International Journal of Engineering Science Invention (IJESI)
ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726
www.ijesi.org ||Volume 7 Issue 9 Ver II || Sep 2018 || PP 19-25

Effectiveness of Composite Absorber on Solar Air Heater with Double Glass Cover

A.Jayakumar[1], S. Saravanan[2] And N. Krishna Mohan[3]
[1]Research Scholar, [2]Associate Professor, [3]Professor, Department of Mechanical Engineering, Annamalai University, Annamalainagar, Tamilnadu, India
Corresponding Author; A.Jayakumar

Abstract: *This research focuses on experimental investigation that was carried out to study the performance of two identical flat plate solar air heaters with two different absorber material, one in conventional type (type-1 absorber black coated galvanised iron plate) and the other one composite absorber (type-2 absorber clear toughened glass placed above the black coated galvanized iron plate). The aim of this study is to experimentally analyse the performance of this system and to alleviate the problems of black coated galvanised iron plate used as absorber material in Commercial/Existing solar air heater.*
The efficiency of the solar air heaters for the two positions of absorber at different mass flow rates (single flow) were experimentally established. Various efficiencies at different time intervals, with solar intensity were also plotted on the graphs. On the basis of energy output rate, solar air heater composite absorber (type-2) is more effective and the difference between the inlet and the outlet air temperature is higher than that of the conventional absorber (type-1).
Keywords - *Solar air heater, Galvanised iron plate, Composite absorber, Toughened glass, Outlet air temperature, efficiency*

Date of Submission: 06-09-2018 Date of acceptance: 24-09-2018

I. Introduction

In the present world, the prosperity of a nation is measured by the energy consumption of that nation and that total domestic product of a country is directly linked with energy consumption. The demand for energy resources is increasing day by day. Conventional energy resources are finite, depleting fast and this fossil fuel will gradually come to an end. The burning of fossil fuels introduces many harmful pollutants into the atmosphere and contributes to environmental problems like global warming and acid rain. Solar energy is free and environmentally clean and therefore it is recognised as one of the promising alternative energy resources.

Solar air heater is a simple device that heats air by utilizing renewable solar energy from the sun. Solar air heaters have been developed with the aim of reducing the consumption of conventional fuels. Heated air is utilized in various fields like agriculture, and processing industries. It is used for drying agricultural products such as seeds, fruits, vegetables, marine products and that too as a low-temperature energy source. In civil engineering field, it is used for space heating, heating of buildings to maintain comfort during winter season and for industrial process in textile and paper industries and so on. Many researchers have attempted various designs to enhance the thermal efficiency of a flat plate solar air heater.

In the present study, the composite absorber (type-2) is used as absorber plate in the solar air heater and has been compared with the conventional solar air heater (type-1) for different mass flow rate of air.

Persad et al.,[1] presented the analytic models which were developed for the thermal performance prediction of a two-glass-cover solar air heater operated in both the single-pass and two-pass modes. It has been reported that the two-pass mode of operation is consistently superior to the single pass mode by 2 to 9 percent. Chetan Mamulkar et al., [2] studied experimentally the performance evaluation of double flow solar air heater. Air flow from both sides of copper plate is more efficient than that of any other kind of solar air heater. Adnane Labed et al., [3] presented the performance investigation of single- and double pass solar air heaters through the use of various shape of obstacles. The double-pass flat plate solar air heater with trapezoidal obstacles exhibited higher efficiencies. Mahmood et al., [4] experimentally investigated the double pass solar air heater with transverse fins and without absorber plate. The double pass counter flow solar air heaters, with four transverse fins and wire mesh layers used as an absorber plate with porous media, resulted in a higher thermal efficiency. Rajendra Karwa et al., [5] studied on the performance of solar air heater having v-down discrete rib roughness on the airflow side of the absorber plate along with that for a smooth duct air heater. The mathematical model presented and compared with the predicted and experimental thermal efficiency. Bhupendra Gupta et al., [6] analysed experimentally a single and double pass smooth plate solar air collector with and without porous media to find the thermal efficiency of flat plate solar air heater. The double flow mode is more efficient than the single flow mode and using of porous media increased the system efficiency and the outlet temperature.

Chandan Kumar et al.,[7] analysed experimentally the performance of solar air heater with three different modifications in absorber plate. On the basis of energy output rate, double pass solar air heater with iron scraps in one of absorber plates was found to be more effective than those of others. Veena Pal et al., [8] experimentally investigated the performance study of a solar air heater. By increasing surface roughness for improving the heat transfer rate from the absorber plate. Foued Chabane1 et al., [9] experimentally studied on the heat transfer in a single pass of solar air heater without fins, and with fins attached under the absorbing plate. The highest collector efficiency and air temperature rise were achieved by the finned collector. Kaushik Patel, et al., [10] reviewed to enhance the efficiency of double pass solar air heater. The absorber material of uncoated metallic wiry sponge resulted in the maximum efficiency. Chandra Bhushan et al., [11] investigated experimentally the thermal performance of the double pass solar air heater having a collector angle inclination of 60° with double flow channel. The absorber plate temperature and outlet temperature increased with increase in solar intensity when the mass flow rate of air was constant. Gade Bhavani Shankar et al., [12] studied the performance analysis of a conventional air heater. The heat transfer coefficient increased with mass flow rate by 50%, due to increase in temperature difference.

After studying number of papers related with solar air heater it was observed that no experimental or simulation analysis has been carried out so far to study the performance of the device using absorber GI plate composite material (type-2: absorber black coated galvanised iron plate inserted below the two toughened glasses).

II. OBJECTIVE

Solar air heater is simple in design with a small or an affordable minimum maintenance. Solar air heaters are important equipments used for effective utilization of solar energy. In the existing solar air heater, the absorber plate is usually Galvanised Iron, Copper or Aluminium sheet coated with matte black paint. The hot air coming from this system can also be used in process applications such as spices drying, fruits and vegetable dehydration, medicinal plant, marine foods (fish), house hold eatables and drying of crops (i.e., tea, coffee, corn). Odour of paint has its impact on end products. To overcome this problem, a new type of composite absorber material has been attempted and experimental investigation on its performance has been taken as prime objective of this research work.

III. COMPOSITE ABSORBER

Galvanised iron plate of 20SWG coated black matte paint at the top above that 4 mm thick clear toughened glass is placed so that due to self weight of the glass, the glass plate and GI plate join together without air gap and form composite absorber.

IV. EXPERIMENTAL SETUP

Experimental setup has been designed for experimental investigation as shown in Figs. 1 & 2. Two identical solar air heater setup of collector area 2 m^2 is designed and fabricated. One absorber with galvanised iron plate of 20 SWG coated black matte paint with one glass cover 4 mm thick clear toughened glass type-1 and another composite absorber with double glass cover. Glass wool with insulating material on the back of the bottom of plate and on the casing sides to minimise the heat losses. Shutters are provided to open and close the passage of air. The air heaters were placed facing due south to receive maximum solar intensity throughout the day. Experiments were conducted for three mass flow rates. Fig. 3 shows the photographic view of the experimental setup.

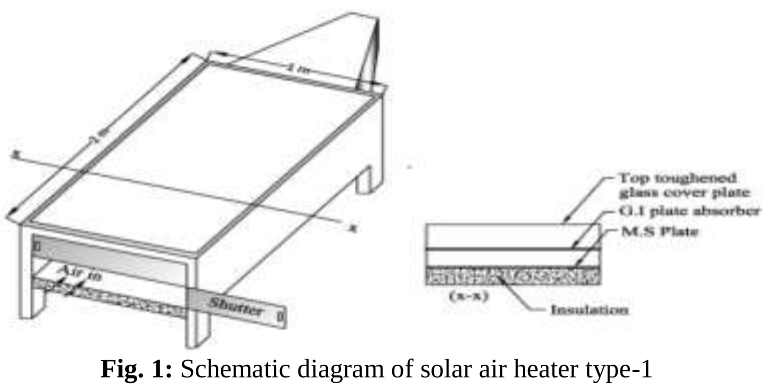

Fig. 1: Schematic diagram of solar air heater type-1

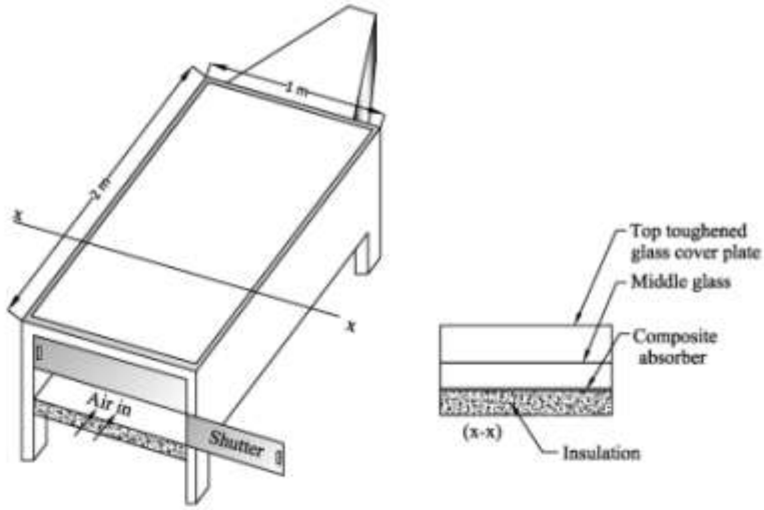

Fig. 2: Schematic diagram of solar air heater type-2

Fig .3: Photographic view of experimental setup.

V. EXPERIMENTAL MEASUREMENTS

During the experiment, the air to be heated was allowed at uniform mass flow rate to pass through the two different absorbers. T-type copper- constantan thermocouples were used and the recording interval was normally taken as 30 minutes because no rapid variations should occur during these experiments. The inlet and the outlet temperature of air, the absorber plate and glass plate temperature were measured. The solar radiation has been measured by means of Pyranometer. Digital anemometer was used to measure the velocity of air. The experiment was carried out between 9.30 a.m. and 4 p.m.

VI. RESULTS AND DISCUSSION

The performance analysis of flat plate air heater of two types of absorber plate materials was done experimentally, in Solar Energy Laboratory, Department of Mechanical Engineering, Annamalai University, Annamalainagar, Tamil Nadu, India (11.3921□N latitude and 79.7147□E longitude). Graphs were plotted between Time Vs Efficiency with solar intensity, air inlet and outlet temperature and Time Vs absorber plate temperature are shown in Figs. 4 to 12.

Figs. 4, 5 and 6 show the variation of efficiency and solar intensity of two types of absorber material for different mass flow rate of air 0.00848 kg/s, 0.01272 kg/s, 0.0169 kg/s. The thermal efficiency of type-2 solar air heater for a flow rate of 0.0169 kg/s. was found to range between 24% and 46%. The thermal efficiency is higher in the composite absorber type-2 than in the conventional type-1.

As the mass flow rate of air increased, the efficiency also increased. Comparing the two configurations of the absorbers tested, the type-2 was found to show higher thermal efficiency throughout the day, followed by type-1. The type-1 was found to show the lower value all the day. The variation of solar intensity for the experimental days, the intensity increased and reached maximum at mid day and then decreased.

Figs. 7, 8 and 9 show the outlet and inlet air temperature plot. The outlet air temperature was higher in the case of composite absorber plate type-2 than in the conventional absorber type-1 for different mass flow rate of air (0.00848, 0.01272 and 0.0169 kg/s). Comparing the two configurations of the absorbers tested the type-2 obtained maximum air outlet temperature of 92□C for the flow rate of 0.0169 kg/s.

Figs. 10, 11 and 12 show the absorber plate temperature of conventional and modified type. The absorber plate temperature was higher in the case of type-2 than in the conventional type for different mass flow rate of air (0.00848, 0.01272 and 0.0169 kg/s). Comparing the two absorbers tested the type-2 obtained maximum absorber plate temperature of 107 □C for the flow rate of 0.0169 kg/s.

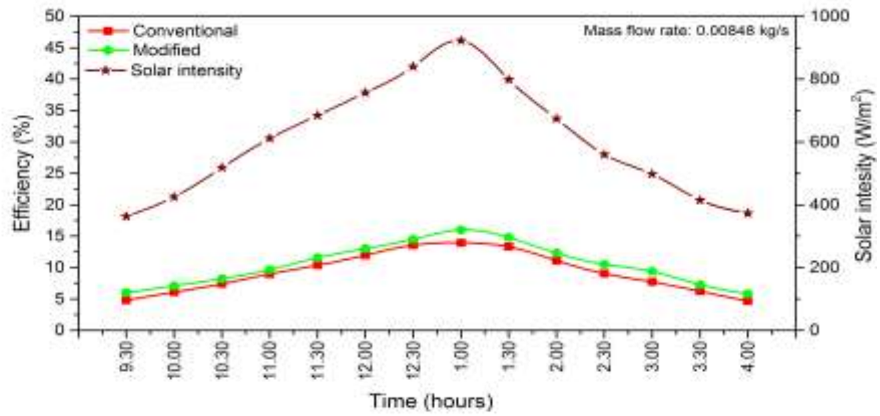

Fig. 4: Variation of thermal efficiency for mass flow rate of 0.00848 kg/s

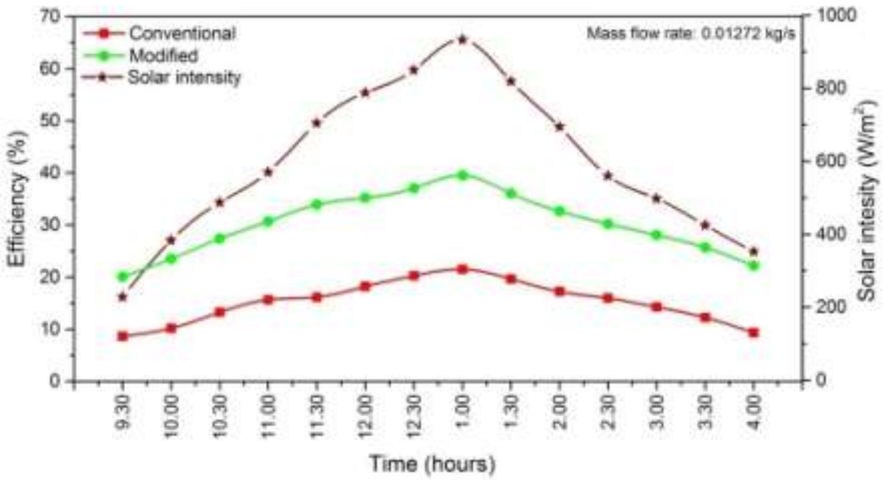

Fig.5: Variation of thermal efficiency for mass flow rate of 0.01272 kg/s

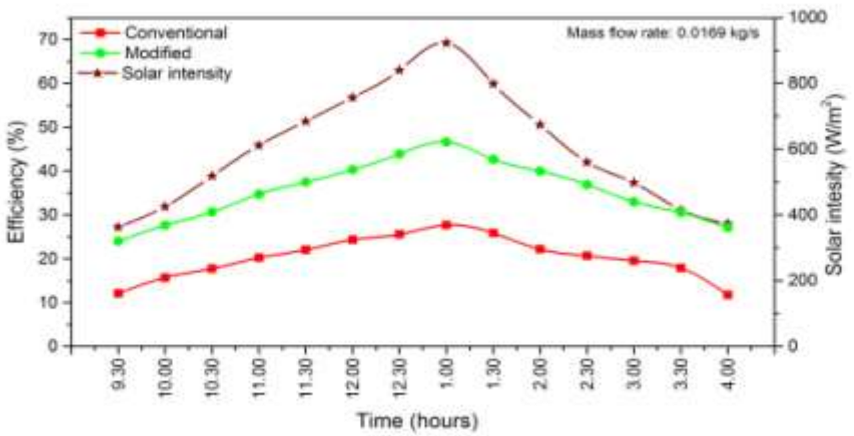

Fig. 6: Variation of thermal efficiency for mass flow rate of 0.0169 kg/s.

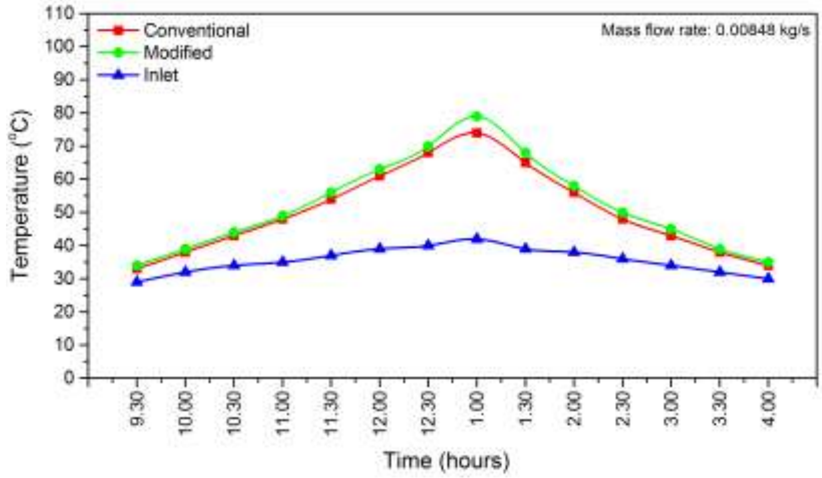

Fig. 7: Variation of different temperatures for flow rate 0.00848 kg/s.

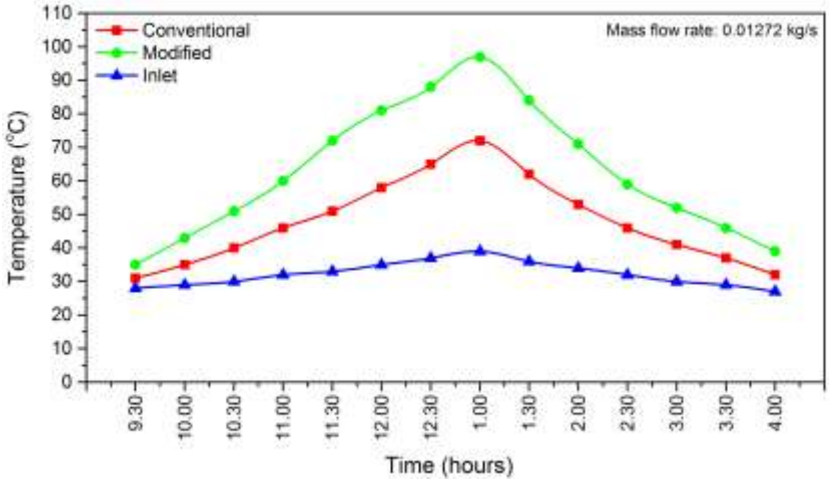

Fig. 8 Variation of different temperatures for flow rate 0.01272 kg/s

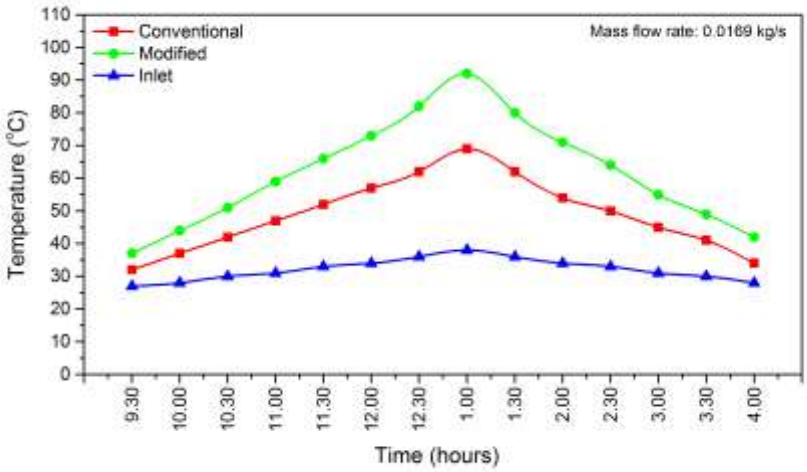

Fig. 9: Variation of different temperatures for flow rate 0.0169 kg/s

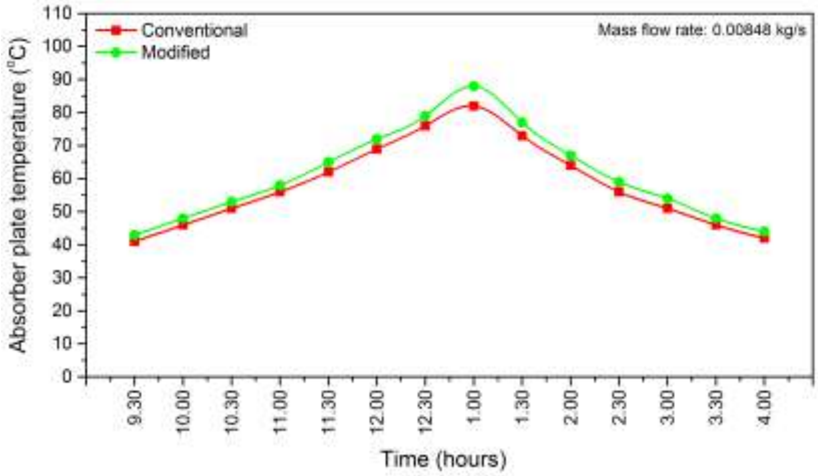

Fig. 10: Variation of Absorber plate temperatures for flow rate 0.00848 kg/s

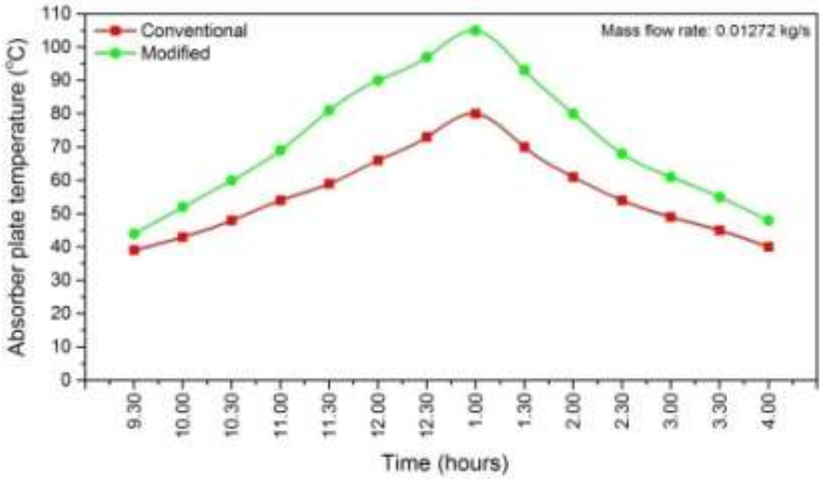

Fig. 11: Variation of Absorber plate temperatures for flow rate 0.01272 kg/s

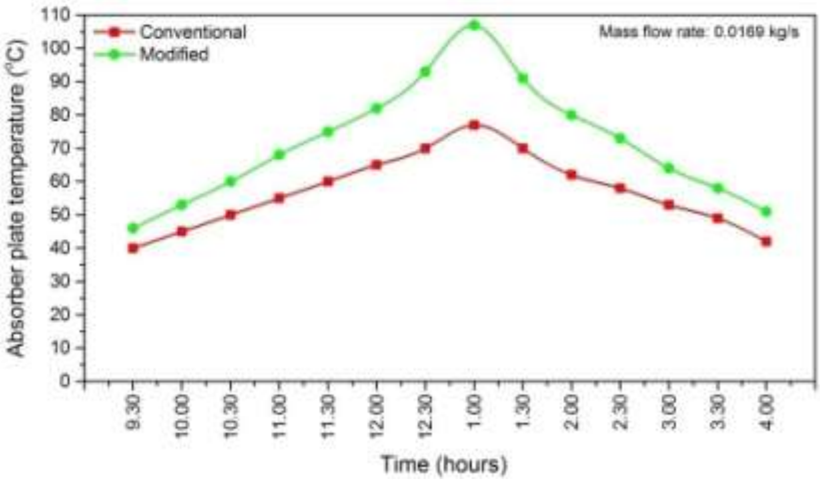

Fig. 12: Variation of Absorber plate temperatures for flow rate 0.00169 kg/s

In the new design of composite absorber type-2, both glass and galvanised iron plate transfer the heat to the flowing air which increased the heat gained by the air than that of the conventional type-1. The results indicate that type-2 composite absorber performed more satisfactorily than the conventional absorber type-1 with respect to efficiency of solar air heater.

VII. CONCLUSION

The following conclusions were drawn from the investigative experiments conducted on flat plate solar air heater with two different configurations of the absorber plate material. Selection of absorber material has an influence on the performance of flat plate solar air heaters.

Due to toughened glass, placed above the Galvanised Iron plate more radiation was received by the composite absorber. Maximum temperature of outlet air was obtained for composite absorber type-2, when compared to the conventional absorber type-1, in all the experiment. The thermal efficiency of air heater is higher in the composite absorber.

With this type of composite absorber only glass surfaces was in direct contact with the air and the degradation of absorber material does not occur, as moisture present in the air has no direct contact with the galvanised iron plate of composite absorber.

The hot air coming from this will not have any adverse effect on the quality of drying product, due to paint. It was found that the thermal efficiency of composite absorber solar air heater type-2 is higher than the conventional solar air heater type-1.

REFERENCES

[1]. P. Persad and Satchunanathan S (1983), The thermal performance of the Two-pass, Two-Glass-cover solar Air heater, Journal of Solar energy engineering, Aug., Vol. 105/255.

[2]. Chetan Mamulkar and Katekar V.P. (2012) Performance evaluation of double flow solar air heater, National conference of innovative paradigms in Engineering & Technology (NCIPET-2012) , Proceedings published by international journal of computer applications (IJCA).

[3]. Adnane Labed, Noureddine Moummi, Adel Benchabane,Kamel Aoues and Abdelhafid Moummi (2012), Performance investigation of single and double Pass solar air heaters through the use of various fin geometries, International journal of sustainable Energy, Vol. 31(6), December, pp. 423-434.

[4]. A.J. Mohmood and Aldabbagh B.Y., Double pass solar air heater with transverse fins and without absorber plate. World academy of science, Engineering and Technology, International journal of Mechanical, Aerospace, industrial, Mechatronic and Manufacturing Engineering, Vol. 7 (6), 2013.

[5]. Rajendra Karwa and Girish Vhitoshiya (2013), Performance study of solar air heater having v-down discrete ribs on absorber plate, ELSEVIER Energy 55, pp. 939-955.

[6]. Bhupendra Gupta Jitendra Kumar Waiker, Gopal Prasad Manikpuri and Brahman Singh Bhalavi, Experimental analysis of single and double Pass smooth plate solar air collector with and without porous Media, American journal of engineering research (AJER) Vol. 2(12), pp.144-149.

[7]. Chandan Kumar, and Hari Singh (2014), experimental performance analysis of solar air heater with three different modifications in absorber plate, International journal of advanced technology in engineering and science, June, Vol. 2(6).

[8]. Veena Pal, Ajeet Kumar Rai and Vivek Sachan (2015), Performance study of solar air heater, International journal of Mechanical Engineering and Technology, Vol. 6(7), July, pp. 01-07.

[9]. Foued Chabane, Nesrine Hatraf, Noureddine Moummi (2014), Experimental study of heat transfer coefficient with rectangular baffle fin of solar air heater, Research article, Front energy, Vol. 8(2), pp. 160-172.

[10]. Kaushik Patel, Sukritindra Soni, Umang Soni (2015), A review enhance the efficiency of Double pass solar Air heater, International journal on recent and innovation trends in computing and communication, (IJRITCC) February, Vol.3(2).

[11]. Chandra Bhushan and Singh S.N (2016), Experimental investigation of double-pass solar air Heater, ELK Asia Pacific Journals – ISBN: 978-81-9390411-8-5 -2016.

[12]. Gade Bhavani Shankar and Kishore P.S. (2017), Performance analysis of a conventional air heater, International journal of research – Granthaalayah, April, Vol. 5(4).

A.Jayakumar"Effectiveness of Composite Absorber on Solar Air Heater with Double Glass Cover "International Journal of Engineering Science Invention(IJESI), vol. 7, no. 9, 2018, pp. 19-25