Effect of Wind on the Performance of Parabolic Disc Type Solar Collector

Madhulesh Yadav (Ph.D Scholar)
Department of Mechanical Engineering
Dr. C.V Raman University,Kota Bilaspur (C.G)

Dr.N. Saikhedkar
Department of Mechanical Engineering
Professor,RITEE,Raipur (C.G)

***Abstract**— In the present work, a new concentrating disc type solar Collector, which may function as a Collector is presented. Such a Collector would heat the pot from its bottom and not have condensation problem on the top glazing insulation. The speed of wind effects the temperature of pot. To solve this problem a Rectangular shaped glass cover is used, which is sited around the pot due to which the effect of wind reduces and the overall efficiency of the system increases. Here in this project a light weight vertical cylindrical shape pot, which is completely black painted at the bottom to absorb reflected radiations from reflector as well as direct radiation received from the Sun and so increases the absorptivity. Efficiency of Disc type Solar Collector is compared with and without glass cover shield*.

Keywords—Disc type solar collector, Performance of collector, Glass cover shield.

I. INTRODUCTION

Due to the nature of solar energy, two components are required to have a functional solar energy generator. These two components are a collector and a storage unit. The collector simply collects the radiation that falls on it and converts a fraction of it to other forms of energy (either electricity and heat or heat alone). The storage unit is required because of the non-constant nature of solar energy.Solar Collectors are practical due to their inherent simplicity and consequent lower costs. Solar Collectors are very important especially for isolated areas where there is no fuel supply.

The solar focusing type of dish collector maintains its optical axis always pointing directly towards the sun. The geometry of the concentrator allows reflecting the incident solar rays onto the receiver, which is located at the focal plane of the collector. During its rotation, the receiver experiences change in the complete behavior of the fluid and the heat transfer characteristics. The estimation of heat losses from the receiver is an important input to the performance evaluation of the solar collector. Solar energy collectors are special kind of heat exchangers that transform solar radiation energy to internal energy of the transport medium. The major component of any solar system is the solar collector. This is a device which absorbs the incoming solar

radiation, converts it into heat, and transfers this heat to a fluid (usually air, water, or oil) flowing through the collector.

II. LITERATURE SURVEY

Theoretical analysis for the simple model of the solar Collector was reported by VM Shrestha [6]. The effect of the present box-type solar Collector is modified slightly, and three versions were analysed. Mathematically and simulated by computer in order to see the effects on the stagnant temperature of the Collector under simulation conditions. It was found that the stagnant temperature is much enhanced in all modified models. If the external surface of the absorbing top plate is treated with selective coating, the performance is very much enhanced. N.D. Kaushika [12] presents viability aspects of paraboloidal dish solar collector systems. The basic geometrical optics equations for multifaceted paraboloidal dish solar collectors are presented in the form helpful for engineering design. Trade-off strategies are discussed to establish a balance between many constraining factors related to system cost, survival, reliability and lifetime properties. Performance data for experimental dish collectors of 5 m diameter, involving undemanding accuracy of optical profile and short focal length (1.8 m), are presented. In this situation modified cavity and the semicavity receivers tend to have a higher efficiency than cavity designs. Current research and application trends of dish collector systems are indicated.

N.D. Kaushika and K.S. Reddy [14] presents the design, development and performance characteristics of a low cost solar steam generating system which incorporates recent design and materials innovations of parabolic dish technology. The concentrator is a deep dish of rather imperfect optics, made of silvered polymer reactors setted in the aluminum frame of a satellite communication dish. Conventional cavity receivers tend to be inadequate for this concentrator. Semi-cavity and modified cavity receivers, thermally optimised, with the fuzzy focal image have, therefore, been investigated. Preliminary held measurements and cost, as well as performance analyses of the system.In a trial to see the wind effect on the performance of a solar Collector, Grag *et al.*[2] found that when the wind speed exceeds about 10 Km/hr, the pot temperature does not exceed 80°C under Delhi conditions. The same pot containing 1 litre of water comes to a boil in less than half an hour in calm weather.

Several crteria were established by Adel M. A. Khalifa, *et al* [13] for comparing the performance of solar Collectors tested under different insolation conditions.Of these the overall utilization effeciency were found to be espically useful in comparing the boiling water experiments.

M.M. El- Kessaby [15] presents a complete design and fabrication of a parabolic square disc solar Collector is .A simulation model for transient state was introduced to predict the pot, fluid, air gap and cover temperatures. Satisfactory agreement are obtained by comparing experimental and theoretical results

III. PLAN OF RESEARCH WORK

The system consists of a disc type reflector made of a circular shaped frame, covered with anodized aluminum strips and can be assembled and fixed by nuts. There are four wheels at the base of the frame to allow Sun tracking. The pot is sited on the base at the focus f the collector, which is attached to frame by hollow iron rods. There is a wind protector glass cover of rectangular shape 42 cm x 46 cm x 33 cm is used to protect the pot from wind and sited on the rectangular base around the pot.

Fig:1 Schematic picture for proposed Solar Collector

The temperature of the fluid inside the pot was measured using a thermometer (Digital) inserted at the middle height of the fluid. The temperature of the pot and temperature of air between pot and glass cover is measured using thermometer. The disc was suspended to the frame by a rod which can be rotated in fixed frame to allow for adjusting the disc to any desired inclination angle so that a focus on the bottom of the pot would be performed.

Fig: 2 Thermometers used for Temperature Measurement

The pot used is made from Aluminum of cylindrical shape. The pot is black painted so as to absorb more radiations. The normal incidence radiation was measured using a normal incidence pyrhenometer (Standardised Calibrated).The wind speeds were measured using a hand held anemometer.

Details for Circular Disc Reflector

Base material: Iron channel made Frame

Aperature area: 17.77 m^2

Reflector surface: Made of Aluminum

Length of strip: 73 cm

Width of strip: Top edge 13.5 cm, Bottom edge 2.5 cm

IV. METHODOLOGY

Different types of energy transfer in the pot and glass cover takes place. A reflected radiation from reflector is incident on the pot, so radiation heat transfer takes place on the bottom of the pot, this energy is the radiated energy (q_1). Radiated Energy is energy is further divided into following parts,

1. The energy transferred to the cooking water (q_f) as useful energy

2. The energy stored in the material of the pot (q_u)

3. Some energy losses takes place from side walls (q_{cs}), Energy transfer from the bottom to the air (q_{cb}) and Radiation energy loss from the bottom to the ambient (q_{r1}) and from sides to the cover (q_{r2}).

The energy which is lost by pot are received by air, which is present in air gap between pot and glass cover and further delivers this energy to both pot and the cover.

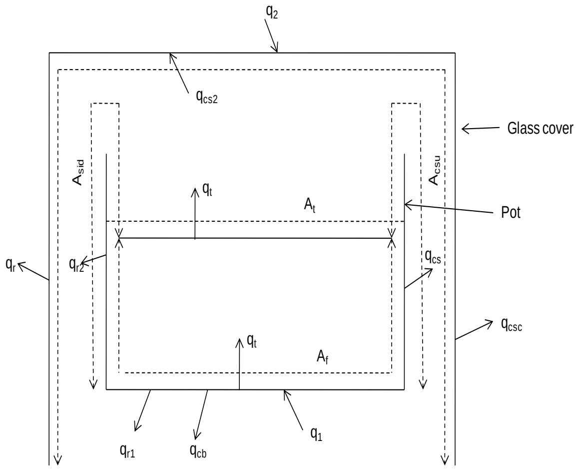

Fig: 3 Different Types of Energy Transfer

Glass cover is a box shaped transparent cover placed over the pot. Direct radiation is incident on the glass cover and this radiated energy (q_2) is transferred to air present between pot and glass cover. Some loss of energy (q_r) at the surface of the cover to ambient takes place. Distribution of the different energy transfer in the pot and glass cover is shown in the figure 3

Energy Balance Equation for Water

The Heat energy received by the pot is transferred to water. The heat energy received by the water due to heat convection from the pot as q_f is used to raise the internal energy of the fluid and the rest is lost as heat convected by air at the top surface. This energy balance equation is given by

$$q_f = q_t + m_f c_f \frac{dT_f}{dt}$$

m_f is mass of water and C_f is specific heat of water

Energy Received By the Water

This is the energy received by the water due to heat convection from the pot. This energy equation is given by

$$q_f = h_f A_f (T_p - T_f)$$

ENERGY BALANCE EQUATION FOR POT

The energy incident on pot is partly used in increasing the internal energy of pot, a part of this energy is transformed to the water, a part is lost by convection from side walls, a part is lost by convection from bottom of pot, a part is lost by radiation from the bottom and a part is lost by radiation from sides to cover. This energy equation is given by

$$q_1 = m_p c_p \frac{dT_p}{dt} + q_f + q_{cs} + q_{cb} + q_{r_1} + q_{r_2}$$

Energy Incident on Pot: This is the radiated energy incident on pot, after reflection from the reflector surface.

This energy equation is given by

$$q_1 = \alpha\rho\, F_s\, I_b\, A_c$$

Energy Loss from Side Walls

This is the energy lost by convection from side walls of the pot to the air gap between pot and glass cover.

This energy equation is given by

$$q_{cs} = h_g\, A_{sid}\, (T_p - T_g)$$

Energy Loss from Bottom of the Pot

This is the energy lost by convection from the bottom of the pot to the ambient.

This energy equation is given by

$$q_{cb} = A_t\, h_a\, (T_p - T_a)$$

Energy Loss from the Bottom

This is the energy lost by radiation from the bottom *of the pot.*

This energy equation is given by

$$q_{r_1} = s\epsilon_p\, A_f\, (T_p{}^4 - T_a{}^4)$$

Energy Loss from Sides to the Cover

This is the energy lost by radiation from sides to cover. This energy equation is given by

$$q_{r_2} = \rho A_{sid}\, (T_p^4 - T_c^4) \left(\frac{1}{\varepsilon_p} + \frac{1}{\varepsilon_c} - 1 \right)$$

Energy Balance Equation for the Air Gap

When glass cover is put over the pot, different energy transfer takes place. The air contained in the air gap received heat from the side walls of the pot, and delivers heat to glass cover is used to increase the internal energy of the air in air gap.

$$q_{cs} + q_{cs_2} = m_a c_a \frac{dT_g}{dt}$$

Energy Received By Glass Cover

The cover loses or gains energy by convection from inner surface areas of the glass cover. This energy equation is given by

$$q_{cs2} = h_g\, A_{csu}\, (T_c - T_g)$$

ENERGY BALANCE EQUATION FOR COVER YIELDS

The last lumped element in this model is the glass cover. Glass cover is a box shaped transparent cover which is placed over the pot. The part of direct radiation received by glass cover and energy from sides to the cover is loss by radiation at the surface of the cover, the part is lost by convection to the ambient at the surface of the cover, some part is lost by convection from inner surface and some part is used to increase the internal energy of the glass cover. This Energy Balance equation is given by

$$q_2 + q_{r_2} = q_r + q_{cs_2} + q_{csc} + m_c c_c \frac{dT_c}{dt}$$

Energy Received By Glass Cover

Surface of glass cover receives radiation from sun and transfers heat to air present between pot and glass cover. This radiation energy equation is given by

$$q_2 = A_{sh} \alpha_c I_b$$

Radiated Energy at the Surface of Cover

This is the loss of energy by radiation at the outer surface of the glass cover.
This radiation energy equation is given by

$$q_r = s€_c A_{csu} (T_c^4 - T_a^4)$$

Convective Energy at the surface of cover

This is the loss of energy by convection to the ambient at the surface of the glass cover. This energy equation is given by

$$q_{csc} = h_a A_{csu} (T_c - T_a)$$

V RESULTS AND DISCUSSION

The experimental temperature and results for the pot. water, air gap without cover and temperature of pot, water, air gap and cover with glass cover for 1 kg of water are tabulated and graphs for temperature of fluid, pot, air gap versus time is plotted respectively. The time required to heat up 1 kg of water upto 95.8°C was 22 minutes for average wind speed of 2.5 *m/sec*, when no glass cover is used while average time to heat up the same amount of water for average wind speed of less than 2.5 *m/sec* when glass cover is used was 18 minutes. This indicates the effect of wind speed on the boiling time. Boiling time decrease by reduction in wind speed. In this proposed design the heat transfer rate will be increased when glass cover is used and the average time to heat up the fluid inside the pot will be reduced. Boiling time decrease by reduction in wind speed.

The value of Utilization Efficiency of Proposed Collector for with and without glass cover will be compared and get higher efficiency when glass covered is used. The overall utilization Efficiency is increased by 2.04 % when glass cover is use, which gives a good indication for fast-cooking.

VI CONCLUSION

The Overall utilization Effeciency of the present Collector can also be increased if double glass cover or a Hemispherical shaped glass covered is used and high temperature black paint is used around the surface of the pot.

Table 1 : Comparision of Energy with and without Glass cover

Types of Energies	Energy with Glass Cover (Watts)	Energy without Glass Cover (Watts)	Percentage Change
q_f	197.11	175.33	12.42% Increases
q_{cs}	16.94	43.98	61.48% Decreases
q_{cb}	218.93	184.50	18.66% Increases
q_{r1}	350.19	290.98	20.34% Increases
q_{cs2}	50.97	-	-
q_r	52.9	-	-
q_{csc}	26.39	-	-

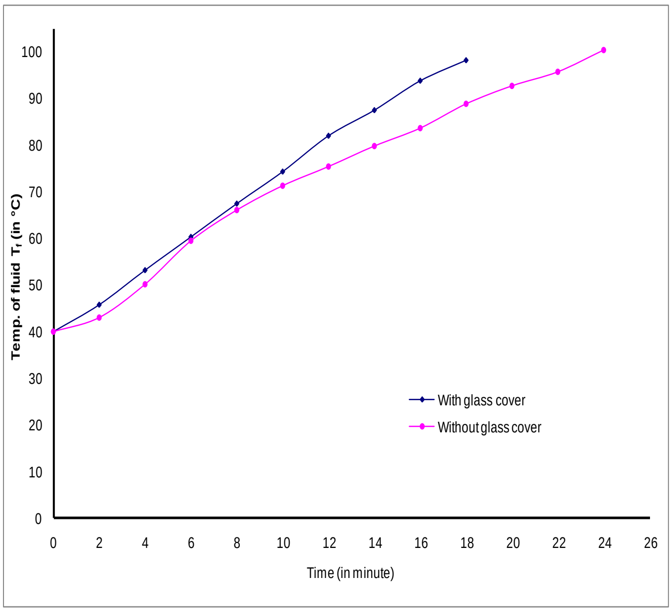

Fig 4 : The Experimental data plotted between temperature of fluid with Glass Cover and without Glass Cover versus time for 1 kg mass of water

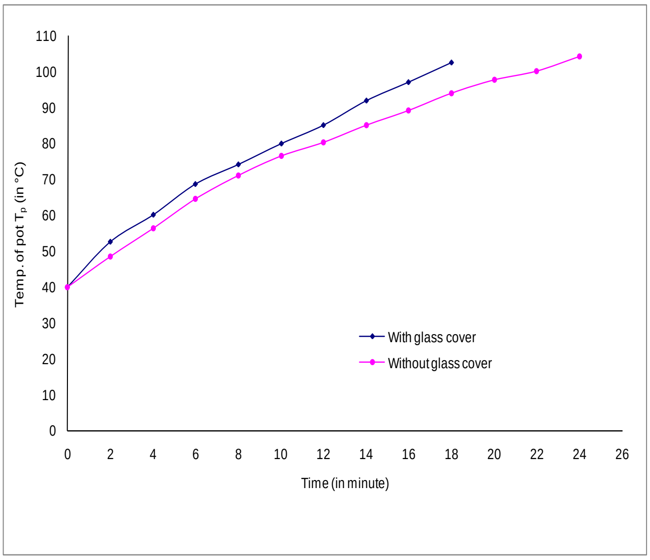

Fig 5 : The Experimental data plotted between temperature of pot with Glass Cover and without Glass Cover versus time for 1 kg mass of water is

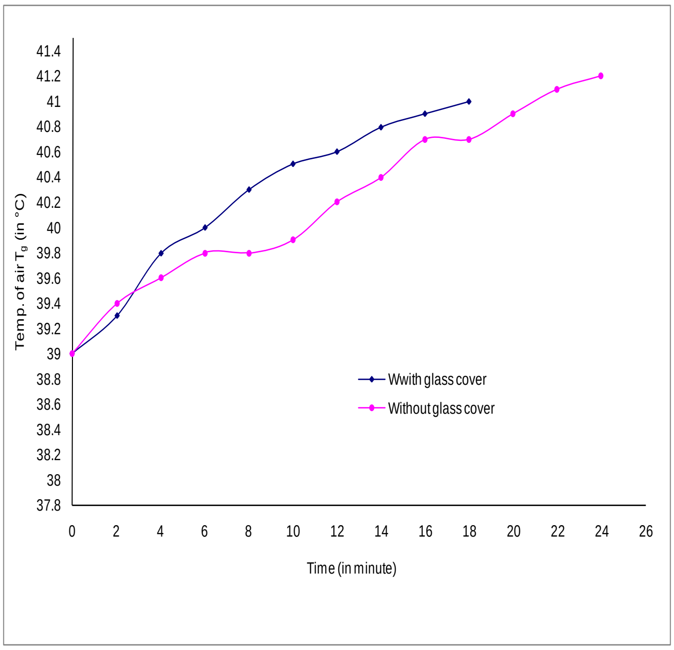

Fig 6 : The Experimental data plotted between temperature of air at air gap between pot and Glass Cover and outside air versus time

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