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"EXPERIMENTAL INVESTIGATION AND PERFORMANCE ANALYSIS OF SOLAR AIR HEATER WITH PACKED BED ABSORBER PLATES"

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ABSTRACT

Non-renewable energy resources such as, fossil fuels which develop hydrocarbon. To improve the financial system of a country, the focus is changed to renewable energy resource like solar energy, which is ecological friendly, acquire in sufficient qualities and endless in Nature. It fulfills the future energy needs. It is used for cooking, drying clothes and medicines, and heating both air and water. To reduce the demand for the conventional fuels, the solar air heaters are developed. The present work experimentally investigated The performance of a forced convection solar air heater was experimentally investigated using Flat Absorber Plate, Circular Absorber Plate and Triangular Absorber Plate with heat absorbing material. The experimentation was done on dated 13.04.2021 and 14.04.201 at Bhopal Madhya Pradesh. The experimental observations were made in a forced convection solar air heater using flat absorber plate, circular absorber plate and triangular absorber plate. The air mass flow rate through the forced convection solar air heater three different air mass flow rates of 0.02 kg/s, 0.04 kg/s and 0.06 kg/s Based on the investigation the pressure drop in circular absorbing plate is more as compare to flat and triangular plate.

The outlet air temperature of a forced convection solar air heater was improved using packed bed absorber plate by about 3 to 18 ^{o}C when compared to the flat absorber plate due to the addition of latent heat storage wax used. The packed bed absorber plate configuration in a forced convection solar air heater provides supplementary heat storage.

Key Words: Solar Air Heater , packed bed absorber , Flat Absorber Plate, Circular Absorber Plate and Triangular Absorber , Heat Absorbing Material.

I. INTRODUCTION

1.1 Solar Energy

The stipulate for the energy resources has increased in everyday life partly because of their usage in domestic appliances. The energy resources are divided as renewable energy resources, which occur natural sun, soil, water, air, and biomass; non-renewable energy resources called conventional energy resources like coal, petroleum, steel etc., are finite and depleting rapidly. The atmosphere is polluted when the fossil fuels are burnt and lead to environmental problems like global warming and acid rain. However, solar energy is environmentally clean source of energy, which is available freely and in adequate quantities throughout the world.

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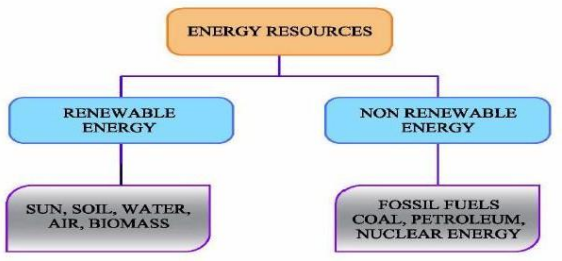

Figure No. 1.1: Classification of Energy Resources

II. THERMO HYDRAULIC PERFORMANCE

Solar Air hear absorbing collector in such a way that it should transfer maximum heat energy to the flowing fluid with minimum power consumption by fan or blower. So in sort to analyze overall performance of solar air heater thermo hydraulic performance must be evaluated by considering both thermal and hydraulic characteristics of the solar are heater absorbing collector. Biplab Das *et al.*, (2021) , increment in mass flow rate by 87% lead to decrement in the magnitudes of stored energy by 10–24% and but the average discharging efficiency was increased by 15%. Abhishek Gautam *et al* (2020), The effects of pore diameter, pore depth, number of pores and mass flow rate is discussed and presented in the present paper. In order to investigate the performance.Saleh Abo *et al* (2020) , Efficiency is greater than efficiency by about 19.4%, 21%, and 40.3%, at inlet air flow rate of 0.075 kg/s, 0.05 kg/s and 0.025 kg/s . Ali Ahmadkhani *et al* (2020) Pressure drop due to the existence of matrix was considered to obtain more realistic outcomes. Radouane Elabahja *et al* (2019) , A numerical model based on the finite volume method and the conservation equations was developed to model the heat transfer and flow processes in the storage unit. Jacek Jan *et al* (2019), the experiment was conducted under steady state artificial radiation conditions in a laboratory environment.F.Basrawic *et al* (2019) , uniform heat flux (indoor) and outdoor solar radiation as heat source. The air mass flow rates used were between 0.0142 kg/s and 0.0360 kg/s. Techno- economic feasibility studies were conducted using cost-benefit ratio (AC/AEG) method. Thermal efficiency .Muhammad Sajawal *et al* (2019) , The air heater is studied for three different configurations. In the first configuration, is no PCM used. In the second configuration, RT44HC having higher melting point .Mehrana Mohammad *et al* (2019) , The results of evaluations showed that the highest total energy consumption of the dryer was equal to 1.163 kWh which was obtained in NGD test mode, while the lowest amount of total energy . Rakesh Kushwaha *et al*., (2018) examined thermal performance for solar air heater with Modified Absorber. Experimentally Computational Fluid Dynamic analysis of solar air heart having triangular shaped bodies place over the absorber .Alsanossi *et al*., (2017) experimentally analysed the performance analysis of single pass solar air heater with jet impingement on wavy shape corrugated absorber plate. The comparison between smooth and corrugated .Gade Bhavani *et al*., (2017) studied the performance analysis of a conventional air heater. Improving the thermal performance of the solar air heaters. In this experimental glass is used as cover material for collectors. Ammar *et al*., (2017) presented theoretical and experimental studies for a double pass solar air heater. The study indicated that the increase in air flow rate through the collector had increased the instantaneous efficiency and the useful energy was gained but it reduced the air outlet temperature rapidly.

III. EXPERIMENTS SET-UP AND EXPERIMENTAL INVESTIGATION

1.3 Experiments Set-up and Experimental investigation. Experiments were conducted for both Conventional and with heat storage materials the solar air heaters were designed, fabricated and constructed with GI Iron , dimensions 2m 1m 0.20 m. The solar air heaters were arranged with various absorber materials and different position of absorber plates

The two absorber plate configurations experimentally investigated.

(i) Flat plate

(ii) Circular absorber plate packed with latent heat storage material.

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(iii) Triangular packed with latent heat storage material.

i. Flat absorber plate ii. Circular absorber Plate iii. tringuler absorber Plate

Figure No. 1.2 . Absorber plates configuration

IV. CALCULATIONS FORMULATION AND PARAMETER

The energy balance equation for a Forced convection solar air heate based on first law of thermodynamics is :

$$\dot{Q}_{ab} = \dot{Q}_u + \dot{Q}_s + \dot{Q}_{loss}$$

$$\dot{Q}_{ab} = A_p \times \alpha \times \tau \times I$$

Amount of heat absorbed by the absorber plate is given by:

Amount of energy stored in the PCM (paraffin wax) is given by following equation.

$$\dot{Q}_{ch} = \frac{m_{pw}\left(c_{pws}(T_{mel} - T_{\text{int}-ch,pw}) + h_{fg} + c_{pwl}(T_{fin-ch,pw} - T_{mel})\right)}{(\Delta t)_{ch}}$$

$$\dot{Q}_{loss} = U_{loss} \times A_p \times (T_P - T_0)$$

The heat lost to the surroundings is given by:

$$h_{c,p-g} = Nu\left(\frac{k_i}{x}\right)$$

The convective heat loss between the plate and the glass is given by:

V. THERMODYNAMIC PERFORMANCE USING DIFFERENT ABSORBER PLATE CONFIGURATIONS

The variations of thermo efficiencies of a forced convection solar air heater using four different absorber plate. The efficiency of a forced convection solar air heater using flat absorber plate was varied between 8.42 and 20.25 with an average value of about 07.16 the efficiency is influenced by pressure drop across the solar collector and solar Intensity falls on the collector.

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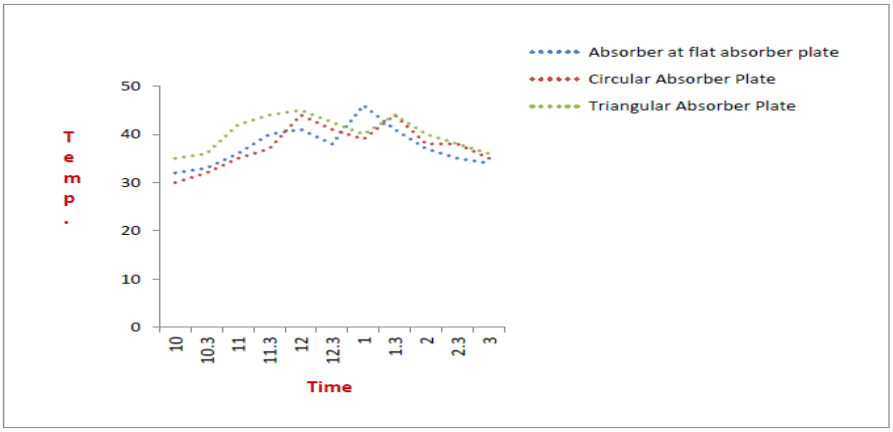

Figure No. 1.3 Comparison of efficiency vs time without wax, 13.04.2021

Similarly, the efficiency of a forced convection solar air heater using circular absorber plate was varied in the range between about 15.34 to 34.68 with an average value of about 25.02.

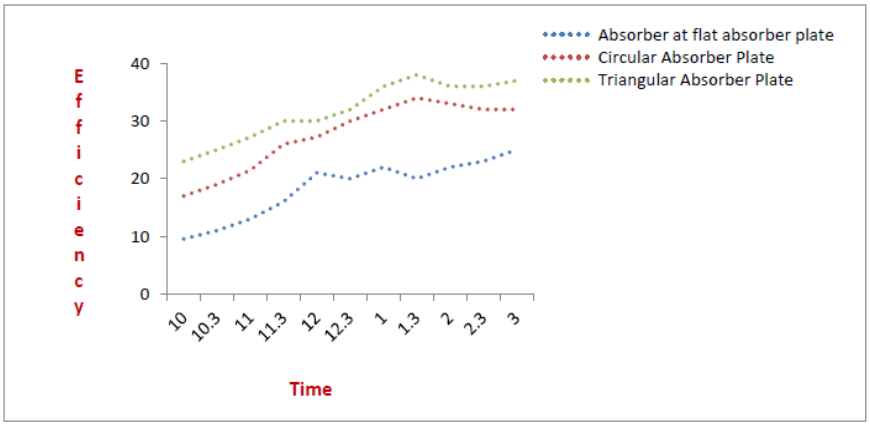

Figure No. 1.4 Comparison of efficiency vs time without wax, 13.04.2021

A maximum efficiency of about 34.68 was observed during 1.30 pm. The paraffin wax packed in the circle tube and triangle tube absorbs the heat during its phase change till 3.00 pm.

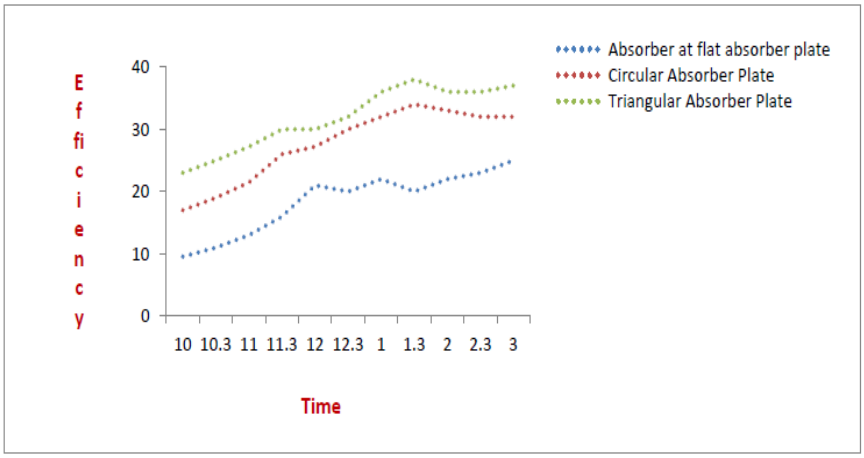

Figure No. 1.5 Comparison of efficiency vs time without wax, 14.04.2021

During the charging period, solar energy was harvested in the form of sensible and latent heat. The harvested solar energy was stored in the paraffin wax. The results confirmed that maximum efficiency was observed triangular plat

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absorber plate

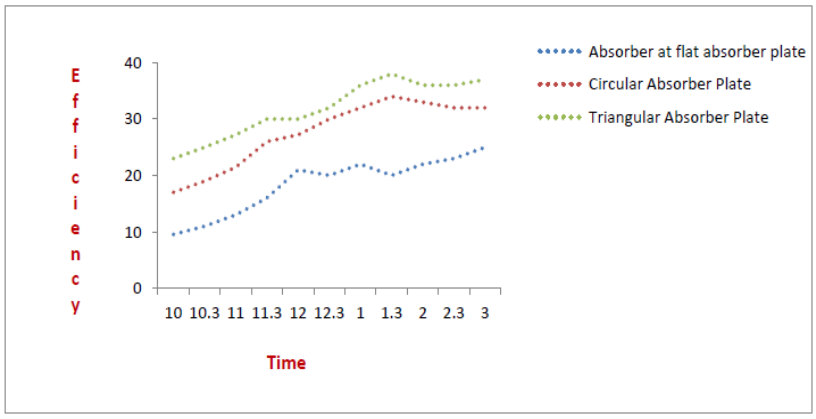

Figure No. 1.6 Comparison of efficiency vs time with wax, 13.04.2021

Comparison of efficiency vs time with wax for dated 13.04.2021 and 14.04.2021 for Flat Absorber Plate, Circular Absorber Plate and Triangular absorber Plate with and without wax packed bed absorber plates is provided additional heat. harvested in the form of sensible and latent heat.

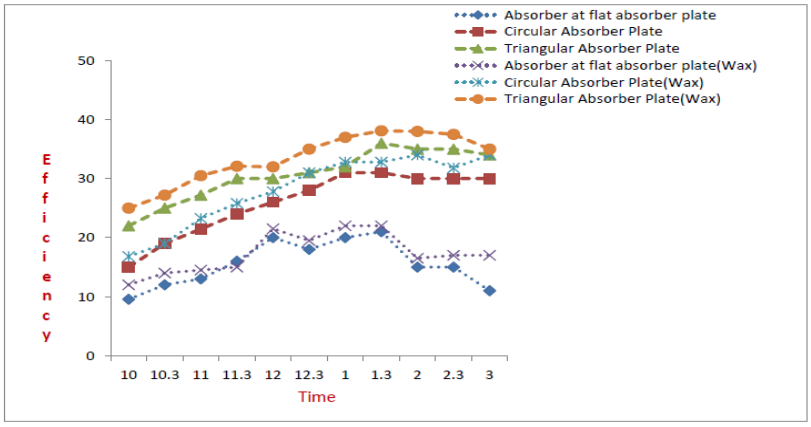

Figure No1.7. Comparison of efficiency vs time with wax, 13.04.2021

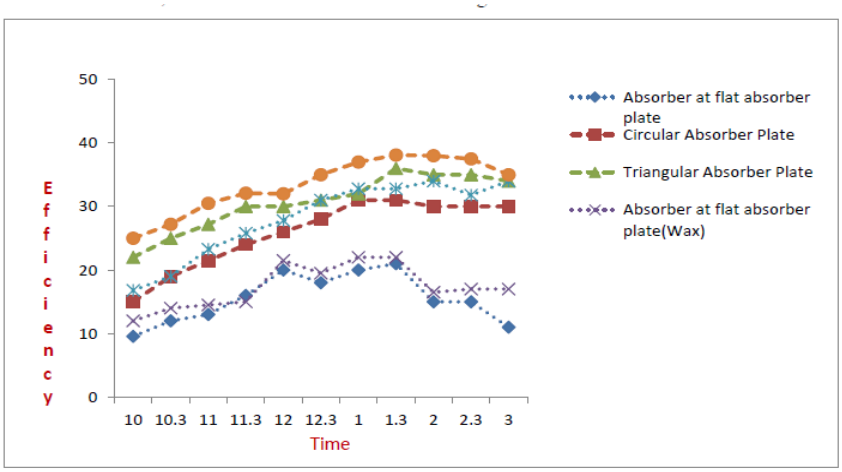

Figure No1.8. Comparison of efficiency vs time with wax, 14.04.2021

The paraffin wax packed in triangular and circular tube absorber plate configurations absorbs the solar energy till 3.00 pm and gets increased to about 44 oC. During the charging period, solar energy was harvested in the form of

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sensible and latent heat. The harvested solar energy was stored in the paraffin wax and released the heat during discharging processes.

VI. PRESSURE DROP

Compares the pressure drops in forced convection solar air heater using flat, triangular and circular tube absorber plate configurations with and without wax. As using different mass flow rate to compare the thermo-hydro performance to increase in air mass flow rate from 0.02 kg/s to 0.04 kg/s.

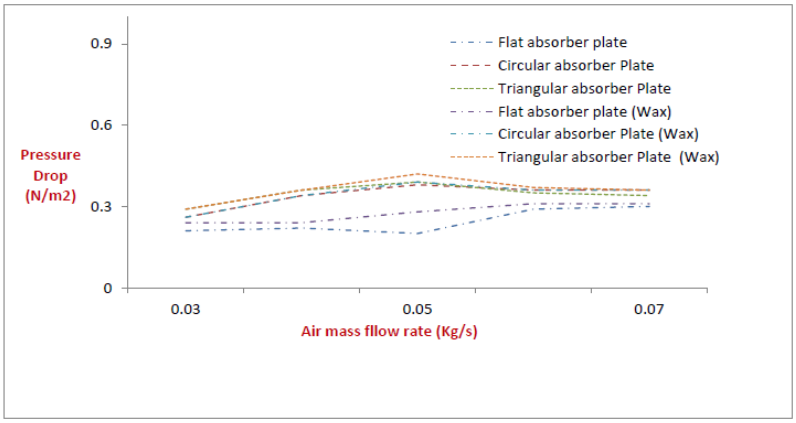

Figure No1.9 Variation of pressure drop vs air mass flow rate with wax dated 13.01.2021

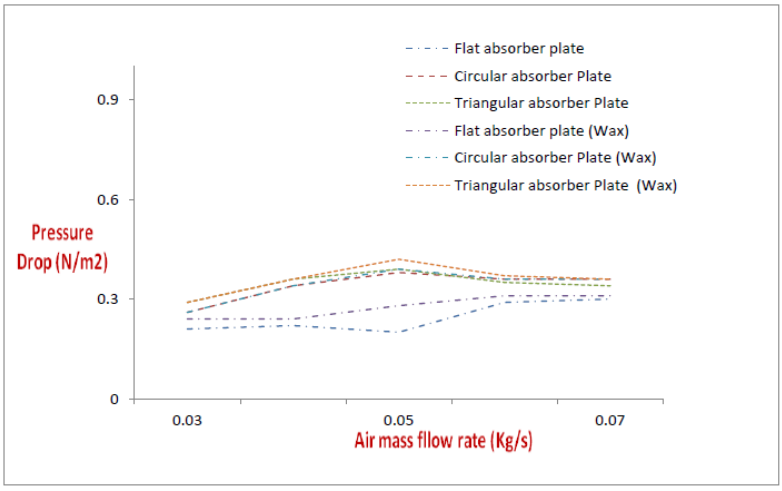

Figure No1.10 Variation of pressure drop vs air mass flow rate with wax dated 14.01.2021

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VII. CONCLUSION

The performance of a forced convection solar air heater was experimentally investigated using Flat Absorber Plate, Circular Absorber Plate and Triangular Absorber Plate with heat absorbing material. The experimentation was done on dated 13.04.2021 and 14.04.201 at Bhopal Madhya Pradesh. The performance of solar air heaters using different types of absorber plates to have realistic performance comparison. The major result observed in these research investigations is mentioned.

The experimental observations were made in a forced convection solar air heater using flat absorber plate, circular absorber plate and triangular absorber plate. Air temperatures at the inlet and the outlet of a forced convection solar air heater for absorber plate are varied 3 to 18% more as compare to flat plate without heat absorbing material.
The air mass flow rate through the forced convection solar air heater three different air mass flow rates of 0.02 kg/s,

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0.04 kg/s and 0.06 kg/s Based on the investigation the pressure drop in circular absorbing plate is more as compare to flat and triangular plate. The pressure drop in the circular and triangular absorber plate is about 21 to 52% higher.

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