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Thermal Performance of A Biomass Air Heater

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A B S T R A C T

In the present work, an attempt was made to investigate the thermal performance of a flat plate biomass air heater. Analytical Thermal model for the flat plate solar air heater is presented. Experimental observations were made in Indian (30º N, 81º E) climatic conditions. Maximum 8 % variation is found between the theoretical and experimental values of outlet air temperature of the biomass air heater. Maximum instantaneous collector efficiency of 60 % is obtained in the present study. The Reynolds number was calculated for different velocity of flow. Air outlet temperatures were compared with experimental values.

Keywords: Biomass Heater, Reynolds Number, Heat Transfer Coefficient

1. Introduction

Air heaters are devices used to heat air Forced air products moderate and control air temperature by circulating air past a heat source with a fan or blower. As the air current flows through the heater it absorbs thermal energy and then exits the heater at an elevated temperature. Walid Aissa et al.[1] uses granite as a heat storage material. The outlet air temperature was increased by 150c during the testing run .Soteris A. Kalogirou explains common types of solar collectors of systems that could provide significant environmental and financial benefits [2]. Amir Hematian et al.[3] showed that the collector efficiency in forced convection was about 21% higher than the natural convection. Umesh Toshniwal et al.[4] reviewed that, the solar dryer is better than the sun drying techniques. M. Mohanraj et al.,[5] investigated Indirect forced convection solar dryer with gravel as a heat storage material for chilly drying. A.Senthilrajan et al [6] uses biomass for solar desalination. A.Senthilrajan et al [7] uses biomass heater in hemispherical still.

2. Experimental Setup

A biomass air heater is fabricated, with G.I sheet with absorber plate of size (1m x 0.9m), the thickness of the cover plate is 4mm. A flat plate single pass

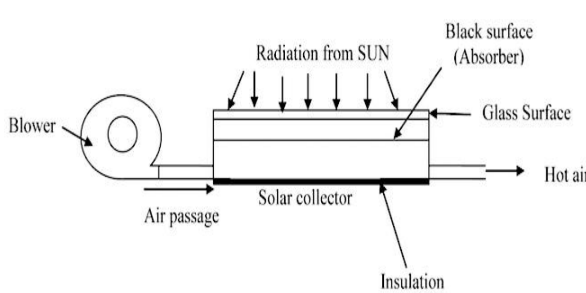

Fig.1 Experimental setup

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air heater was constructed to obtain the thermal efficiencies. Here air is used as a working fluid; the observer plate is painted black in order to absorb the maximum radiation. An exhaust fan is provided at the inlet of the setup, since setup designed for forced convective mode. Insulation is provided at the base of the absorber plate which minimizes the heat loss through base of the system. A desired flow rate is maintained through fan regulator, the temperature at the different point of the system is measured with the help of k-type thermocouple. Solar intensity and wind velocity are measured with solar meter and anemometer respectively. A biomass boiler of 500mmx350mm supplies heat to the heater. Biomass fuels are used as a fuel in the boiler. Heat supplied is circulated to the heat exchanger tubes where air is passed. The entire setup is insulated to reduce heat loss.

3. Energy Balance Analysis

The following equations are used to calculate massflow rate,Reynolds number, heat transfer coefficient

1. Mass flow of air
   $L= Q/1.08(T_h-T_a)$

2. Nre = pvD/m

3. $H = qm (t_h-t_a)$

4. Results and Discussion

Experiments were conducted in the summer seasons of Indian climatic conditions and in the premises of Ramanathapuram. Observations taken for a particular day were used in the study. Fig.2 shows the variation of biomass heat with respect to time of the day. Fig. 3 shows the variation of air temperature at the outlet of the heater. Theoretical instantaneous temperature values were obtained using the expression obtained through the mathematical modeling. Maximum 8 % variation is obtained between the theoretical and experimental values.
Variation of heat input with Time
The Fig.2 shows the variation of heat input initially the biomass boiler starts working and supplies only 600w then it goes on increasing order up to 1200w then it begins to decline due to reduced input of fuels. The heat produced inside the boiler is supplied to the heater by heat exchangers.

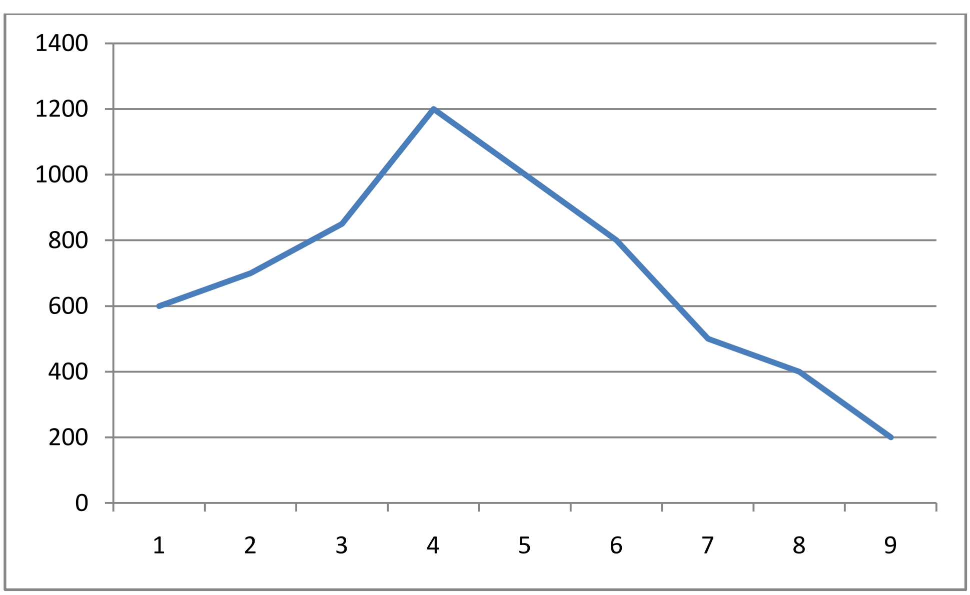

Fig. 2 Heat input with time

4.1 Variation of Outlet Temperatures

The fig.3 shows the variation of outlet temperature due to low quality of heat during initial periods the outlet temperature becomes low. After attaining steady state the temperature of air also increases and reaches a maximum of 70c after that it begins to decrease. The study also reveals the theoretical variation is close with experimental values.

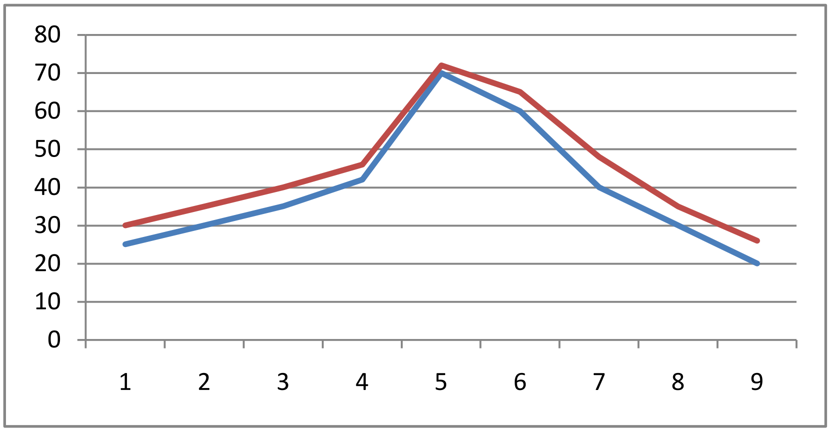

Fig.3 air out let temperature –Theoretical and Experimental

4.2 Reynolds Number

The variation of Reynolds number is shown in Fig.4. As the velocity of flow increases the number is also increased it was maximum at a velocity of 0.83m/s.

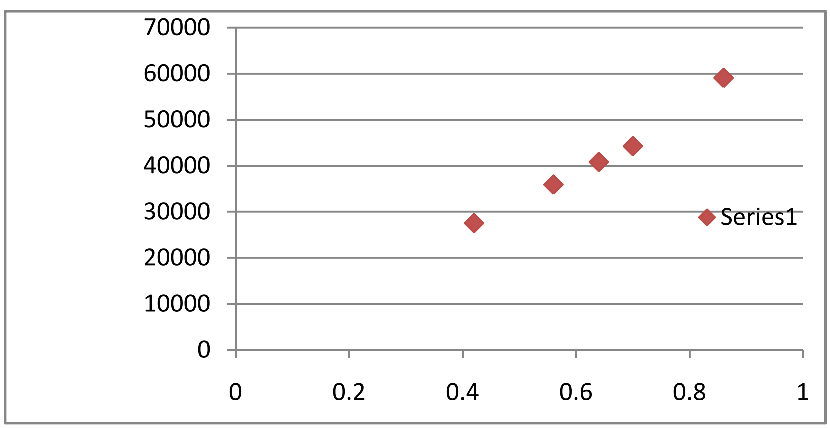

Fig.4 Reynolds number Vs flow rate

4.3 Effect of Efficiency

The efficiency of air heater is low at the starting because os low input and reaches maximum at 60% then decreases gradually to 20%.

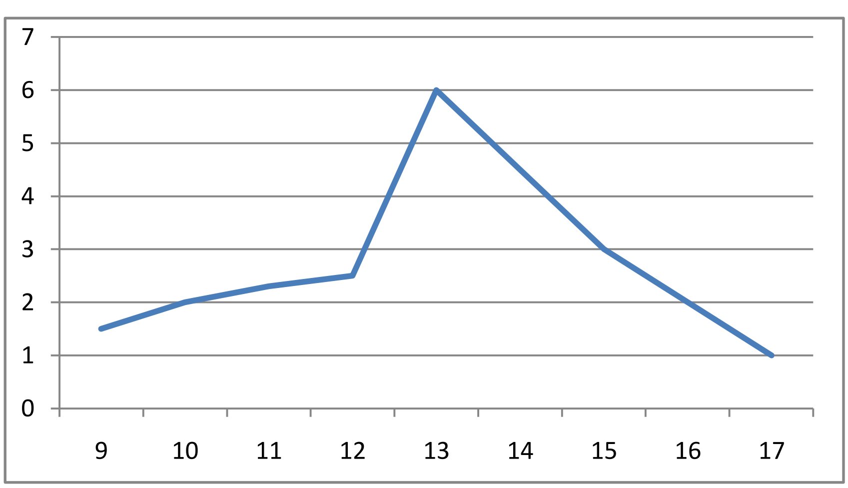

Fig.5 Efficiency Vs Time

5. Conclusion

The details of a Mathematical model for a solar air heater using heat transfer expressions for the collector components and empirical relations for estimating the various Heat transfer coefficients. It predicts the thermal performance of a solar air heater over a wide range of operating condition namely biomass intensity and inlet air temperature. Average collector efficiency of 36 % and maximum instantaneous thermal efficiency of 60% is obtained.

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