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Performance Analysis of Double Pass Solar Air Heater

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***Abstract*—** The depletion of fuel sources leads to energy crisis. So, the use of alternative energy is always better option. Out of available resources like solar, wind, biomass, tidal, geothermal energy etc., solar energy is always the easiest source to extract useful energy, because it is available in ample amount. The objective of the present work was to develop double pass solar air heater and to check its performance. In this work, effort was made to improve the efficiency of solar air heater by employing double pass with zigzag and spiral tubing. In the first pass, zigzag shaped tubes are used, while spiral shaped tubes are used in second pass. The efficiencies and observations drawn on different times and availability of sunlight by keeping the experimental unit at different inclinations. The possible applications and scope of this solar air heater also have been suggested. The objective of this paper is to discuss the performance of a double pass solar air heater.

Keywords *- Solar Energy, Solar Air heater, Double Pass, Heat Transfer Rate, Efficiency.*

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I. INTRODUCTION

Solar Energy is one of the most important non conventional sources of energy. The sun is the most powerful heat generator with which neither of the heat sources created by mankind can compete. Annually, the solar energy obtained by earth is 15000 as much as the power industry of the whole world can produce. It means that only a tiny part of solar energy is used for the sake of mankind. In this work, we are focusing on double pass solar air heater. Double pass solar air heater is a device which heats the air by using solar energy. Double pass solar air heater is mainly used for heating application. But, the main drawback of solar air heater is the low heat transfer rate between the absorber plate and the air. This results in the low efficiency of the solar air heater. Hence, to increase the heat transfer rate and the efficiency of solar air heater various techniques are used. Here in this work, copper tubes having zigzag shape for first pass and tubes having spiral shape for second pass are used. Solar air heater is a simple device that heats air by utilizing solar energy from the sun. It has a wide range of applications involves drying of agricultural products, such as seeds, fruits, vegetables and space heating.

II. OBJECTIVES AND SCOPE OF WORK

The objectives of this project are -

1. To fabricate the double pass solar air heater with better efficiency at low possible cost.
2. Performance analysis of double pass solar air heater.

Scope of work –

Though this solar air heater has the advantage of increased heat transfer rate up to a particular limit and higher temperature range for outlet air, but it has one main disadvantage that it cannot be operated in evening or night time when solar radiation intensity is low up to zero. Hence future scope for this project is the application of thermal energy storage so as to store energy at day time and utilise it for the night time so that it will be in operation for maximum hours of the day.

III. LITERATURE REVIEW

Sumit Kumar Singh et.al (2015) Performance Analysis of Solar Air Heater Using Three Wire Mesh:-work experiments has been performed on a solar air heater using three wire mesh and the result are discussed in change in thermal performance of solar air heater. In the set up there are two absorbing material viz. sand and charcoal. Three wire mesh of aluminum is used to improvement of thermal performance and a numbers of experiments are done on that and the changes in thermal performance are recorded .So the maximum temperature difference is up to 290^0C was recorded with this solar air heater and the average temperature increased is15.5^0C.

Chandan Kumar et.al (2014) Experimental performance analysis on solar air heater with three different modification in absorber plate :-The experimental analysis aims to compare three different types of designed solar air heater in which one arrangement having single pass(Type1) and two having double pass(Type II and III) air flow to achieve maximum heating value. Iron scraps are used in one of absorber plate of double pass solar air heater (Type III) to increase roughness and surface area. On the basis of energy output rate, double pass solar air heater (Type III) is more effective and difference between the input and output air temperature is higher than others. For better temperature difference, lower air flow rates should be preferred.

P. T. Saravanakumar et.al (2012) Numerical and thermal performance of the flat plate Solar Air Heater With and without thermal storage: The heat transfer characteristic and performance of the flat plate air heater with and without thermal storages are studied experimentally. The mathematical models described that the heat transfer of the plate solar air heater are derived from the energy equation. The implicit

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method of finite difference scheme is employed to solve these models. The effect of the thermal conductivity of the thermal storage on the heat transfer characteristic and performance is considered. The results obtained from the model are validated by comparison with experimental data. There is a reasonable agreement between the present model and experimental data. This study presents the mathematical model for predicting the heat transfer characteristic and performance of the air heater with the thermal storage material.

Rakesh Chaudhary et.al (2016) Experimental based on solar air heater using double pass with different segmentation on absorber plate: In this experimental method substantially improves the collector efficiency by increasing the fluid velocity and enhancing the heat-transfer coefficient between the absorber plate and air. Solar radiation passes through a transparent cover and impinges on the blackened absorber surface of high absorptive; a large portion of this energy is absorbed by the plate and then transferred to the transport medium in the fluid those carried away for storage or use. In the first type(Type I), Spring coil will be arrange as perpendicular to direction of air in, while in Type II that will be arrange in zigzag on absorber plate. Type III is a flat plate (without spring coil). The efficiency increases with increasing air mass flow rate. For the same flow rate, the efficiency of the double pass is found to be higher than the single pass.

IV. METHODOLOGY OF WORK

As A double pass solar air heater of 1150 mm length, 570 mm width and 170 mm height was fabricated using aluminium plate as absorber. Wooden box is made as a frame for the setup. For increasing the absorptance, aluminium plate is coated with black oil paint. To reduce the heat losses to the atmosphere, the collector bottom and lateral sides were insulated with 30mm thick thermocol and to reduce convective losses, the collector top side was covered with a 3 mm glass plate. Also arrangement of stand made up of iron rods is made in order to facilitate the manual tilting of the heater as per the hourly calculations of angle of inclination. Double pass mainly refers to the passage of air flow through the setup. Here two passes are made by using 1/2 inch diameter copper tubes. First pass is made of zigzag shape and the second pass refers to the spiral shape. Also it should be noted that first pass of zigzag shape is placed on above side of the absorber plate and the second one of spiral shape is placed below the surface of absorber plate. And after the end of second pass, same outlet pipe of copper tube is taken out of the wooden box frame. The heater was tilted with calculated angle with respect to the horizontal positioning in North-South direction to receive the maximum solar radiation. Using a blower, the air was forced through the inlet in the zigzag shaped tubes between the top glass cover and the absorber plate and then recirculates in opposite direction through the spiral shaped tubes between the absorber plate and the insulation. Also, for the evaluation of performance, temperatures at various points are measured using K type thermocouples and Digital Temperature Indicator(DTI).

V. EXPERIMENTATION

Fig 1. Fabricated set up of Double pass solar air heater

Experimental procedure started with the calculations of the optimum angle of tilt also known as scope as per explained in calculation part. According to obtained optimum angle, we adjusted the main iron stand alignment. It consists of several holes with the 2 bolts arrangement in square pipes for setting the various angle of inclinations. So setup was placed in north-south direction and tilt angle was adjusted on hourly basis calculations. Then after having the required alignment of the setup, electric blower was started and air was forced to pass through the nozzle of blower and from successive pipe into the inlet tube. Air then passed through the first pass i.e. through zigzag tubes which is in contact with absorber plate and hence gets heated with modes of heat transfer such as conduction and convection. Since copper tube also radiates heat and sun radiations are there, so radiation mode of heat transfer must be there. Next to the first pass, preheated air then passed through the spiral shaped second pass. And since that spiral shape is in contact with absorber plate hence heat transfer takes place from absorber plate to spiral tube through conduction and then spiral tube to the air flowing inside it through convection. It results in further heating and rise in temperature of air. And finally heated air comes out from outlet pipe which then can be utilized for various application purposes. For analyzing the performance of the heater, temperatures at various points had been measured with the help of K type thermocouples and DTI. The various temperatures measured are: temperature above absorber plate, temperature below absorber plate, inlet temperature of air, outlet temperature of air and the temperature at end of first pass which is considered to be the inlet temperature of second pass. Also the flow velocity of air through outlet pipe is measured using sensing anemometer. And the solar intensity is measured by using sensing solar meter.

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VI. CONCLUSION

In this project, a double pass solar air heater has been designed and developed. An experimental study conducted on the performance evaluation of double pass solar air heater on the different time and from that it is observed that double pass solar air heater with zig-zag and spiral tube gives greater outlet temperature with maximum 110^0C as compared to conventional systems which were producing maximum temperature of 80^0C. Also the general efficiency of flat plate collector heater is very less and after some modifications conventional systems had an efficiency of nearby 27% but here with this comparatively simple experimental setup, we are getting the maximum efficiency of 35%. And due to such higher temperature range, it can be conveniently used for grain drying purpose.

VII.FUTUROSCOPE

Though this solar air heater has the advantage of increased heat transfer rate upto a particular limit and higher temperature range for outlet air but it has one main disadvantage that it cannot be operated in evening or night time when solar radiation intensity is low up to zero. Hence future scope for this project is the application of thermal energy storage so as to store energy at day time and utilize it for the night time so that it will be in operation for maximum hours of the day.

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