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Inclined Heat Exchanger Unit Assisted Sk-14 PSC for off place cooking

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Abstract--- ***Different types of solar cookers developed for cooking food were available in box type and parabolic solar cookers. Parabolic solar cooker (PSC) has a unique property of producing higher temperature up to 250°C. It has a wide range of applications such as making chapattis, baking of food material and distillation, but it creates an inconvenience to the user due to its high amount of glare. The principal objective of the present study was to use a inclined heat transfer fluid (HTF) column as heat exchanger unit and to evaluate the thermal performance of a PSC assisted with inclined cylindrical heat exchanger unit having various viscosity values for off place cooking. Experiments were conducted for cooking food on a normal day. During the experiment, it is assumed that the Thermo-physical properties are independent of temperature. In this study, the Effect of variation of length of HTF column on the cooking time was studied at the optimized angle of inclination.***

***Index Terms*— HTF, Off-place cooking, PSC, Solar Energy**

I. Introduction

Box type solar cooker and PSC were commonly used [1] for cooking food in the noon. Out of these two, box type solar cooker was more popular due to its simplicity of handling and operation [2]. The major drawback of box type solar cooker was that its use was limited for cooking material through boiling only. Solar concentrators have their applications in preparing chapattis, in increasing rate of evaporation of wastewater, in food processing, and in making drinking water from brackish or seawater. It produces a high temperature around 250°C. The major drawback with PSC was that it generates a high amount of glare from its reflector and hence will be an inconvenience to the user. Therefore it was necessary to design a heat exchanger unit for SK14 PSC having a facility of retrieval of heat energy at a distant place from the PSC.

Schneider et al [3] have studied laminar natural convection in a cylindrical enclosure at different temperatures having inclination angles between 0° to 180°. It was found that maximum heat transfer rate with greatest velocities were found for L/D=1 within angular variation between 45° - 60°. Popiel et al., [4] have performed experiments on free convection in an isothermal vertical square cylinder with a range of L/D within 1 - 21 and results were in agreement with the theoretical calculations. Murty et al [5] have studied the energy transport phenomenon in an inclined cylindrical heat exchanger unit assisted sk-14 PSC experimentally. Murty et al [6] have optimized the angle of inclination of the HTF column experimentally and reported the variation of the heat transfer coefficient, friction factor and Reynolds number with time during cooking experiment. Murty et al [7], [8] have studied the thermal performance of a heat exchanger column assisted sk14 PSC with/without storage with HTF of various viscosity values. Murty et al [9] have studied the variation of diameter of inclined cylindrical heat exchanger unit assisted sk-14 PSC experimentally.

In this paper a cylindrical inclined heat exchanger unit for PSC was designed, fabricated and its thermal performance was evaluated by varying the length of HTF column. It was based on the principle of natural convection of HTF within an inclined adiabatic cylinder.

During the present experiment the following assumptions were made:

- SK14 PSC supplies a constant heat to the cylindrical vessel (S1) of the HTF system.
- Specific heat, density, viscosity and thermal conductivity of HTF remain constant.

II. Design and Description of the System

Fig. 1 shows the sketch of the Heat exchanger unit for SK-14 PSC. The experimental set up consists of a cylindrical (source) vessel (S1), cylindrical (destination) vessel (S2), outer concentric cylinder (S3) aluminum cooking pot with lid (S4), cylindrical tube (C), HTF, PSC (P). A cylindrical vessel (S1) of 0.09 m height and 0.066 m radius was painted black and it was kept at the focus of PSC. A cylindrical tube (mild steel) was welded at the upper portion of cylindrical vessel (S1). The cylindrical vessel (S2) has a height of 0.23 m and radius of 0.089 m. It was joined to a mild steel inclined cylindrical tube (C) of 0.9m length and 0.024 m radius. It was used to transfer HTF from source vessel (S1) to the destination cylindrical vessel (S2).

A concentric cylindrical pot (S3) of 0.072 m radius and 0.14 m height was fixed in the cylindrical vessel (S2), with a facility of transferring heat from HTF. An aluminum pot (S4) with an airtight lid of 0.16m length and 0.07 m radius and it was inserted in the outer heat transfer pot (S3) tightly in such a way that those two surfaces were in good thermal contact.

The cylindrical vessel (S2) and the cylindrical tube (C) were insulated from surroundings by using glass wool of thickness 0.04 m. HTF was used for carrying heat from cylindrical vessel (S1) to aluminum cooking pot S4. The

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thermo-physical properties of various heat transfer fluids of were given in table I.

TABLE I
THERMO-PHYSICAL PROPERTIES OF HTF

Heat Transfer fluid	Turpentine
Density,Kg/cu.m	850
Sp. Heat, KJ/Kg K	2200
Viscosity,Ns/m^2	0.00149

III. WORKING PRINCIPLE

The cylindrical vessel (S1) of the heat exchanger unit was placed at the focus of the PSC. An inclined cylinder (C) contains initially HTF at the room temperature. The cylindrical vessel was blackened and it was exposed to focus of the PSC. When solar radiation was focused, temperature differences generate density differences, which result in natural convection within HTF column. With time, convection currents improve their velocity against inertia producing nearly a constant mass transfer of the HTF leads to constant buoyancy forces within the cylinder (C). As time passes, due to a continuous flow of heat energy in the cooking pot, rice was cooked.

IV. EXPERIMENTATION

The experimental PSC assisted with inclined cylindrical heat exchanger unit was designed and developed for experimentation. Calibrated thermocouples K-type (Cu-Constantan) were inserted at various positions. A known amount of HTF was introduced in the heat exchanger unit. Aluminum cooking pot was inserted containing rice and water of known mass. The tracking of reflector of the PSC was continuously monitored and the ambient temperature, Source temperature, Food temperature and temperatures of HTF at various positions were measured with a Data acquisition module at an optimized angle (45 degree) of inclination of the heat exchanger unit with the horizontal.

V. RESULTS AND DISCUSSION

A. *Measurement of temperatures*

Various cooking experiments were conducted on a PSC assisted with inclined cylindrical heat exchanger unit containing HTF of various viscosity values. On the date 15-05-2007, cooking experiment was conducted on PSC assisted with inclined cylindrical heat exchanger unit at an optimized angle of inclination of 45°. Experiment was started at 10:00 A.M. by exposing the system to solar radiation

The variation of the ambient temperature, temperature of HTF and food in inclined heat exchanger cylindrical system experimentation were noted at regular intervals of time during the experiment and it is shown in fig. 2.

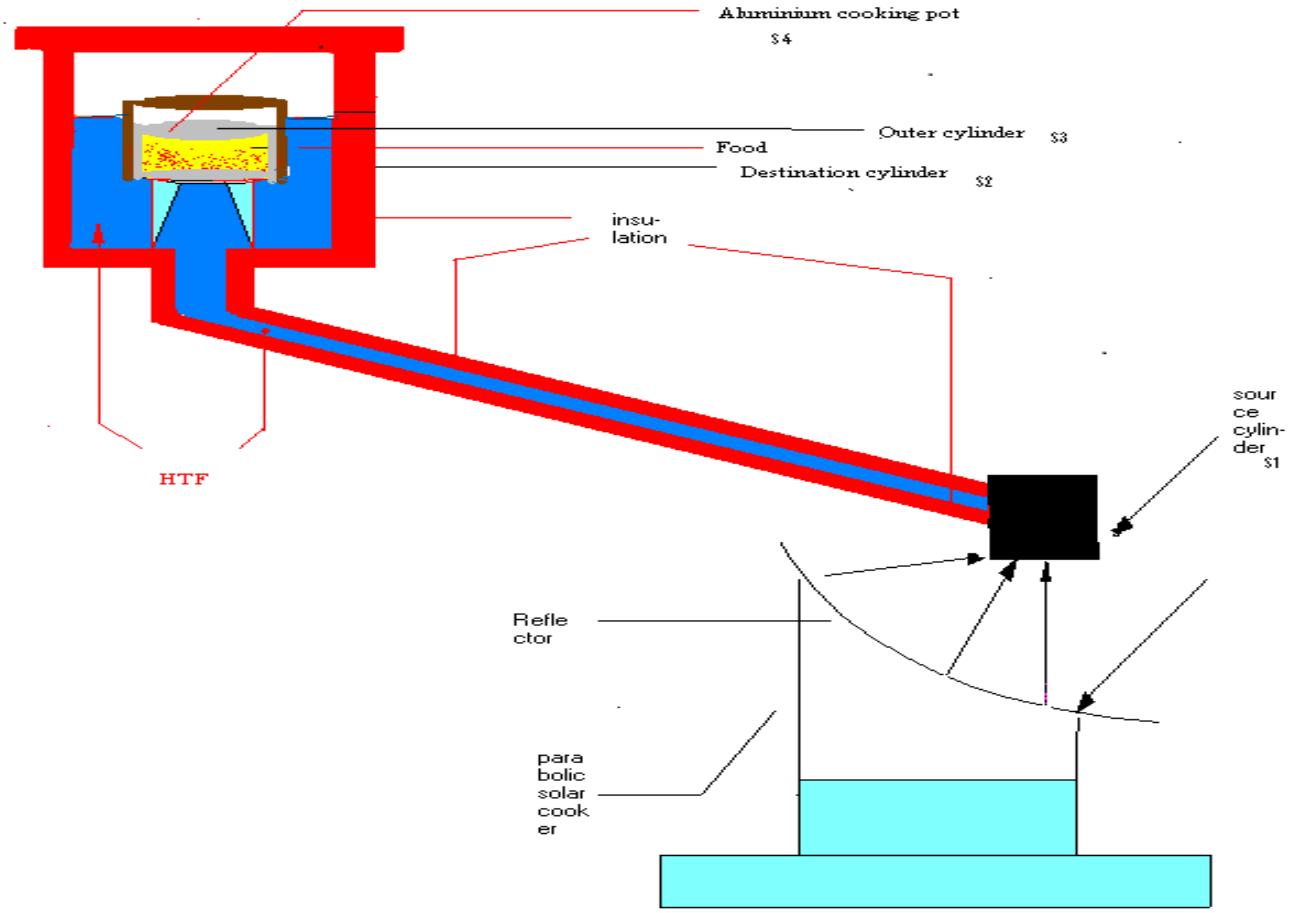

Fig. 1. Schematic of the inclined heat exchanger unit assisted SK-14 PSC.

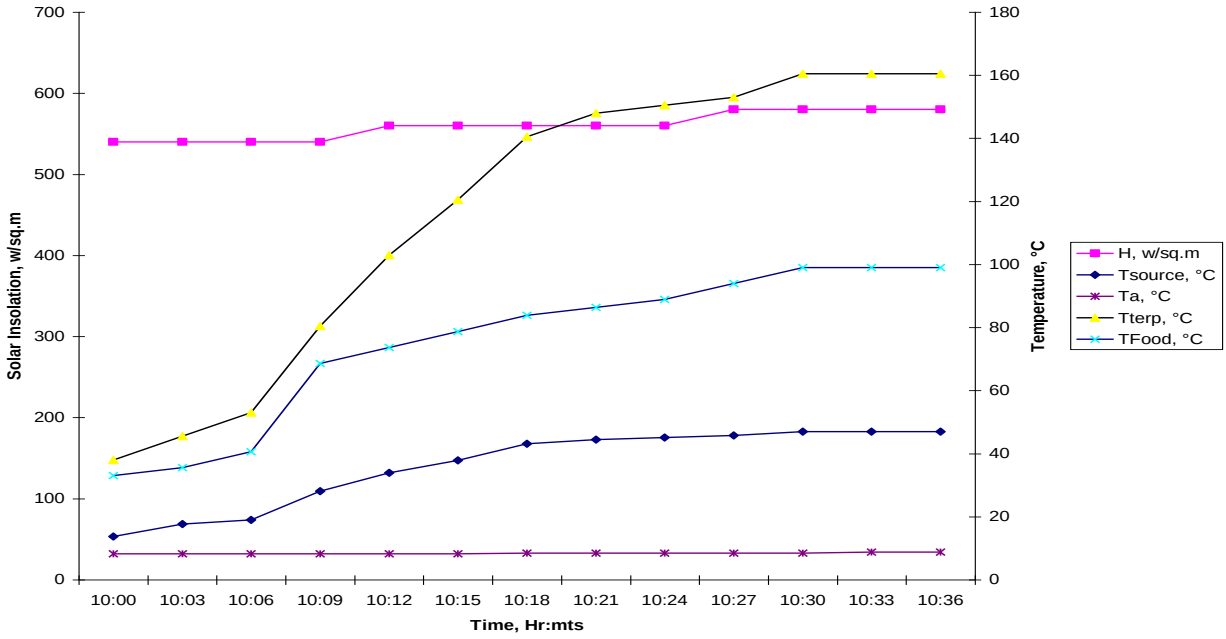

Fig. 2. Variation of food temperature, source temperature, temperature of HTF and ambient with time in an inclined cylindrical heat exchanger unit with Turpentine as HTF.

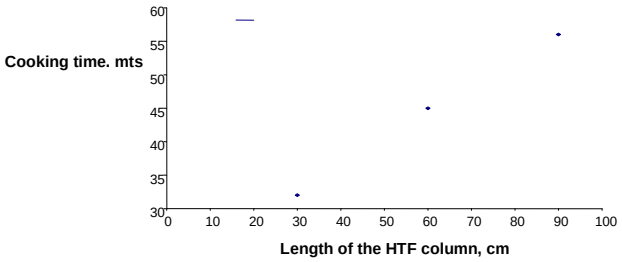

Fig. 3. Variation of cooking time with length of the HTF column

B. Cooking experiment by varying the length of heat exchanger unit

The experiments were repeated by decreasing the length of the HTF column. Variation of cooking time with length of HTF column is shown in the fig. 3. It is observed that as the length of HTF column increases, the cooking time also increases.

VI Conclusion

An inclined cylindrical heat exchanger unit assisted SK 14 PSC containing HTF as a heat-exchanging medium was designed and fabricated. Experiments were conducted for an off place cooking by varying the length of the HTF column unit at the optimized angle of inclination of heat exchanger unit.

It is concluded that the HTF of low viscosity should be preferred to minimize the cooking time.

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