EXPERIMENTAL PERFORMANCE ANALYSIS OF SOLAR AIR HEATER WITH THREE DIFFERENT MODIFICATIONS IN ABSORBER PLATE

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ABSTRACT:

The experimental analysis aims to compare three different types of designed solar air heater in which one arrangement having single pass(TYPE I) 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. Internal dimension of solar air heater was taken (1200×600×170) mm and thickness was 12mm.The energy output rate of solar air heaters were evaluated for various air flow rate (4.14, 3.89 and3.64 m/s) and tilt angle 26 degree. Various temperature verses time graphs were also plotted. 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.

KEYWORDS: ***Single pass solar air heater, Double passes solar air heater, Absorber plate with iron scrap, Experimental analysis, Energy analysis.***

I. INTRODUCTION

Solar air heaters are such type of devices which is used to heat air by using solar energy. Application of such types of solar air heaters are where the requirement of air temperature is below 60°C[1].Solar air heaters are used in drying of industrial and agricultural purposes and space heating [2]. These are the main application of solar air heaters. Now a day's various types of solar air heaters are used for industrial and agricultural application. The disadvantages of solar air heater is that it has low density of air as working substance, low thermal capacity of air and need of handling large volume of air than liquid. However in case of thermal storage water is superior to air. Some of the important advantages of solar air heaters are such as lower construction cost, lower weight and no freezing, boiling and pressure problems [3-4]. Various theoretical models and designed parameters are used to improve the disadvantages of solar air heaters [5-6]. These designed parameters are evaluated on the basis of experimental data. There are various factors which affect the solar efficiency such as number of glass plates, collector length, collector depth, types and shape of plates, wind speed etc [7-8].

For further improvement in solar air heaters, various studies and experimental work is going on. For obtaining effective solar air heater, we have calculated various temperature of glass cover, absorber plates. Inlet and exit air temperatures and different types of geometry of roughness elements of absorber plates. Radiation data is also

desirable for energy analyses of solar air heater. Therefore, main focus of the study will be on the detailed energy analyses of different designed flat plate solar air heaters for evaluating performance and optimizing the designed heaters with the maximum energy efficiency under given operating condition [9-10].

In this study, experimental analyses were done to compare the performance of designed flat plate solar air heaters with single pass solar air heaters (TYPE I), double pass solar air heaters (TYPE II) and double pass solar air heaters with iron scrap for increasing roughness (TYPE III).Main aim was to compare these parameters to get maximum energy output rate at various air flow rates.

Nomenclature		
• T	Temperature, °C	Subscript
• M	Mass flow rate, Kg/s	o outlet
• Cp	Specific heat capacity of air, J/Kg. K	i inlet
• I	Solar radiation intensity, w/m^2	
• A	Area, m^2	

II. LITERATURE REVIEW

Since 1700s, there were numerous inventions occurred in America to harness the sun's energy for heating home. E Morse was the first American person who designed and produced solar air heater in1881.Its structure was simple like a wall hung timber framed cabinet made up from a black sheet of metal covered with a sheet of glass. It functioned purely by convection, facing the sun hot air would be emitted from the solar heated steel plate within the cabinet. This would rise and enter the building via an opening in the wall behind the cabinet. Hence little attention was given to this system.

In 1920s, "solar house terminology was used first in newspaper of Chicago to describe south facing windows to obtain heat directly from sun. In 1940s, major development was taken in the field of solar collectors by another American K-Miller.

American developed a number of variations in the field of solar collector between the periods of 1940s to 1950s. In 1970, biggest research work in the field of solar energy concentration is carried by the combined effect of America and Canada.

A solar air heater consists of an absorber plate with a parallel plate below forming a passage of high aspect ratio through which the air to be heated flows. As in the case of the liquid flat plate collectors, transparent cover system is provided above the absorber plate, while a sheet metal container filled with insulation is provided on the bottom and sides. Solar air heaters are simple in design and require little maintenance. In addition, since the fluid does not freeze, the solar air heater has the advantage of not requiring any special attention at temperatures below 0^{o}C.there is no corrosion and leakage problems. Disadvantages associated with solar air heaters are such as large volume of fluid have to handled, electrical power required to blow the air etc.

There are various type of solar air heaters are available. They are as follows.

1.) Flow between the cover and absorber plate.
2.) Conventional air heater with continuous longitudinal fins.
3.) Two pass solar air heaters.
4.) Overlapped glass plate air heaters.
5.) Matrix air heaters.

III. RESEARCH METHODOLOGY

3.1 EXPERIMENTAL SETUP AND MEASUREMENT PROCEDURE:

Solar air heater consists of absorber plate, transparent cover, insulation material, and frame and air passage. A photograph of experimental set-up, construction detail and main properties of different solar air heaters are shown in fig.1, fig. 2 and table 1 respectively.

Fig 1.Experimental set-up of the solar air heater

The external dimension of all three type of solar air heaters are 1200×600×170 mm. Single glass cover were used in all three types of solar air heaters. Type I was single pass solar air heater and Type II and III were double pass solar air heaters. In absorber plate of type III, iron scraps were used for roughness. The skeleton of solar air heater was manufactured by ply wood of 12mm thickness and absorber plate was manufactured by aluminium sheet of 30 gauges. Transparent glass cover was taken which have thickness of 4mm.thermocol insulation was provided which have thickness of 22mm.Insulation was provided to reduce heat loss. Two holes were made at both sides of skeleton for inlet and outlet in the dimension of 30mm in diameters. The tilt angle of solar air heater was taken 26° by adjustable part. Solar air heater was placed in direction of north-south without any shadow. The radiation was measured by solar meter and it was placed parallel to the collector surface. Air is circulated by radial fan which was powered by electrical motor and flow between the absorber plate and glass cover in type I. And in type II and III, it flows below the absorber plate and came out above the absorber plate from another side. Air flow rate was adjusted by fan regulator for different speed.

Experiments on solar air heaters were performed in clear days of May and June in Jaipur, Rajasthan. Tests were conducted between 10:15 to 15:15 solar times. The solar radiation, wind speed, air velocity in the heater, ambient air temperatures, heater inlet and outlet air temperatures were taken in every 30 minutes interval periods and data is logged to data logger and respective graphs were plotted. Anemometer was used for measuring wind speed, thermocouples were used for measuring different temperatures at different point of solar air heaters and solar power meter was used for measuring solar radiation.

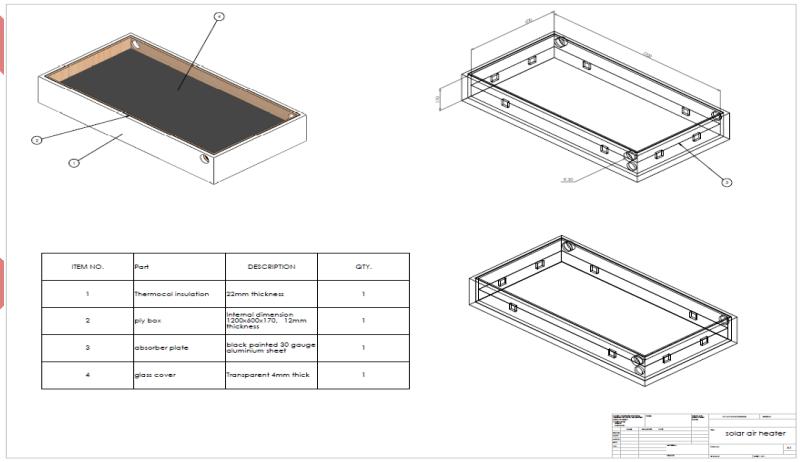

Fig 2.construction detail of the solar air heater

Table 1: Main Properties Of Different Type Of Solar Air Heater

PARAMETERS	TYPE I	TYPE II	TYPE III
• Absorber plate	Dull black painted aluminium sheet of 30 gauge thickness	Dull black painted aluminium sheet of 30 gauge thickness	Dull black painted aluminium sheet with iron scrap of 30 gauge thickness
• Insulation	Thermocol of 22 mm thickness	Thermocol of 22 mm thickness	Thermocol of 22 mm thickness
• Transparent cover	Single glass(4mm thickness)	Single glass(4mm thickness)	Single glass(4mm thickness)
• Frame	Ply wood	Ply wood	Ply wood
• External dimension	1200×600×170 mm	1200×600×170 mm	1200×600×170 mm
• Airflow regime	Above absorber plate	Below absorber plate	Below absorber plate

IV. RESULT AND DISCUSSION

The variation of different temperatures of solar air heater due to all the three types of modification in absorber plate was shown in fig.1, fig.2, fig.3, fig.4 and fig.5.The maximum solar radiation intensity recorded in case of single pass solar air heater was 1230 w/m^2. The maximum solar radiation intensity recorded in the case of double pass solar air heater was 1265 w/m^2. The maximum solar radiation intensity recorded in the case of double pass solar air heater with iron scrap was 1277 w/m^2.

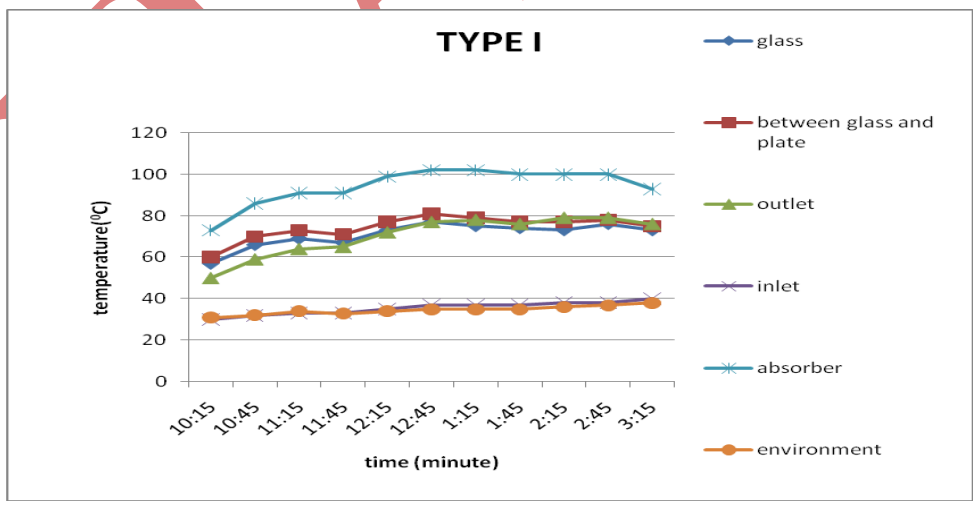

Fig.1. variation of different temperatures of type I on 23rd may 2014

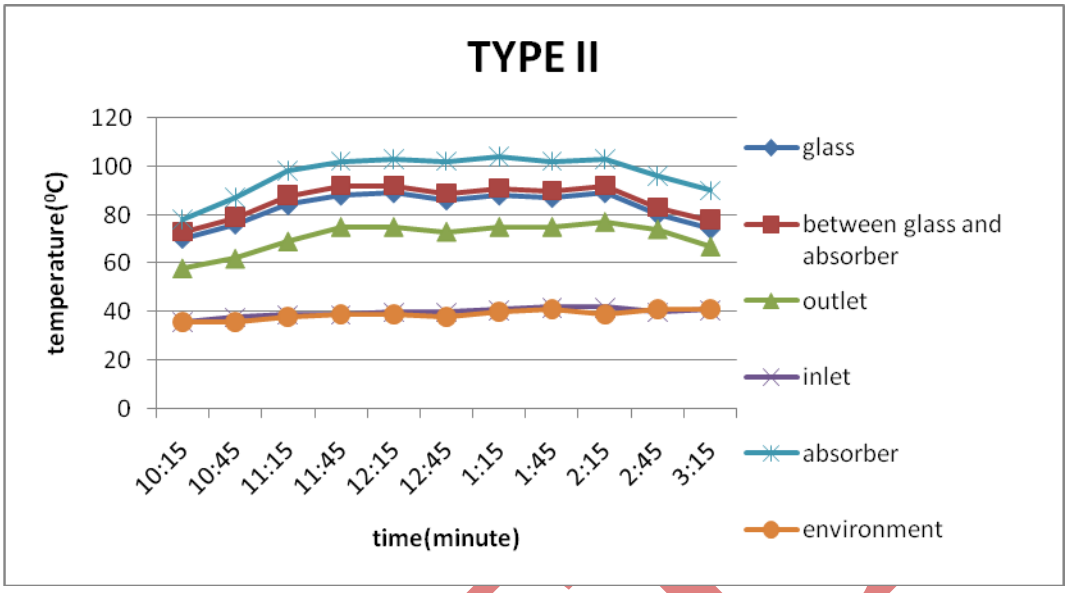

Fig.2. variation of different temperatures of type II on 24th may 2014

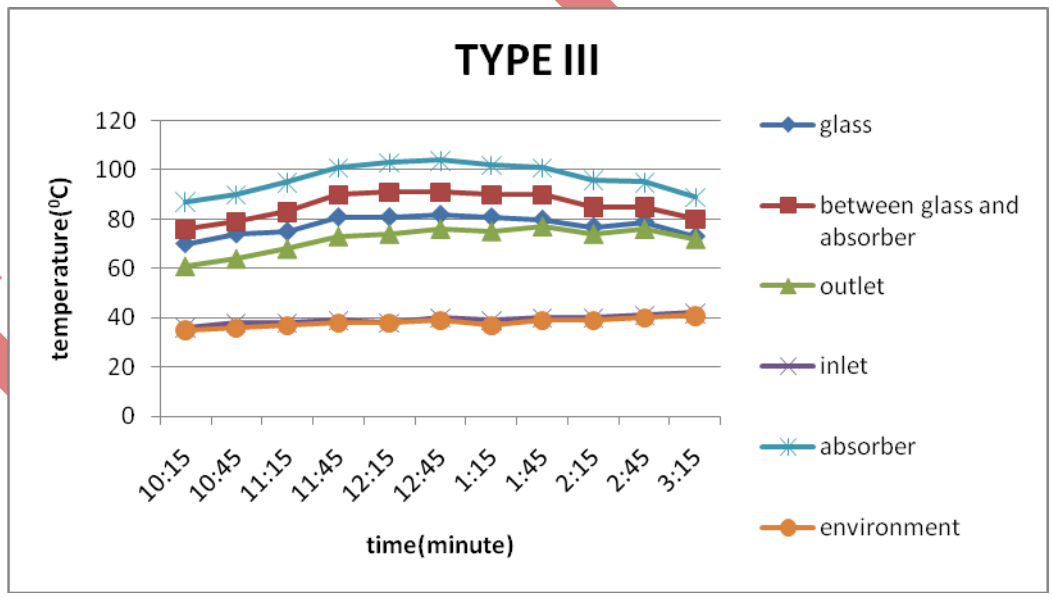

Fig.3. variation of different temperatures of type III on 25th may 2014

Temperature of absorber plate was also recorded. Temperature of absorber plate reached up to 104℃. as we know that absorber plate is the hottest part of solar air heater. Temperature of exit air reached a maximum value of 79℃ in the case of single pass solar air heater and in case of double pass solar air heater, it reached 77℃.in the case of double pass solar air heater with iron scraps on absorber plate, it reached 79℃ during the period of 2:15pm.There was appreciable rise in temperature from 10:15 am and after that from 2:45pm, all the temperatures reached the low value.

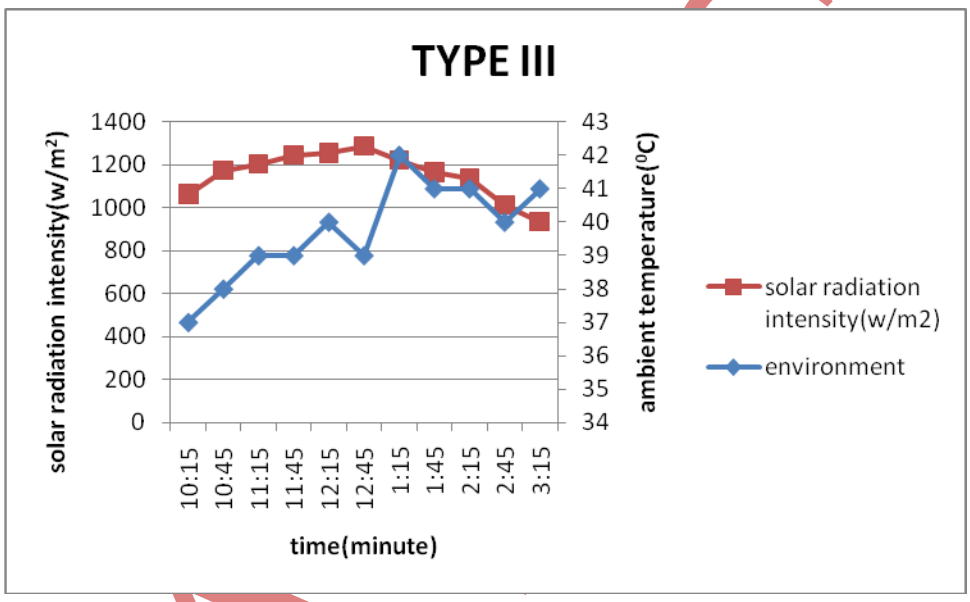

Fig.4.comparision of solar radiation intensity and ambient temperature

The comparison of solar radiation intensity and ambient temperature was shown in fig.4.The exit air temperature comparison was shown in fig.5 and a comparative value analysis was done.

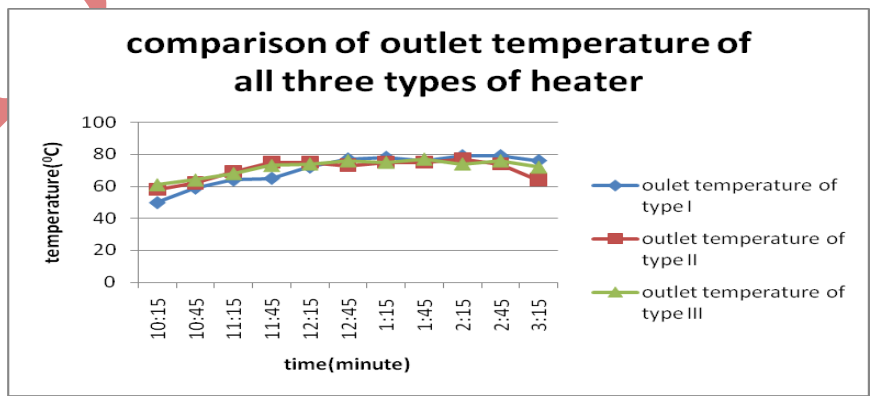

Fig.5. comparison of outlet temperature of all three types of heate

V. CONCLUSION

In this study, various modifications in absorber plate were investigated. Solar air heater was tested for three different types of absorber plate configuration at a tilt angle of 26^0. The main conclusions drawn during the study of solar air heater are as follows:-

- Absorber plate temperature of type III collector is higher than type I and II.
- Outlet temperature or exit temperature of type I collector is higher than type II and III.
- Solar radiation intensity was found maximum when experiment is carried with type III.
- Efficiency of the collector was found maximum in the case of type I collector.

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