"Study of Solar Energy Storage in Solar Cooker with Phase Change Materials and Improving its Performance"

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ABSTRACT

Box type solar cooker is one of the efficient solar equipment which will be beneficial for the rural as well as urban areas. It will serve the needs of energy with its effective implementation. Solar energy can be utilized for the cooking purpose. With available many equipment box types solar cooker is efficient and effective way of using it for cooking purpose. It absorbs all the solar energy struck on it. The use of renewable energy source is an effective way for cooking purpose. Fortunately, India is blessed with ample amount of solar radiation. Hence, solar cookers have good potential in India. A limitation of solar cookers is that cooking can only be done during sunshine hours. If solar cookers are provided with heat storing medium, then there is possibility of cooking food during off sunshine hours also. This is why a better model that incorporates both the traditional heat trapping cum concentrator mechanism and the latest techniques like that which uses a solar battery.

Keywords: *Box type solar cooker, Solar Energy, Renewable Energy*

I. INTRODUCTION

Energy is the backbone of human activities. The importance of energy in economic development is very critical as there is a strong relationship between energy and economic activity. Historically fossil fuel in its solid phase, i.e. wood and coal, has been the prime source of energy. The increment in global energy demands due to population growth and 20th century industrial revolution leads fossil fuel through a transitional phase. It is being widely realized that for sustainable development presently used energy mediums such as fossil fuel and nuclear power have to be quickly replaced by renewable energy sources. The latter are sustainable and have the potential to meet present and future projected global energy demands without indicting any environmental impacts. Renewable energy sources such as solar, wind, hydropower and biogas are potential candidates to meet global energy requirements in a sustainable way [1]. The continuous increase in the level of greenhouse gas emissions and the hike in fuel prices are the main driving forces behind efforts to more effectively utilize various sources of renewable energy. In many parts of the world, direct solar radiation is considered to be one of the most prospective sources of energy. The scientists all over the world are in search of new and renewable energy sources. One of the options is to develop energy storage devices, which are as important as developing new source of energy. The storage of energy in suitable forms, which can conventionally be converted into the required form, is a present-day challenge to the technologists [2].

Phase change materials possess the ability to change their state with a certain temperature range. These materials absorb energy during the heating process as phase change takes place, otherwise this energy can be transferred to the environment in the phase change range during a reverse cooling process. The insulation effect reached by the PCM depends on temperature and time; it takes place only during the phase change.

II. METHODOLOGY

The primary objective of the project is to develop solar cooker system with PCM. Parabolic dish based solar cooker system can be utilized for cooker development by using several modifications. [29] PCM is the prime

material used to modify the conventional system. It is added in the vessel which after heating turns in to liquid and vice versa.

Acetanilide material is implemented as phase change material. It is selected because of its high latent heat of fusion which is about 222 kJ/kg. It has the ability to change its phase with application of heat.

Following parameters are important for PCM selection

[1] Melting point
[2] Latent heat of fusion
[3] Heat transfer coefficient
[4] Good PCM properties

The experiment is conducted to investigate the thermal performance of solar cooker with Phase change thermal storage unit. The test section of solar cooker is based on box type collector.

Basic components of set up is

[1] Box type collector
[2] Solar Cooker
[3] Insulator box
[4] Acetanilide PCM

Photograph: Actual Experimental Set up Vessel

Properties of Phase Change Material

[1] Required melting point of PCM - 105^0C to 125^0C
[2] Name - Acetanilide
[3] Melting point - 118^0C
[4] Appearance- White powder
[5] Latent heat L - 222 kJ/kg
[6] Specific heat capacity Cp – 2 kJ/kgC
[7] Density =1219 kg/m

Photograph: Insulator Box

Photograph: Glazing

Photograph: Temperature Indicator

System comprises of various functioning mode like charging mode, discharging mode, standby mode for its effective operation. With this set up actual cooking operation is performed to check whether all these instruments comply to our requirement or not.

III. RESULTS AND DISCUSSION

The feasibility of the solar energy storing and its use is checked using this set up. Also, PCM and its capability to change its phase to achieve cooking temperature is very important.
The performance of the existing system is enhanced using PCM material.
The experiments were conducted outdoor in clear sky and high heat radiation available throughout the day. The readings like performance indicators are recorded for temperature pf PCM using thermocouple. Also, it is measure for the cooking medium inside the pot, solar radiations and ambient temperature too.

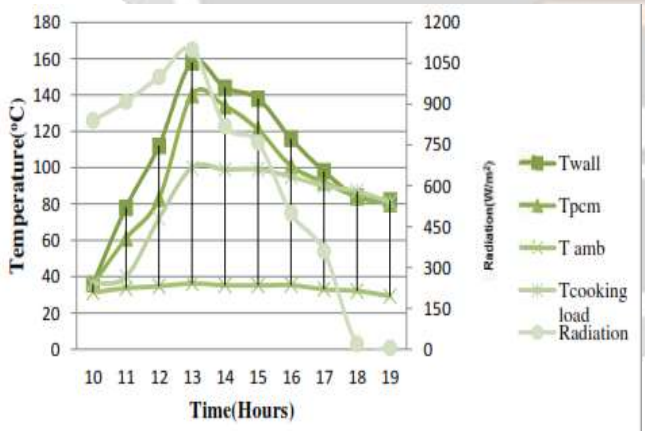

Figure 1: Experimental Variation of Temperature with Time in Cooker with Glazing (Loading at 10am)

Figure 1 shows variation of temperature and solar radiation intensity with time in case of solar cooker with cooking load and glazing (Loading at 10am) The Experimental Variation of Temperature with Time in Cooker with Glazing will observe that; the PCM temperature increases proportional to solar intensity till 13 hours, after 13 hours solar intensity drops rapidly causing decrease in wall temperature
of PCM vessel and this result in decrease in drop of PCM temperature. Cooking load temperature increases slowly up to 100^0 C and remain at 100^0 C for next three hours due to higher temperature of PCM. After 14 hours cooking pot is kept in insulting box.

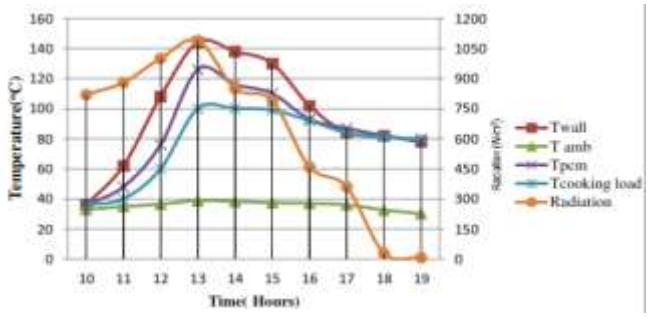

Figure 2: Experimental Variation of Temp with Time in Case of Solar Cooker without Glazing (Loading at 10 am)

As the solar intensity increases, PCM temperature of solar cooker, cooking medium temperature and wall temp increases proportional to solar intensity. In this case maximum temp achieved by PCM is lower compare to cooker with glazing. This cooker is less efficient compare to cooker with glazing and this is due to loss of heat by air flowing around the cooker. Cooking load temperature is at 100^0C for lower duration of time causing loss of water.

IV Concluding Remarks

In this work, use of phase change material for evening / night cooking is discussed. The use of a solar cooker is limited because cooking of food is not possible due to frequent clouds in the day or in the evening. If storage of solar energy can be provided in a solar cooker, then there is a possibility of cooking food during clouds or in the evening and the storage will increase the utility and reliability of the solar cookers. Hence, PCM is the best option to store the solar energy during sun shine hours and is utilized for cooking in late evening/night time.

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