) Vs Solar Radiation
(Readings taken on 18.06.2018)





V. CONCLUSION

From this work solar cooking technology, it may be concluded that the storage material chosen is Phase change material (PCM) Acetamide is best for application
This study covers solar cookers with energy storage materials (PCM) for storage units.
Efficiency (ɳ) varies with respect to solar radiation (I).

It is observed by analysis that the average and Food heating i,e medium cooling efficiency is = 40.10%

The negative regression index shows that efficiency decreases with increase in radiation because infield heat loss to the atmosphere. Loss increases as radiation increases.

The capital cost of box cooker, without PCM and with PCM is evaluated as Rs 1500/-,3333/-,2240/- respectively which shows that the cost per cycle per day is lowest

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