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Investigation of the thermal performance of Copper wire mesh and V-corrugated plate solar air heater

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Abstract: Climate is a vital global problem on which the whole world is focusing. One of the main reasons for climate change is the use of fossil fuel reserves for electricity and heat production. There are many policies and funds for the promotion of renewable electricity production but the heating sector receives less attention. Therefore, it is important to develop and promote alternative energy technologies for heat production. There new able resources of energy receive prominent attention in recent years, as it is proven to be a viable alternative of conventional energy sources. Solar energy which is available for free of cost in almost all parts of the world is a non-polluting reservoir of fuel. The challenge is to develop efficient technology to convert the solar radiation to the required form of energy.

Solar air heaters (SAHs) form the foremost component of solar energy utilization system. These air heaters absorb the irradiance and convert it into thermal energy at the absorbing surface and then transfer this energy to the air flowing through the collector, SAHs are inexpensive and most used collection devices because of their inherent simplicity. SAHs are found in several solar energy applications, especially for space heating and agriculture drying.

In this work, the performance of solar air heater carried out experimentally is discussed. The venue of the experiment is Pondicherry University, Pondicherry, India. Two solar air heaters, double pass and single pass (underflow) installed at the Centre for Green Energy Technology, Pondicherry University are used in the experiment and their efficiencies are calculated for forced convection and a comparison is done based on the result.

Keywords:

INTRODUCTION

1.1 Solar Energy

Worldwide changes have served as playground in realizing the significance of sun-based vitality in decrement of ozone harming substances. Sunlight based vitality is the world's most ceaseless wellspring, [1] and also the most plentiful source of non-conventional energy emitting energy at a figure of 3.8×10^{23} kW/s of which, roughly 1.8×10^{14} kW/s is trapped by the earth [2]. Thisamount (60%) ofsolarenergy that hits the Earth is very extensivethat only inan year's time it is about twice as much as all the other consolidated non-sustainable assets on Earth, for example, coal, oil, gaseous petrol, and mined uranium [3].

Sun powered vitality has colossal potential, especially in India. The nation normally has 300 bright days out of the 365 each year and gets a normal hourly radiation of 200 MW/km [4]. Additionally, due to the fast-growing population, and increasing industrialization, the solar source has a high energy demand. Many developing countries depend heavily on the fossil fuels for their energy needs. This causes the gradual depletion of fossil fuel resources, leading to further environmental degradation. Consequently, there is a great need to explore and develop renewable energy sources such as solar technology to cope up with the energy demand in the present-day circumstances [2].

According to Synergy Enviro Engineers 2020, Pondicherry has a tremendous solar energy prospective due to its relatively high solar irradiance with an average measurement of about 5.36 kWh/m²/day, which serves as an enormous capacity for solar energy extraction [5]. This study has been experimentally designed to test the warm exhibitions of copper wire mesh and v-corrugated plate solar air heaters under the prevailing weather conditions of Pondicherry University, Kalapet, Puducherry in the coordinates 12.0183°N (latitude), 79.8568°E (longitude).

Solar Energy Utilization

⇩ ⇩

Direct Method	Indirect Method (utilizes water)
Thermal	Wind
Photo-Voltaic	Water Pond
	Biomass
	WaveEnergy
	Ocean Thermal
	Marine Currents

1.2 Solar Radiation

Sun based radiation is the brilliant vitality transmitted by the sun from an atomic response that makes electromagnetic vitality [6]. Absorption occurs due to the presence of water vapor and ozone in the atmosphere and other particulate matter. The dispersed radiation is redistributed every which way, some returning into space and some arriving at the earth surface [7].The spectrum of sun based radiation is closer to that of a black body with atemperatureof 5800 kelvins. From electro magnetic spectrum, about portion of the radiation is in the obvious short-wave. The other half is generally in the close infrared area, with some is in the bright piece of the range. Theunitof measurement of solar radiation is watt per squaremeter (W/m^2) and is usually measured using a pyranometer or a pyrheliometer [6].

Solar radiations being a perpetual source of natural energy has increasingly been appreciated for their sway on living matter and the viability of its application for useful purposes [8]. Sun oriented radiation advances can be characterized into two gatherings specifically, active and passive heating. Active heating-based strategies incorporate utilizing sun oriented boards, siphons or fans to change over sun oriented vitality into helpful yields. Then again, passive heating-based methods incorporate structuring spaces as indicated by characteristic flow, finding structures regarding the sun or choosing high thermal conductive materials[3]. All these techniques have an incredible potential for a wide assortment of utilizations because solar energy is ample and handy. Thus, sun based radiation is quickly making strides as an enhancement to the non-inexhaustible wellsprings of vitality, which have a limited stockpile [8].

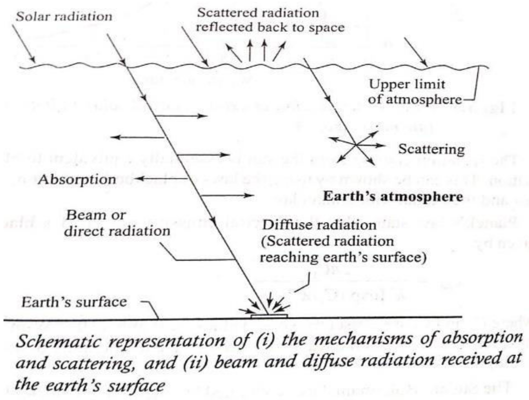

Fig 1.2 Solar Radiation on the Environment [9]

1.3 Solar Air Heater

Solar air heater is a gadget which changes sun oriented vitality to warm vitality. It has been in use for many years now. In 1881, an American, E. Morse, designed and produced the first accredited solar air heater [2]. Then half century later, The United States of America and Canada funded for the vast research and development of solar energy systems, considerably for the homeowners to invest in their solar products. European architects also designed solar air collectors to meet the designer's needs.

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Currently, there are manufactures who have patented solar air handling systems which are acclaimed internationally [10].

Solar air heaters are renewable, economical, eco-sustainable and user-friendly [2]. The main advantage of solar heat ers is thatitisin expensive and simple to design.It works without specific consideration and insignificant support in this manner making it solely viable for summer houses in light of the fact that thusly the indoor condition of structures is kept up at an ideal level even in chilly atmospheres. It also has no fuel expenditure after the set-up cost [6].Corrosion and leakage problems are less severe in air heaters in comparison to liquid heater solar systems [11]. Ultimately, it is an eco-accommodating framework which has zero ozone depleting substance outflows which assume an indispensable job in keeping up our air [6].

Execution improvement can be accomplished by utilizing assorted materials, different shapes and various measurements and formats of the segments of sun based air warmer. Factors, for example, sort of safeguard plate, glass spread plate and wind speed, influencing the sun powered air warmer productivity can be changed and altered likewise [6]. Significantly, to make the sunlight based air heaters financially suitable, their warm effectiveness ought to be improved by upgrading the convective warmth move coefficient[1]. Among the most encouraging thoughts for better execution in terms of storage of sun corporated energy is the latent heat of fusion utilizing natural and inorganic materials termed as 'Phase Change Materials'. They can store the overabundance of warm vitality for the entire duration of the day and recoup it at night during its hardening [13].

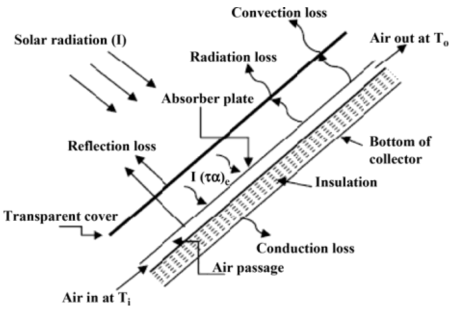

Fig 1.3 Conventional Solar Air Heater [14]

Source → Process → Output

Solar Radiation

Fig 1.4 General Overview of Solar Radiation and Heater [12]

1.3.1 Classification of Solar Air Heaters

Chiefly, all solar air heaters can be assorted under the two headings- porous media assisted and non-porous media assisted [16]. This depends on the sort of absorber plate utilized which has an immediate connection to the air channel stream, its productivity can be improved altogether by changing the air channel plan.The different solar air heaters are briefly explained below [3].

1.3.1.1 Non-Porous Media Assisted

Inthe non-porous absorber,the air stream passes through either above or below the absorber plate.Selective coating should be pertained to upgrade collector effectiveness.It comprises the typical type air heaters such as regular flat plates, and V-corrugated sheets [6].

A. Flat Plate type Solar Air Heater

Flat plate type is one of themost straightforward types of solar air heater and in corporatesat least one glass cover and an absorber plate. Air canstream either above or underneath the absorber plate which does not comprise of a fin,hindranceorroughness component. Thedevelopment ofaflat solar air heater is easy;ithas minimum cost.Also, the effectiveness of this solar air heater is comparatively lower than other kinds[3].

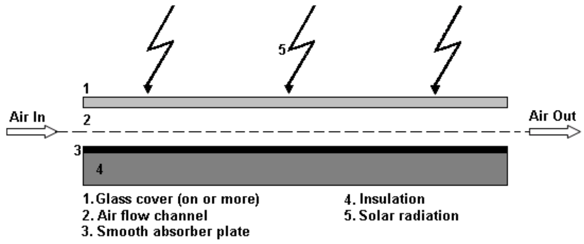

Fig 1.5 Flat Plate type SolarAir Heater [3]

B. v-Corrugated Sheet Solar Air Heater

v- Corrugated Sheets arethe arrangement of parallel edges and grooves reached out on the superficial area of the absorber plate which is a productive method to improve the presentation of solar air heaters. This sort of heater has a roughened absorber plate normally with grooves. The harshness component mounted on the absorber plate expands the zone of assimilation as well as gives the blending of air streaming iand has a better heat transfer coefficient, thus improving its effectiveness [3].

Fig 1.6 Schematic View of V-corrugated Sheet (Double Pass) Solar Air Heater [1]

1.3.1.2 Porous Media Assisted

Solar Air

Heated Air

The porous type utilizes porous substances like wire-mesh and matrix as the absorber. The reduction of porosity builds the heat transfer coefficient but also expands the pressure drop through the channel. Heat transfer between the air and the absorbent can be upgraded extensively by optimum porosity and thickness of the media [3].

A. Wire-Mesh Solar Air Heater

This air heater uses wire grid or mesh as the absorbent. Various geometrical parameters can be added to upgrade its thermal performance [18]. Copper is generally preferred as the absorber plate because of its high conductivity and corrosion resistivity [23]

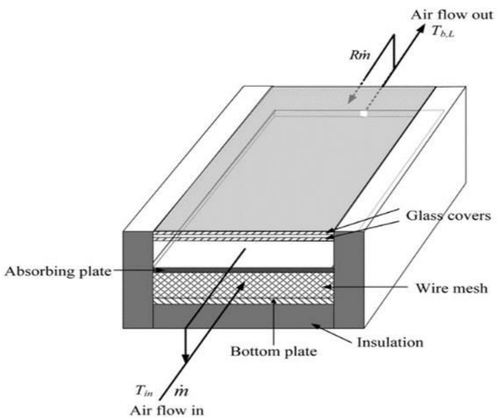

Fig 1.7 Wire Mesh Solar Air Heater [19]

B. Matrix Solar Air Heater

The main advantage of this heater is, sun based radiation enters to an incredible profundity and is ingested along its way. In this manner, the radiation loss diminishes causing the air stream to warm up as it goes through the matrix. It must be noticed that an ill-advised decision in its porosity and thickness causes decrease in efficiencies [20].

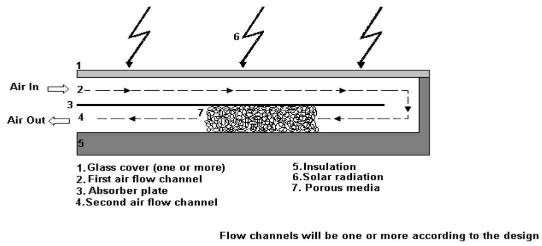

Fig 1.8 Schematic drawing of a Matrix packed (porous media) Solar Air Heater [3]

1.3.2 Construction of a Solar Air Heater

The primary parts of a solar air heater are an absorber plate, air ducts, insulation and a glazing. The utilization of a blower is discretionary for the air supply [3]. Due to its simple design, countless solar air heaters have been developed till now [15]. The durability, economy, operation and maintenance cost, installation cost are some of the factors for comparison. Moreover, thermal performance and its effectiveness is a major factor to look at [21].

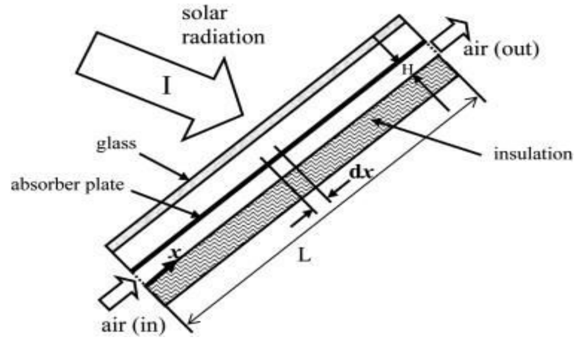

Fig 1.9 Device Configuration of Solar Air Heater

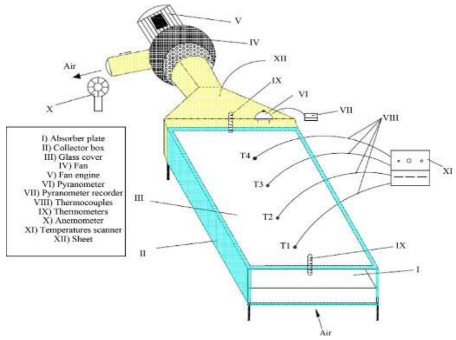

Fig 1.10 Schematic Assembly of Solar Air Heater System [16]

1.3.3 Application of Solar Air Heater

Locations throughout world have solar energy available without any cost which makes it widely applicable and usable [12]. Traditionally, solar energy was used for drying agricultural products, clothes and fuel wood [22]. Now, the hot air of solar heaters is also used for several purposes such as space heating, paint spraying operations, air conditioning, water heating, and various industrial processes [2]. It provides ventilation and process air heating. Solar air heaters serve as weather cladding and feeds into conventional ventilation systems which reduces heat loss through wall and provides better air quality respectively [12]. They are also used for drying of fruits, paddy and various cash crops. Moreover, they have been serving for space heating in the colder climatic zones [22].

METHODOLOGY

3.1 Materials Used

The various devices used in the experiment are listed and described below:

3.1.1 Copper Wire Mesh Solar Air Heater

This sort of solar air heater is a type of porous heater and mixed flow mode of air is circulated throughout the heater. This solar air heater of size 2m*1m is inclined with solar toughened glass used as glazing material. In this heater, copper wire mesh with selective black coating is the collector plate which absorbs the solar irradiaance and rockwool was used to ensure minimum heat loss through the bottom and the sides of the air heater.

Fig 3.1 Copper Wire Mesh Solar Air Heater

Fig 3.2 Copper Wire Mesh Absorber Plate

3.1.2 v- Corrugated Solar Air Heater

This sort of solar air heater is a type of non-porous heater and over flow mode of air is circulated. The size of heater is 2m*1m with solar toughened glass used as glazing material. In this heater, aluminium is the collector plate which absorbs the solar irradiance and rockwool was used as the insulator to facilitate insulation.

Fig 3.3 v- Corrugated Solar Air Heater

Fig 3.4 Aluminium Absorber Plate

3.1.3 Temperature Sensor

It is an electronic gadget that quantifies the temperature of the surrounding and converts the input data into electronic information and records, monitors, or signals temperature changes [26]. PT100sensorisatypeofresistancetemperaturedetector, wherePTstandsforplatinumand 100standsforresistance(100Ωat0°C). In this experiment, digital temperature sensor 'PT100 RTD' (Resistance Temperature Difference) is used in Copper wire mesh solar air heater and v-corrugated solar air heater. PT100 RTD with a range of 200°C are attached to the plates of air heaters. Thesensorswereconnectedtoadataloggerthatrecordedallthe temperatureseveryminute.

The sensors are used to measure the following temperatures for both the solar air heaters:

1) Inlet temperature

2) Glazing temperature

3) Outlet temperature

4) Absorber temperature

5) Ambient temperature

TheprincipleofPT100 RTD operation is to measure the resistance of a platinum element. According toIEC-75, the industry standard for platinum RTD'sis+ /- 0.12%(ofresistance)at0°C,commonlycitedtoasClassBaccuracy.Thisprovidesan accuracy of +/-0.3°C at0°C.

The relation between temperature and resistance is given as,

$$R_2=R_1[1 + \alpha(T_2-T_1)] \quad \text{Equation (3.1)}$$

Where, R_1= conductor resistance at T_1=100 Ω, and R_2= conductor resistance at T_2

By putting the above values and simplifying the equation, weget,

$R_2=100[1+\alpha(T_2-0)]$ $R_2=100+100\alpha T_2$ Equation (3.2)

Therefore, $T_2=(R_2-100)/0.385$ [6] Equation (3.3)

Fig 3.5 PT100 type Resistance Temperature Difference Senor

3.1.4 Data Logger

A data logger simply logs or records data (temperatureinthiscase) and showcases the reading of data collected. All the temperature sensors are connected to a datalogger.The interval at which it records the data can be set by us. Date and time were set befo rebeginning the experiment and at the end of the day, the data can be collected through a pendrive which is converted into excel sheet using Data Acquisition Software (DAS)package was used, to collect data and perform additional statistical analysis.

Fig 3.6 Data logger

3.1.5 Pyranometer

The solar radiation falling on the earth's surface can be measured using a pyranometer in Watt permeter square (W/m^2).

In this experiment, thermo pile pyranometer was used which measures heat generated from sunlight. Based on the Seebeck (thermoelectric effect), a pyranometer works on the basis of measuring the temperature distinction between a clear surface and a dark surface. There is a layering on the thermopile sensor which is black colored and absorbs the solar irradiance, while the clear surface mirrors it. The created potential difference in the thermopile owing to the temperature gradient betwixt the two surfaces aids in divulging information about the amount of solar radiation absorbed [28].

Fig 3.7ThermopilePyranometer

3.1.6 Pyranometer Data Logger

Similar to the data logger that records different temperature from the PT100 type temperature sensors,a pyrano meter data logger logs data from the pyranometer everyone minute.This data logger can then be connected to the computer and using a software called DeltaLog, the solarradiation data can be converted to excel sheets for further use.

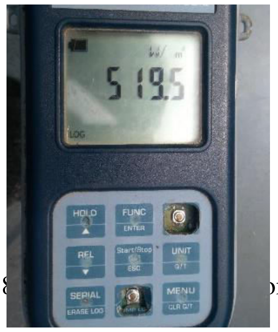

Fig 3.8 meter

3.1.7 Anemometer

An anemometer is a gadget utilized for estimating mass flow rate (wind speed). The term 'anemos' is gotten from the Greek word which signifies 'wind', and is utilized to portray any wind speed instrument utilized in meteorology.

Hot wire anemometers comprise of a fine wire electrically warmed to some temperature over the surrounding. Air streaming past the wire cools the wire. The electrical resistance of most metal relies on the temperature of the metal, a relationship can be acquired between the obstruction of the wire and the stream speed.

In order to measure the airflow, we in sert the tip of the device into a hole made at the outlet section ofthe solar air heater,this means that the velocity of air is measured before entering the blower.

Fig 3.9 Hot Wire Anemometer

3.1.8 Blower

In order to perform the experiment for forced convection, a blower is required to be fixed at the outlet of the solar air heaters. The blower has 6 speeds and the comparison of copper wire mesh solar air heater andv-corrugated solar air heater is done at all speeds and the thermal efficiencies are measured and calculated respectively.

Fig 3.10 Blower fixed at the outlet of Solar Air Heater (left) and Specifications of the Blower used in the experiment

3.2 Software's used

The software's used to carryoutthe experiment are mentioned below, namely:

DAS–is used to convert the data from the temperature datalogger into excel sheets for further use and filtering of the data.

DeltaLog–is used to convert the data from the pyranometer datalogger into excel sheets for further use.

Origin Pro 8.5– is used to make all the graphs from the data obtained from the data loggers.

Microsoftexcel– is the most important software, as all the work is done through excel sheets including the calculations which is then used to make graphs and compare the test results.

3.3 Experimental Setup

The experimental setup was located at Solar Thermal Laboratory, Department of Green Energy Technology, Pondicherry University. The experiment was conducted from December 2019to March 2020. The experiment was carried out between the hours of 10:00 to 17:00every day.

3.4 Experimental Procedure

1. The solar air heater was placed at an optimum angle facing due south for harnessing maximum solar energy falling on it.
2. The digital temperature sensors of PT100 RTD with a range up to 200 ℃ were attached at inlet, outlet, glazing, ambient and absorber plate and placed at their respective positions on both the solar air heaters.
3. The other ends of the temperature sensors were connected to the 16 channel data logger. Temperature was recorded at interval of every one minute.
4. The glazing glass was cleaned regularly throughout the experiment to avoid dirt/foreign particles that could hinder solar absorption.
5. The calibrated pyranometer was kept at a suitable height to prevent shadow effect and was connected to a pyranometer data logger to measure and record solar irradiance data at every one-minute interval.
6. The solar air heaters were connected to external blowers of 550 W at the outlet section for forced convection which were operated at the same speed to obtain same mass flow rate at a time.
7. The experiment was conducted from 1000 hours to 1700 hours.
8. The blowers, pyranometer and the data loggers were switched off at the end of day.
9. The data from data logger was transferred using a pendrive.
10. The temperature and irradiation data were converted to excel sheets using DSA and DeltaLog software respectively.

11. The respective graphs were plotted using Origin Pro 8.5.
12. The entire procedure was repeated for different speeds of blowers i.e. 1-6 for different mass flow rate readings for forced convection.
13. The same speed readings were taken for 3 days to obtain accurate and precise result.
14. The results were recorded and interpreted accordingly.

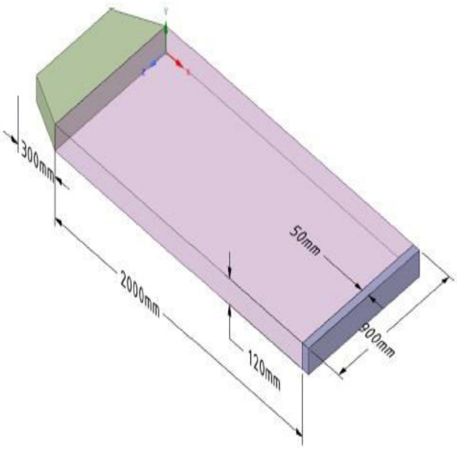

Fig 3.11 Experimental Setup of Solar Air Heater and Dimensions of Solar Air Heater used

Blower Speed	Air Velocity (m/s)
1	0.06
2	0.14
3	0.17
4	0.25
5	0.30
6	0.37

RESULTS AND DISCUSSION

4.1 Calculations

A comparative study between the Copper Wire Mesh and v-Corrugated solar air heater is done on the basis of their thermal efficiency, convective heat transfers co-efficient and daily efficiency in various mass flow rates. The obtained data from the experiment were used to make the following calculations.

The practical thermal heat energy of the air across the heater (Q_u) is given as,

$$Q_u = m\, Cp \Delta T \quad \text{(Equation 4.1)}$$

Where m is the mass flow rate of the air throughout the heater (kg/s), Cp is the specific heat capacity of the air (J/kg.°C) and ΔT is the distinction in outlet and inlet sections temperatures of the air in the heater.

The instantaneous thermal efficiency is shown by the equation,

$$\eta_{th} = \frac{Qu}{IAc} \quad \text{(Equation 4.2)}$$

Where A_c is the area of the solar air collector (m^2) and I is the incident solar irradiance (W/m^2).

The convective heat transfer coefficient 'h' betwixt the air and absorber plate, is shown by,

$$h = \frac{Qu}{Ac\,(Tabs - Tin)} \quad \text{(Equation 4.3)}$$

Where T_{abs} is the absorber plate temperatures (℃), and T_{in} is the inlet air temperatures on the air heater (℃).

The daily efficiency of the heater, η_{da} is shown by,

$$\eta_{da} = \frac{\sum Qu}{\sum Ac\, I} \quad [13] \quad \text{(Equation 4.4)}$$

The mass flow rate is computed by the equation,

$$\boldsymbol{m = \rho . a . v} \quad \text{(Equation 4.5)}$$

Where,

'ρ' is the density of air i.e. 1.043 kg/m^3 (air at 65℃)

'a' is the outlet cross section area where the velocity of air is measured = 0.093 m^2

'v' is the velocity of air measured at the outlet section of the air before being sucked by the blower.

The blower when operated at different speed varied the air velocity and is shown in the table below:

Table 4.1 Blower speed and its adjacent air velocity in m/s

4.2 Temperature Graphs

Temperature versus Time graphs were plotted from the data obtained from the data logger. The best out of three days' data were plotted for better outcome. These graphs represent different temperatures and irradiation with respect to time for both Copper Wire Mesh and v-Corrugated solar air heaters at non-identical mass flow rates.

The legends for both the graphs are shown below:

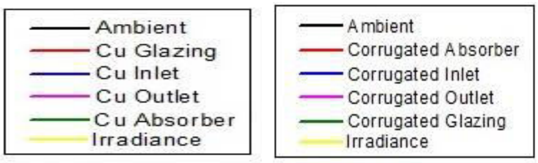

Fig 4.1 Copper Wire Mesh Solar Air Heater elements legend (left), v-Corrugated Plate Solar Air Heater elements legend (right)

Temperature versus Time graphs for Copper wire mesh and v-Corrugated plate solar air heaters at dissimilar mass flow rates are shown below:

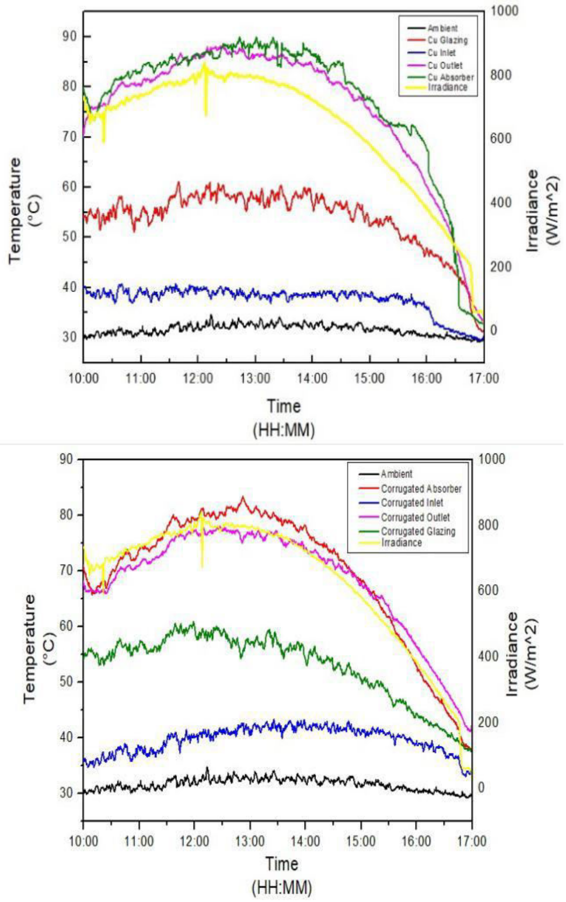

Fig 4.2 Measured temperature of Copper Wire Mesh (left) and v-Corrugated Plate (right) Solar Air Heaters versus time on 03/02/2020 at m= 0.00582 kg/s

The above figure shows the hourly varieties of the temperatures of various components of Copper wire mesh and v-Corrugated plate solar air heaters dated 03/02/2020 at m=0.00582 kg/s. Maximum T_{outlet} and $T_{absorber}$ for Copper wire mesh air heater were found to be 88.20°C and 90.20°C respectively. Average T_{outlet} and $T_{absorber}$ for Copper wire mesh air heater were found to be 75.70°C and 77.80°C respectively.

Similarly, Maximum T_{outlet} and $T_{absorber}$ for v-Corrugated plate air heater were valued to be 77.90°C and 83.10°C respectively. Average T_{outlet} and $T_{absorber}$ for v-Corrugated plate solar air heater were valued to be 68.32°C and 69.46°C respectively.

The maximum solar irradiance was recorded at 786.4 W/m^2 and average solar irradiance was found to be 589.87 W/m^2.

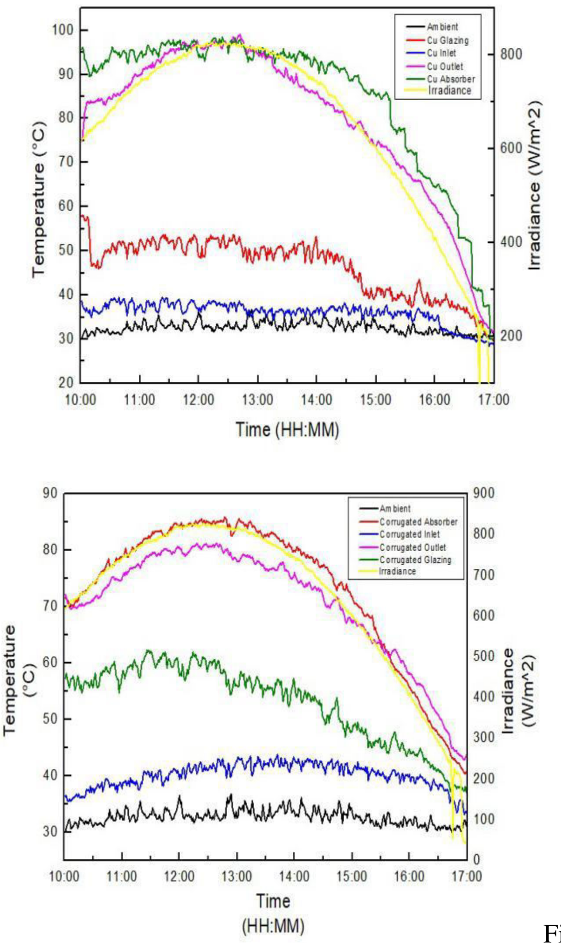

Fig 4.3. Measured temperature of Copper Wire Mesh (left) and v-Corrugated Plate (right) Solar Air Heaters versus time on 06/02/2020 at m=0.01358 kg/s

The above figure shows the hourly varieties of the temperatures of various components of Copper wire mesh and v-Corrugated plate solar air heaters dated 06/02/2020 at m=0.01358 kg/s. Maximum T_{outlet} and $T_{absorber}$ for Copper wire mesh air heater were found to be 99.00°C and 98.50°C respectively. Average T_{outlet} and $T_{absorber}$ for Copper wire mesh air heater were found to be 79.90°C and 84.90°C respectively.

Similarly, Maximum T_{outlet} and $T_{absorber}$ for v-Corrugated plate air heater were valued to be 80.20°C and 85.90°C respectively. Average T_{outlet} and $T_{absorber}$ for Copper wire

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mesh air heater are valued to be 70.45°C and 73.13°C respectively.

The maximum solar irradiance was recorded at 826.6 W/m^2 and average solar irradiance was found to be 647.65 W/m^2.

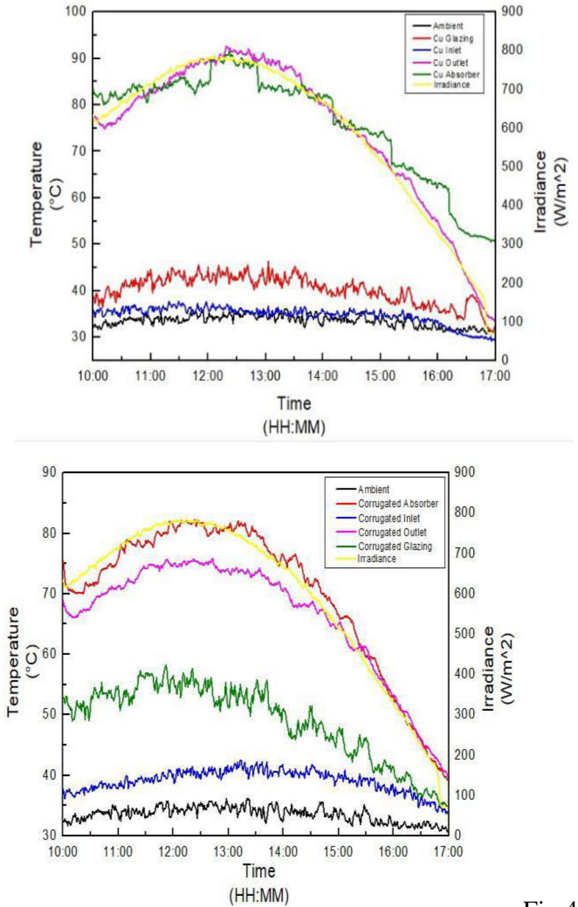

Fig 4.4 Measured temperature of Copper Wire Mesh (left) and v-Corrugated Plate (right) Solar Air heaters versus time on 08/02/2020 at m= 0.01649 kg/s

The above figure shows the hourly varieties of the temperatures of various components of Copper wire mesh and v-Corrugated plate solar air heaters dated 08/02/2020 at m=0.01649 kg/s. Maximum T_{outlet} and $T_{absorber}$ for Copper wire mesh air heater were valued to be 92.60°C and 91.60°C respectively. Average T_{outlet} and $T_{absorber}$ for Copper wire mesh air heater were valued to be 74.34°C and 79.28°C respectively.

Similarly, Maximum T_{outlet} and $T_{absorber}$ for v-Corrugated plate air heater were valued to be 75.20°C and 82.20°C respectively. Average T_{outlet} and $T_{absorber}$ for Copper wire mesh air heater are found to be 65.95°C and 69.76°C respectively.

The maximum solar irradiance was recorded at 841.1 W/m^2 and average solar irradiance was found to be 638.33 W/m^2.

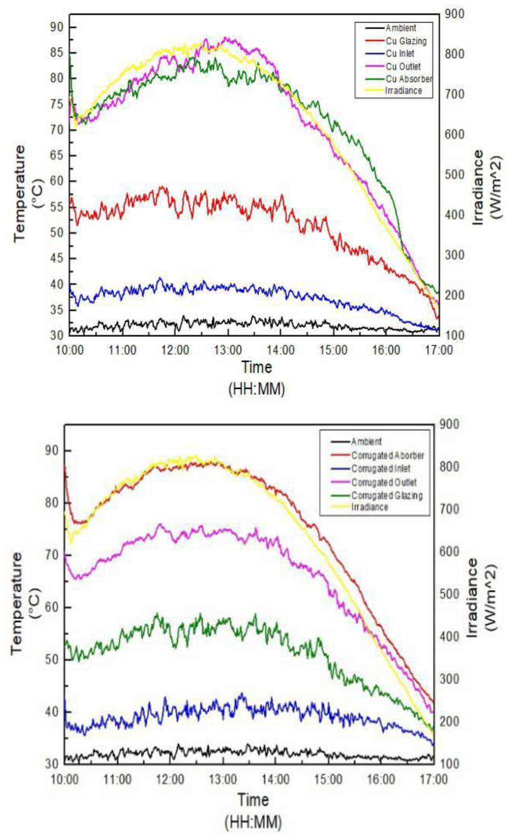

Fig 4.5 Measured temperature of Copper Wire Mesh (left) and v-Corrugated Plate (right) Solar Air Heaters versus time on 04/03/2020 at m= 0.02425 kg/s

The above figure shows the hourly varieties of the temperatures of various components of Copper wire mesh and v-Corrugated plate solar air heaters dated 04/03/2020 at m=0.02425 kg/s. Maximum T_{outlet} and $T_{absorber}$ for Copper wire mesh air heater were found to be 88.10°C and 85.10°C respectively. Average T_{outlet} and $T_{absorber}$ for Copper wire mesh air heater were found to be 71.44°C and 76.76°C respectively.

Similarly, Maximum T_{outlet} and $T_{absorber}$ for v-Corrugated plate air heater were valued to be 76.00°C and 88.00°C respectively. Average T_{outlet} and $T_{absorber}$ for Copper wire mesh air heater are found to be 65.92°C and 75.18°C respectively.

The maximum solar irradiance was recorded at 828.8 W/m^2 and average solar irradiance was found to be 635.83 W/m^2.

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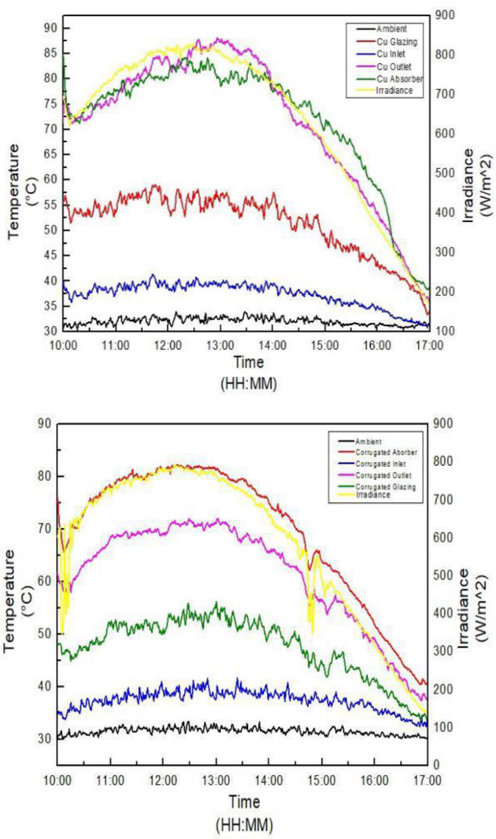

Fig 4.6 Measured temperature of Copper Wire Mesh (left) and v-Corrugated Plate (right) Solar Air heaters versus time on 05/03/2020 at m= 0.02901 kg/s

The above figure shows the hourly varieties of the temperatures of various components of Copper wire mesh and v-Corrugated plate solar air heaters dated 05/03/2020 at m=0.02901 kg/s. Maximum T_{outlet} and $T_{absorber}$ for Copper wire mesh air heater were found to be 86. 00℃ and 83.80℃ respectively. Average T_{outlet} and $T_{absorber}$ for Copper wire mesh air heater were found to be 67.54℃ and 74.31℃ respectively.

Similarly, Maximum T_{outlet} and $T_{absorber}$ for v-Corrugated plate air heater were valued to be 71.70℃ and 83.40℃ respectively. Average T_{outlet} and $T_{absorber}$ for Copper wire mesh air heater are found to be 61.20℃ and 70.60℃ respectively.

The maximum solar irradiance was recorded at 910.4 W/m^2 and average solar irradiance was found to be 682.30 W/m^2.

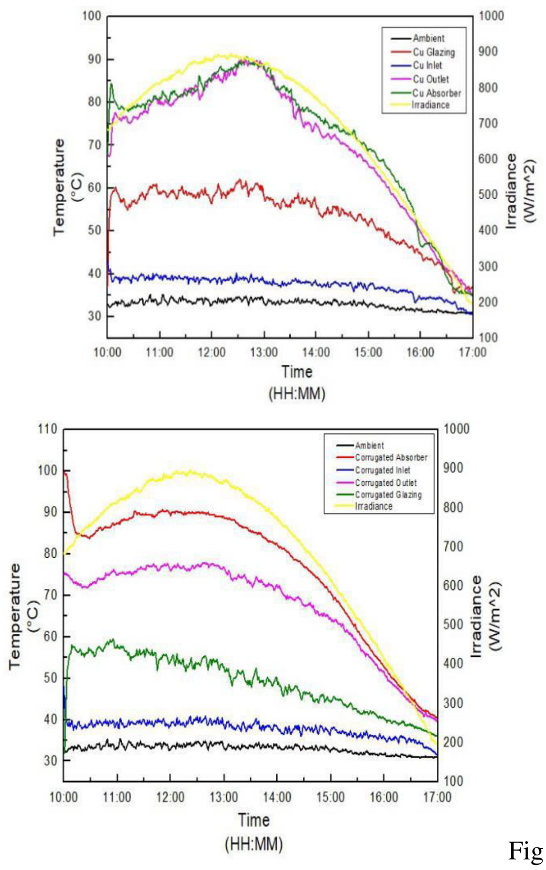

Fig 4.7 Measured temperature of Copper Wire Mesh (left) and v-Corrugated Plate (right) Solar Air Heaters versus time on 16/03/2020 at m= 0.03589 kg/s

The above figure shows the hourly varieties of the temperatures of various components of Copper wire mesh and v-Corrugated plate solar air heaters dated 16/03/2020 at m=0.03589 kg/s. Maximum T_{outlet} and $T_{absorber}$ for Copper wire mesh air heater were found to be 90.10°C and 90.60°C respectively. Average T_{outlet} and $T_{absorber}$ for Copper wire mesh air heater were found to be 70.81°C and 77.51°C respectively.

Similarly, Maximum T_{outlet} and $T_{absorber}$ for v-Corrugated plate air heater were valued to be 77.90℃ and 99.60℃ respectively. Average T_{outlet} and $T_{absorber}$ for Copper wire mesh air heater are found to be 67.31℃ and 76.50℃ respectively.

The maximum solar irradiance was recorded at 1114.4 W/m^2 and average solar irradiance was found to be 814.89 W/m^2.

4.3 Outlet Temperature (T_{out}) Graphs

The following graphs show the contrast between the temperature outlet of Copper wire mesh and v-Corrugated plate solar air heaters.

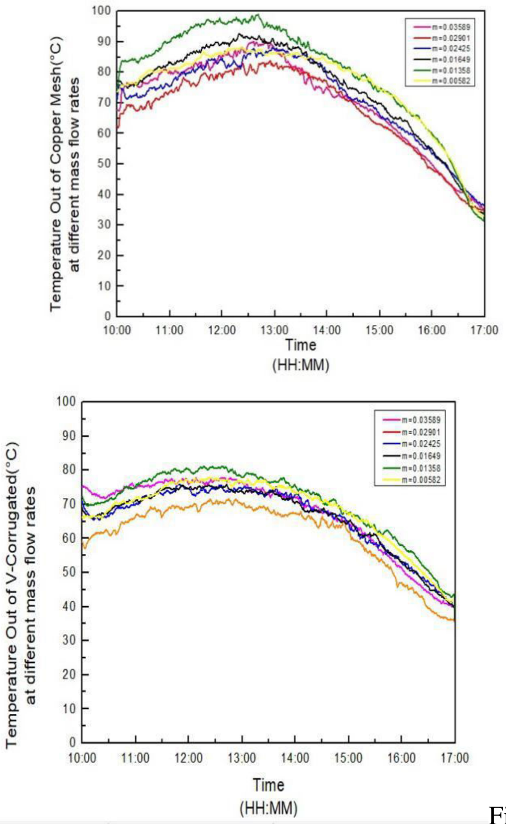

Fig 4.8
Outlet temperature of Copper Wire Mesh (left) and v-Corrugated Plate (right) Solar Air Heaters versus time different mass flow rates.

The above graphs show the temperature outlet curves of both Copper wire mesh and v-Corrugated plate air heaters at various mass flow rates. A comparative study of the outlet temperatures at particular mass flow rates of air are shown below:

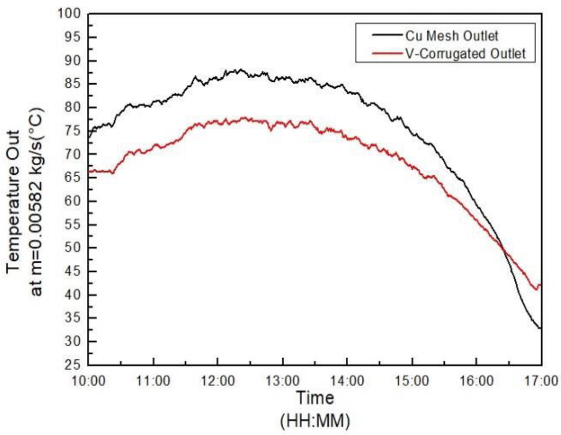

Fig 4.9 Outlet Temperature (℃) of Copper Wire Mesh and v-Corrugated Plate Solar Air Heaters versus time at m= 0.00582 kg/s

Figure 4.9 shows a correlation of temperature distinction of outlet air betwixt Copper wire mesh and v-Corrugated solar air heaters at m= 0.00582 kg/s. It concludes that outlet temperature in Copper wire mesh is elevated than that of v-Corrugated plate solar air heater.

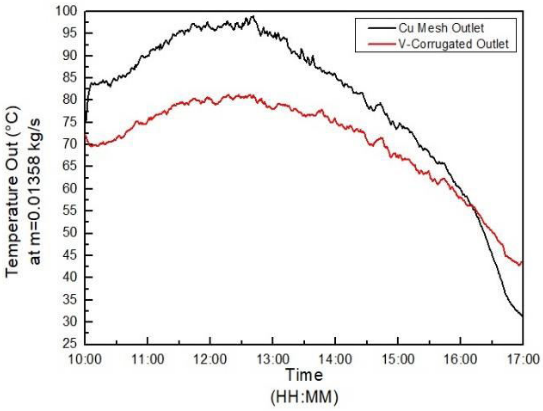

Fig 4.10 Outlet Temperature (℃) of Copper Wire Mesh and v-Corrugated Plate Solar Air Heaters versus time at m= 0.01358 kg/s

Figure 4.10 shows a correlation of temperature distinction of outlet air betwixt Copper wire mesh and v-Corrugated solar air heaters at m= 0.01358 kg/s. It concludes that outlet temperature in Copper wire mesh is elevated than that of v-Corrugated plate solar air heater.

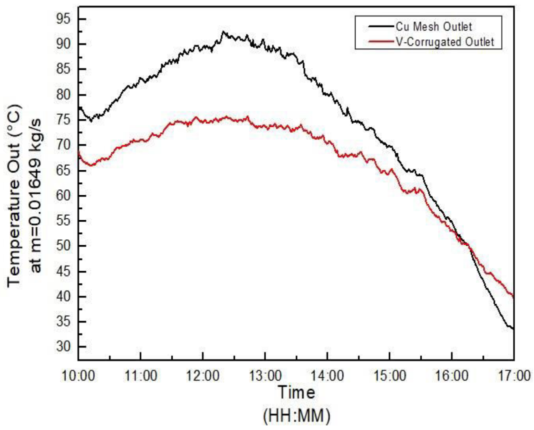

Fig 4.11 Outlet Temperature (℃) of Copper Wire Mesh and v-Corrugated Plate Solar Air Heaters versus time at m= 0.01649 kg/s

Figure 4.11 shows a correlation of temperature distinction of outlet air betwixt Copper wire mesh and v-Corrugated solar air heaters at m=0.01649 kg/s. It concludes that outlet temperature in Copper wire mesh is elevated than that of v-Corrugated plate solar air heater.

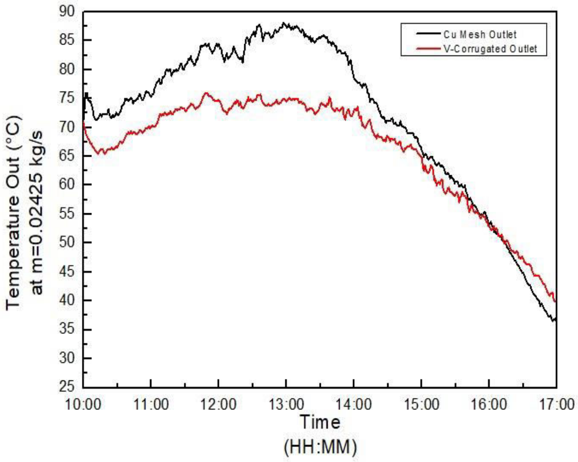

Fig 4.12 Outlet Temperature (℃) of Copper Wire Mesh and v-Corrugated Plate Solar Air Heaters versus time at m= 0.02425 kg/s

Figure 4.12 shows a correlation of temperature distinction of outlet air betwixt Copper wire mesh and v-Corrugated solar air heaters at m= 0.02425 kg/s. It concludes that outlet temperature in Copper wire mesh is elevated than that of v-Corrugated plate solar air heater.

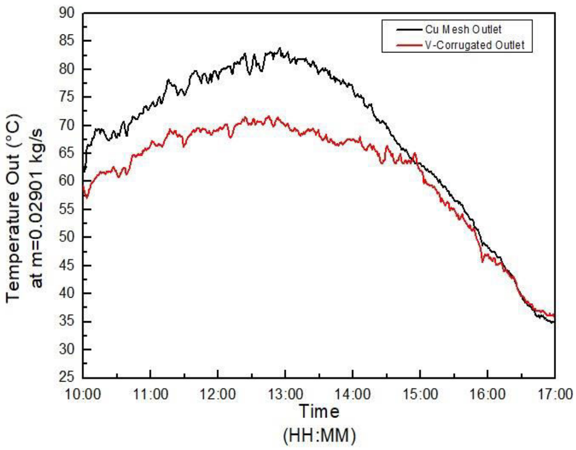

Fig 4.13 Outlet Temperature (℃) of Copper Wire Mesh and v-Corrugated Plate Solar Air Heaters versus time at m= 0.02901 kg/s

Figure 4.13 shows a correlation of temperature distinction of outlet air betwixt Copper wire mesh and v-Corrugated solar air heaters at m= 0.02901 kg/s. It concludes that outlet temperature in Copper wire mesh is elevated than that of v-Corrugated plate solar air heater.

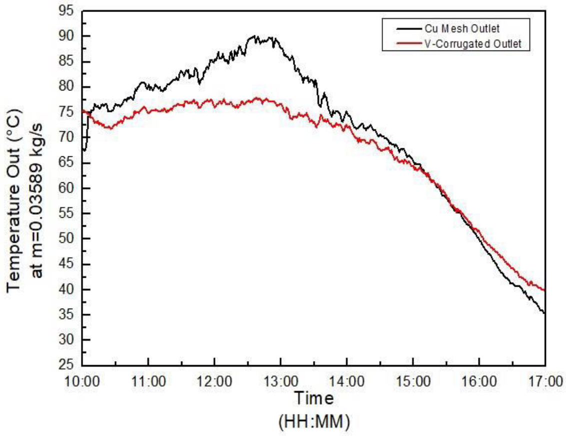

Fig 4.14 Outlet Temperature (℃) of Copper Wire Mesh and v-Corrugated Plate Solar Air Heaters versus time at m= 0.03589 kg/s

Figure 4.14 shows a correlation of temperature distinction of outlet air betwixt Copper wire mesh and v-Corrugated solar air heaters at m= 0.03589 kg/s. It concludes that outlet temperature in Copper wire mesh is elevated than that of v-Corrugated plate solar air heater.

The above graphs summarize that difference in the outlet temperature (T_{out}) between the two solar air heaters is higher in nether mass flow rates than in elevated mass flow rates of air.

4.4 Efficiency Graphs

Instantaneous Thermal Efficiency versus Time graphs for Copper wire mesh and v-Corrugated plate solar air heaters at different mass flow rates are shown below.

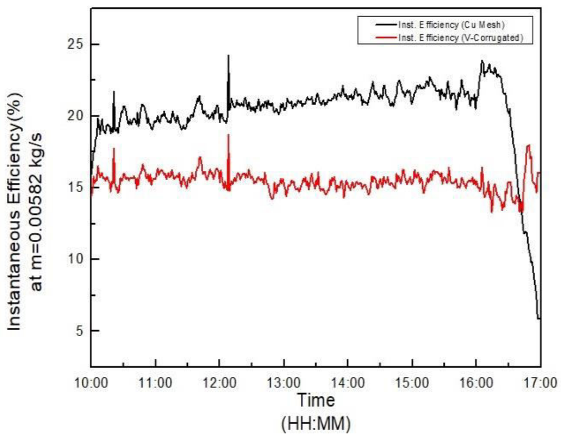

Fig 4.15 Instantaneous Thermal Efficiency (%) of Copper Wire Mesh and v-Corrugated Plate Solar Air Heaters versus time at m= 0.00582 kg/s

The above figure shows a contrast of instantaneous thermal efficiencies betwixt Copper wire mesh and v-Corrugated plate solar air heaters at m= 0.00582 kg/s. It is established that copper wire mesh solar air heater has better thermal efficiency among the two air heaters. The maximum thermal efficiency of Copper wire mesh and v-Corrugated plate solar air heaters were valued to be

24.26% and 18.68% respectively while the average thermal efficiency were found to be 20.36% and 15.45% respectively.

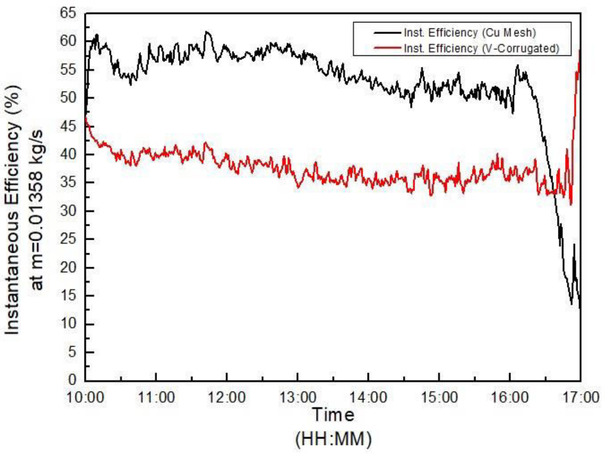

Fig 4.16 Instantaneous Thermal Efficiency (%) of Copper Wire Mesh and v-Corrugated Plate Solar Air Heaters versus time at m=0.01358 kg/s

The above figure shows a contrast of instantaneous thermal efficiencies betwixt Copper wire mesh and v-Corrugated plate solar air heaters at m= 0.01358 kg/s. It is established that copper wire mesh solar air heater has better thermal efficiency among the two air heaters. The maximum thermal efficiency of Copper wire mesh and v-Corrugated plate solar air heaters were valued to be 61.76% and 56.69% respectively while the average thermal efficiency were found to be 52.68% and 37.72% respectively.

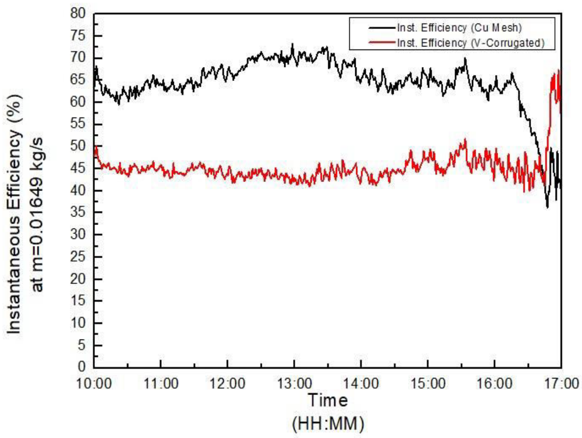

Fig 4.17 Instantaneous Thermal Efficiency (%) of Copper Wire Mesh and v-Corrugated Plate Solar Air Heaters versus time at m= 0.01649 kg/s

The above figure shows a contrast of instantaneous thermal efficiencies betwixt Copper wire mesh and v-Corrugated plate solar air heaters at m= 0.01649 kg/s. It is established that copper wire mesh solar air heater has better thermal efficiency among the two air heaters. The maximum thermal efficiency of Copper wire mesh and v-Corrugated plate solar air heaters were valued to be 73.19% and 69.69% respectively while the average thermal efficiency were found to be 64.17% and 45.36% respectively.

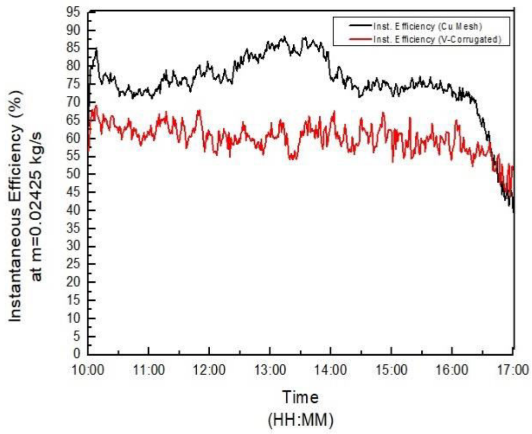

Fig 4.18 Instantaneous Thermal Efficiency (%) of Copper Wire Mesh and v-Corrugated Plate Solar Air Heaters versus time at m= 0.02425 kg/s

The above figure shows a contrats of instantaneous thermal efficiencies betwixt Copper wire mesh and v-Corrugated plate solar air heaters at m=0.02425 kg/s. It is established that copper wire mesh solar air heater has better thermal efficiency among the two air heaters. The maximum thermal efficiency of Copper wire mesh and v-Corrugated plate solar air heaters were valued to be 88.44% and 69.25% respectively while the average thermal efficiency were found to be 75.15% and 60.10% respectively.

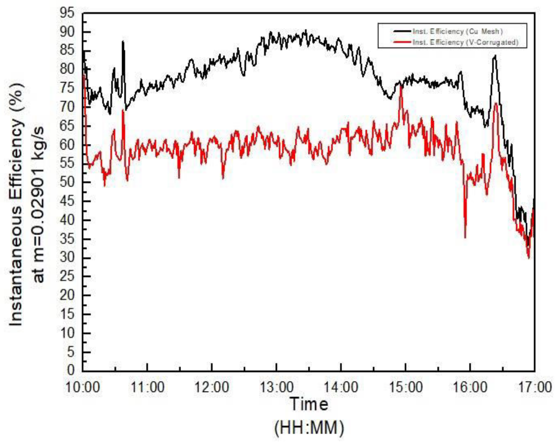

Fig 4.19 Instantaneous Thermal Efficiency (%) of Copper Wire Mesh and v-Corrugated Plate Solar Air Heaters versus time at m= 0.02901 kg/s

The above figure shows a contrast of instantaneous thermal efficiencies betwixt Copper wire mesh and v-Corrugated plate solar air heaters at m= 0.02901 kg/s. It is established that copper wire mesh solar air heater has better thermal efficiency among the two air heaters. The maximum thermal efficiency of Copper wire mesh and v-Corrugated plate solar air heaters were valued to be 90.57

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and 78.48% respectively while the average thermal efficiency were found to be 76.76% and 58.37% respectively.

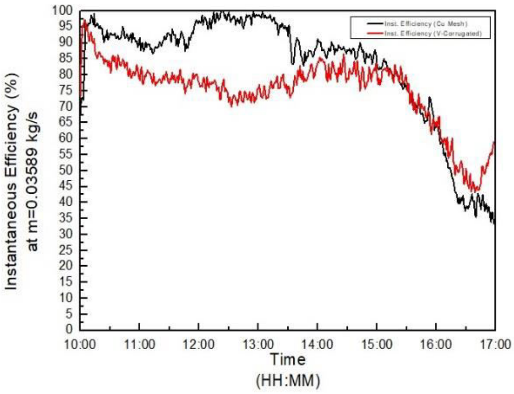

Fig 4.20 Instantaneous Thermal Efficiency (%) of Copper Wire Mesh and v-Corrugated Plate Solar Air Heaters versus time at m= 0.03589 kg/s

The above figure shows a contrast of instantaneous thermal efficiencies betwixt Copper wire mesh and v-Corrugated plate solar air heaters at m= 0.03589 kg/s. It is established that copper wire mesh solar air heater has better thermal efficiency among the two air heaters. The maximum thermal efficiency of Copper wire mesh and v-Corrugated plate solar air heaters were valued to be 99.7% and 97.02% respectively while the average thermal efficiency were found to be 82.5% and 74.93% respectively.

4.5 Convective Heat Transfer Coefficient Graphs

Convective heat transfer coefficient increases as mass flow rate increases. The following graphs show the link between the convective heat transfer coefficient and the time of the day of the experiment for both Copper wire mesh and v-Corrugated plate solar air heaters.

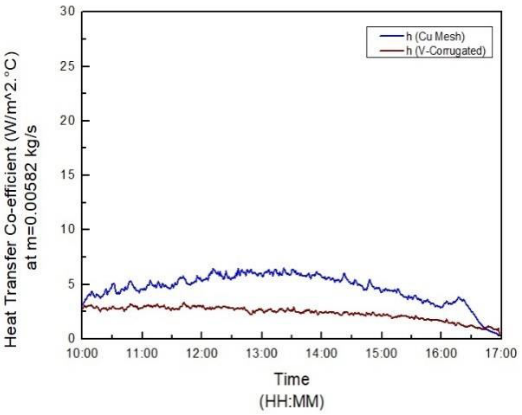

Fig 4.21 Convective Heat Transfer Coefficient (W/m^2. °C) of Copper Wire Mesh and v-Corrugated Plate Solar Air Heaters versus time at m= 0.00582 kg/s

Figure 4.21 shows the convective heat transfer coefficient (h) of both Copper wire mesh and v-Corrugated plate solar air heaters at m= 0.00582 kg/s. It is obvious that ‘h’ increases as the solar irradiation increases in turn increasing the useful heat collected by the absorber plate while decreasing the heat losses from the same. It also shows that ‘h’ of Copper wire mesh solar air heater is elevated than that of v-Corrugated plate solar air heater. The maximum ‘h’ of Copper wire mesh and v-Corrugated plate solar air heaters were valued to be 6.49(W/m^2. °C) and 3.36(W/m^2. °C) respectively while the average value of ‘h’ were found to be 4.67(W/m^2. °C) and 2.38(W/m^2. °C) respectively.

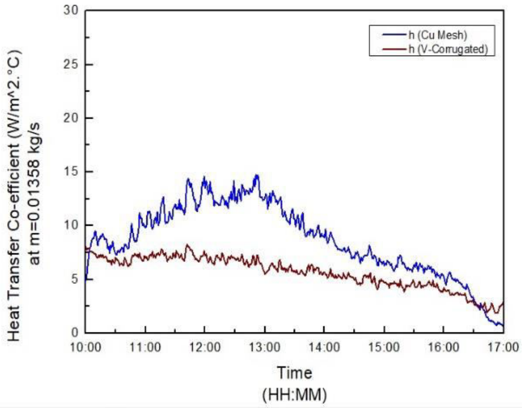

Fig 4.22 Convective Heat Transfer Coefficient (W/m^2. °C) of Copper Wire Mesh and v-Corrugated Plate Solar Air Heaters versus time at m= 0.01358 kg/s

Figure 4.22 shows the convective heat transfer coefficient (h) of both Copper wire mesh and v-Corrugated plate solar air heaters at m= 0.01358 kg/s. It is obvious that ‘h’ increases as the solar irradiation increases in turn increasing the useful heat collected by the absorber plate while decreasing the heat losses from the same. It also shows that ‘h’ of Copper wire mesh solar air heater is elevated than that of v-Corrugated plate solar air heater. The maximum ‘h’ of Copper wire mesh and v-Corrugated plate solar air heaters were valued to be 14.74(W/m^2. °C) and 8.22(W/m^2. °C) respectively while the average value of ‘h’ were found to be 8.67(W/m^2. °C) and 5.64(W/m^2. °C) respectively.

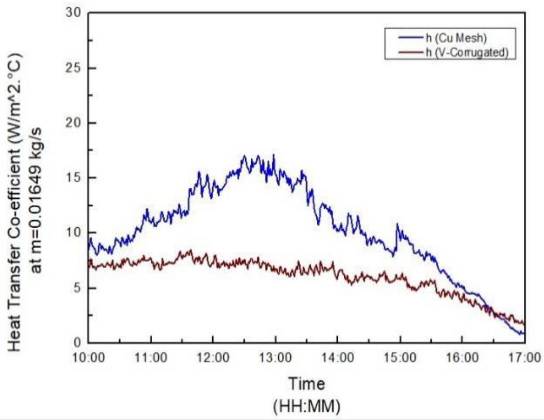

Fig 4.23 Convective Heat Transfer Coefficient (W/m^2. °C) of Copper Wire Mesh and v-Corrugated Plate Solar Air Heaters versus time at m= 0.01649 kg/s

Figure 4.23 shows the convective heat transfer coefficient

(h) of both Copper wire mesh and v-Corrugated plate solar air heaters at m= 0.01649 kg/s. It is obvious that ‘h’ increases as the solar irradiation increases in turn increasing the useful heat collected by the absorber plate while decreasing the heat losses from the same. It also shows that ‘h’ of Copper wire mesh solar air heater is elevated than that of v-Corrugated plate solar air heater. The maximum ‘h’ of Copper wire mesh and v-Corrugated plate solar air heaters were valued to be 17.35(W/m^2. °C) and 8.48(W/m^2. °C) respectively while the average value of ‘h’ were found to be 10.09(W/m^2. °C) and 6.03(W/m^2. °C) respectively.

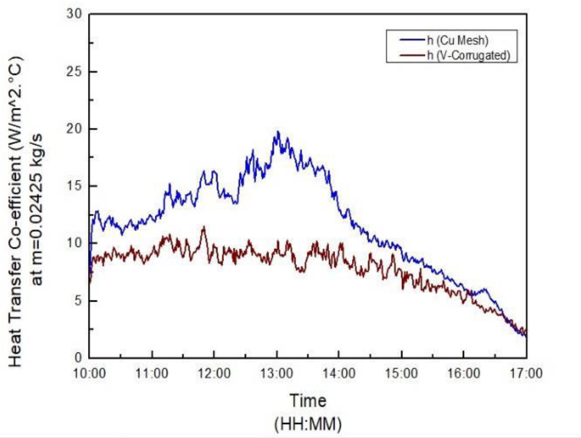

Fig 4.24 Convective Heat Transfer Coefficient (W/m^2. °C) of Copper Wire Mesh and v-Corrugated Plate Solar Air Heaters versus time at m= 0.02425 kg/s

Figure 4.24 shows the convective heat transfer coefficient (h) of both Copper wire mesh and v-Corrugated plate solar air heaters at m= 0.02425 kg/s. It is obvious that ‘h’ increases as the solar irradiation increases in turn increasing the useful heat collected by the absorber plate while decreasing the heat losses from the same. It also shows that ‘h’ of Copper wire mesh solar air heater is elevated than that of v-Corrugated plate solar air heater. The maximum ‘h’ of Copper wire mesh and v-Corrugated plate solar air heaters were valued to be 19.81(W/m^2. °C) and 11.52(W/m^2. °C) respectively while the average value of ‘h’ were found to be 11.56(W/m^2. °C) and 7.81(W/m^2. °C) respectively.

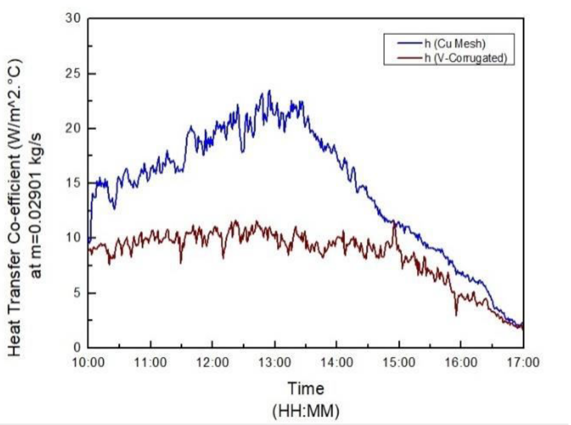

Fig 4.25 Convective Heat Transfer Coefficient (W/m^2. °C) of Copper Wire Mesh and v-Corrugated Plate Solar Air Heaters versus time at m= 0.02901 kg/s

Figure 4.25 shows the convective heat transfer coefficient (h) of both Copper wire mesh and v-Corrugated plate solar air heaters at m= 0.02901 kg/s. It is obvious that ‘h’ increases as the solar irradiation increases in turn increasing the useful heat collected by the absorber plate while decreasing the heat losses from the same. It also shows that ‘h’ of Copper wire mesh solar air heater is elevated than that of v-Corrugated plate solar air heater. The maximum ‘h’ of Copper wire mesh and v-Corrugated plate solar air heaters were valued to be 23.47(W/m^2. °C) and 11.64(W/m^2. °C) respectively while the average value of ‘h’ were found to be 14.30(W/m^2. °C) and 8.38(W/m^2. °C) respectively.

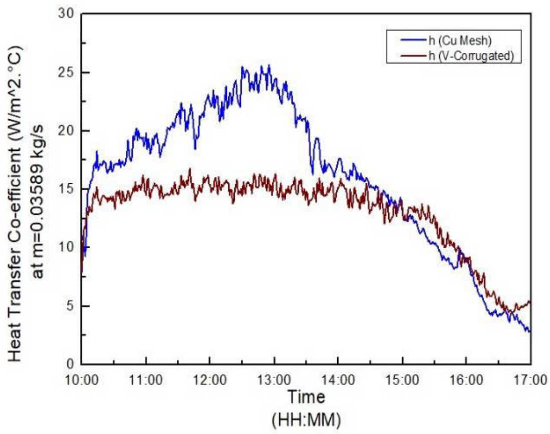

Fig 4.26 Convective Heat Transfer Coefficient (W/m^2. °C) of Copper Wire Mesh and v-Corrugated Plate Solar Air Heaters versus time at m= 0.03589 kg/s

Figure 4.26 shows the convective heat transfer coefficient (h) of both Copper wire mesh and v-Corrugated plate solar air heaters at m= 0.03589 kg/s. It is obvious that ‘h’ increases as the solar irradiation increases in turn increasing the useful heat collected by the absorber plate while decreasing the heat losses from the same. It also shows that ‘h’ of Copper wire mesh solar air heater is elevated than that of v-Corrugated plate solar air heater. The maximum ‘h’ of Copper wire mesh and v-Corrugated plate solar air heaters were valued to be 25.66(W/m^2. °C) and 16.78(W/m^2. °C) respectively while the average value of ‘h’ were found to be 15.92(W/m^2. °C) and 12.98(W/m^2. °C) respectively.

4.6 Daily Efficiency Graphs

The following graph show the link between daily efficiency and the mass flow rate for both Copper wire mesh and v-Corrugated plate solar air heaters.

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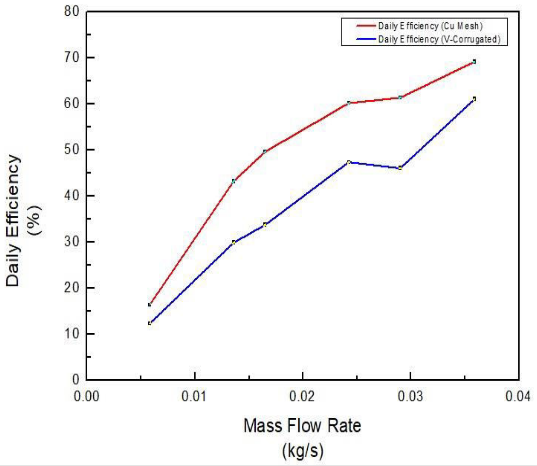


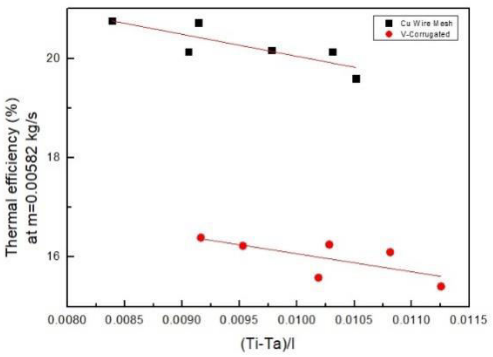
Fig 4.27 Daily Efficiency (%) of Copper Wire Mesh and v-Corrugated Plate Solar Air Heaters versus mass flow rate (kg/s)

The results obtained from the above graph denotes that the da... air heater are 1... 38% and 69.24... heater are 12.34... d 61.08% at m= ...)2901 and 0.035...

Equation	y= a + b*x		
Weight	No Weighting		
Residual Sum of Squares	0.96793	0.43734	
Pearson's r	-0.93456	-0.96305	
Adj. R-Square	0.84176	0.90933	
		Value	Standard Error
B	Intercept	68.17678	0.41068
B	Slope	-597.59401	113.75687
D	Intercept	47.74975	0.5405
D	Slope	-508.11558	71.04861

4.7 E...

The fo... s for both Coppe... air heaters at various mass flow rates.



Equation	y = a + b*x		
Weight	No Weighting		
Residual Sum of Squares	0.29271	0.40312	
Pearson's r	-0.83004	-0.70368	
Adj. R-Square	0.61121	0.36895	
		Value	Standard Error
B	Intercept	24.46249	1.41974
B	Slope	-442.08414	148.5114
D	Intercept	19.68262	1.86785
D	Slope	-361.67951	182.59782

Fig 4.28 Efficiency Curves of Copper Wire Mesh and v-Corrugated Plate Solar Air Heaters versus $(T_{in}-T_{amb})/I$ at m= 0.00582 kg/s (left) and the table showing slopes of lines of best fit (right)

Figure 4.28 represents the typical efficiency curves for both Copper wire mesh and v-Corrugated plate solar air heaters against the parameter $(T_{in}-T_{amb})/I$ for m=0.00582 kg/s. The least square curve fitting is used to shape the regression lines shown above. The generated lines have negative slopes as shown in the above table for absorber plates.

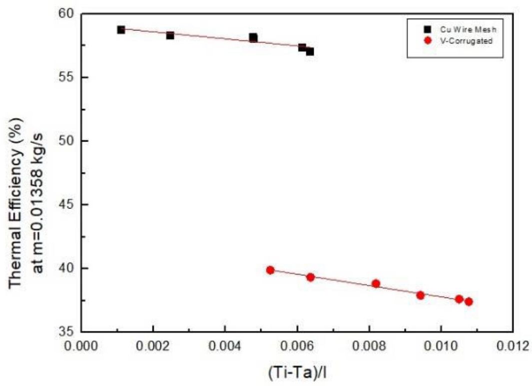
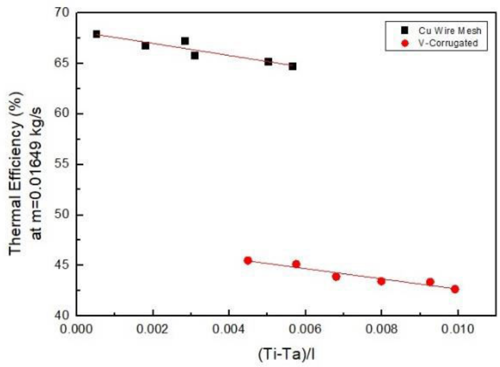


Fig 4.29 Efficiency Curves of Copper Wire Mesh and v-Corrugated Plate Solar Air Heaters versus $(T_{in}-T_{amb})/I$ at m= 0.01358 kg/s (left) and the table showing slopes of lines of best fit (right)

Figure 4.29 represents the typical efficiency curves for both Copper wire mesh and v-Corrugated plate solar air heaters against the parameter $(T_{in}-T_{amb})/I$ for m=0.01358 kg/s. The least square curve fitting is used to shape the regression lines shown above. The generated lines have negative slopes as shown in the above table for absorber plates.



Equation	y= a + b*x		
Weight	No Weighting		
Residual Sum of Squares	0.33162	0.0827	
Pearson's r	-0.91216	-0.99177	
Adj. R-Square	0.79006	0.9795	
		Value	Standard Error
B	Intercept	59.15492	0.28886
B	Slope	-275.9941	62.00029
D	Intercept	42.23917	0.2484
D	Slope	-444.55843	28.69891

Fig 4.30 Efficiency Curves of Copper Wire Mesh and v-Corrugated Plate Solar Air Heaters versus $(T_{in}-T_{amb})/I$ at m= ... slopes of

Equation	y= a + b*x		
Weight	No Weighting		
Residual Sum of Squares	2.53259	2.05346	
Pearson's r	-0.77585	-0.19814	
Adj. R-Square	0.50242	-0.20093	
		Value	Standard Error
B	Intercept	95.3734	5.58661
			385
			544
			462

Figur... curves for both ... solar air heate... m=0.01649 kg/s. ... shape the regre... lines have nega... absorber plate...

Equation	y= a + b*x		
Weight	No Weighting		
Residual Sum of Squares	2.947	4.13196	
Pearson's r	-0.15339	-0.79257	
Adj. R-Square	-0.22059	0.5352	
		Value	Standard Error
B	Intercept	88.79188	3.35655
B	Slope	-213.48561	687.64697
D	Intercept	90.60428	4.68314
D	Slope	-2430.4875	934.98311

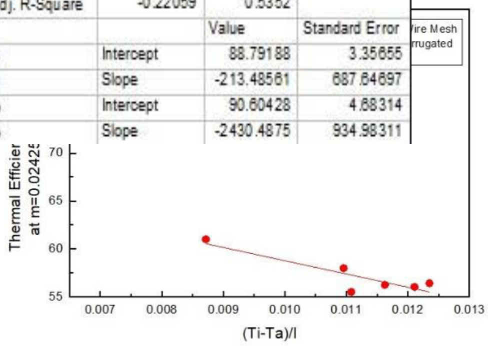


Fig 4.31 Efficiency Curves of Copper Wire Mesh and v-Corrugated Plate Solar Air Heaters versus $(T_{in}-T_{amb})/I$ at m= 0.02425 kg/s (left) and the table showing slopes of lines of best fit (right)

Figure 4.31 represents the typical efficiency curves for both Copper wire mesh and v-Corrugated plate solar air heaters against the parameter $(T_{in}-T_{amb})/I$ for m=0.02425 kg/s. The least square curve fitting is used to shape the regression lines shown above. The generated lines have negative slopes as shown in the above table for absorber plates.

Equation	y= a + b*x		
Weight	No Weighting		
Residual Sum of Squares	2.947	4.13196	
Pearson's r	-0.15339	-0.79257	
Adj. R-Square	-0.22059	0.5352	
		Value	Standard Error
B	Intercept	88.79188	3.35655
B	Slope	-213.48561	687.64697
D	Intercept	90.60428	4.68314
D	Slope	-2430.4875	934.98311

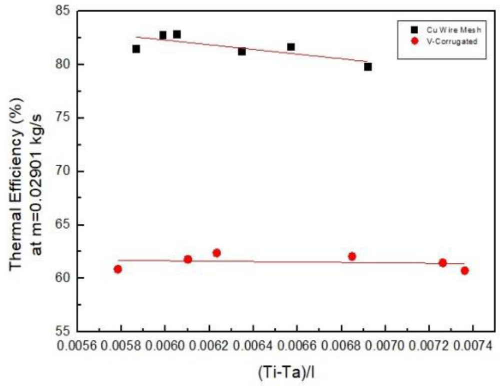
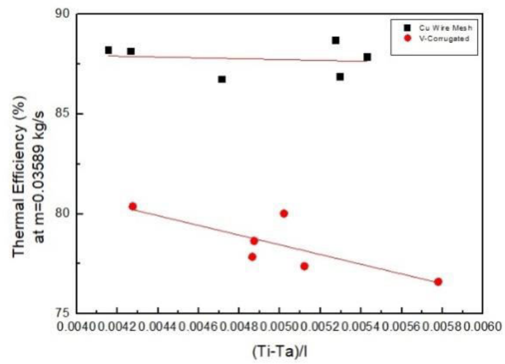


Fig 4.32 Efficiency Curves of Copper Wire Mesh and v-Corrugated Plate Solar Air Heaters versus $(T_{in}-T_{amb})/I$ at m= 0.02901 kg/s (left) and the table showing slopes of lines of best fit (right).

Figure 4.32 represents the typical efficiency curves for both Copper wire mesh and v-Corrugated plate solar air heaters against the parameter $(T_{in}-T_{amb})/I$ for m=0.02901 kg/s. The least square curve fitting is used to shape the regression lines shown above. The generated lines have negative slopes as shown in the above table for absorber plates.



Equation	y= a + b*x		
Weight	No Weighting		
Residual Sum of Squares	0.85174	4.48701	
Pearson's r	-0.95483	-0.8856	
Adj. R-Square	0.88962	0.73036	
		Value	Standard Error
B	Intercept	94.16482	2.59708
B	Slope	-1969.23706	306.42511
D	Intercept	72.62065	4.05668
D	Slope	-1381.49112	362.25589

Fig 4. ... -

Corrugated Plate Solar Air Heaters versus (T_{in}-T_{amb})/I at m= 0.03589 kg/s (left) and the table showing slopes of lines of best fit (right).

Figure 4.33 represents the typical efficiency curves for both Copper wire mesh and v-Corrugated plate solar air heaters against the parameter (T_{in}-T_{amb})/I for m=0.03589 kg/s. The least square curve fitting is used to dshape the regression lines shown above. The generated lines have negative slopes as shown in the above table for absorber plates.

4.8 Discussion

4.8.1 Temperature Curves

Figure 4.2 – 4.7 show the temperature of various elements of Copper Wire Mesh and v-Corrugated Plate solar air heaters at distinct mass flow rates. The graphs show that the temperature readings are directly proportional to the solar irradiance for that particular day. Also, the absorber plate and outlet temperatures of the Copper Wire Mesh solar air heater is elevated than that of v-Corrugated Plate solar air heater at all mass flow rates. The experiment conducted by Durusoju [23] et al. also suggests that the thermal performance of copper is likely to have better thermal conductivity than other metals. As Copper Wire Mesh is porous in nature and the mode of air flow is mixed flow in this air heater, it has increased surface area and the air trapped inside the collector box experiences higher turbulence.

4.8.2 Outlet Temperature (T_{out})

Figure 4.9 – 4.14 show that the outlet temperature of air is elevated in Copper Wire Mesh than that of v-Corrugated Plate solar air heater. The difference in the temperature (outlet) between the two solar air heater increases as the mass flow rate decreases. Kabeel [13] et al. suggests that as the mass flow rate drops, air speed also decreases in turn increasing the level of the absorber surface temperature. Hence, the temperature variation in lower mass rate is higher between the two solar air heaters.

4.8.3 Instantaneous Thermal Efficiencies

Figure 4.15 – 4.20 show that the increment in mass flow rates soars the instantaneous thermal efficiencies of the solar air heaters. The graphs also show that the thermal efficiency of Copper Wire Mesh solar air heater is 1.10-1.41 times better than that of v-Corrugated Plate solar air heater. This result is in agreement with the experimental work performed by Kabeel [13] et al.

4.8.4 Convective Heat Transfer Coefficient

The results of an experimental investigation performed by Durusoju [23] et al. concludes that the use of copper as absorber plate, is an efficacious way to increase the convective heat transfer coefficient in solar air heaters as it exhibits high heat transfer coefficient, promotes turbulence and efficiency. Also, the convective heat transfer coefficient 'h' increases as the solar intensity increases. This leads to an increment in useful heat collected by the absorber plate. Additionally, the heat loss from the collector also decreases. Moreover, as the mass flow rate soars, 'h' increases. Similarly, in this study the Figure 4.21 – 4.26 showcases that the value of 'h' in Copper Wire Mesh solar air heater reaches up to 1.53 times higher than v-Corrugated Plate solar air heater at m= 0.03589 kg/s compared to 1.38 times at m=0.00582 kg/s.

4.8.5 Daily Efficiency Curves

Kabeel [13] et al. indicates that the cumulative practical heat gained by the air for Copper Wire Mesh solar air heater is more than v-Corrugated Plate solar air heater. The daily efficiency of the prior one is found to be better. Also, Fig. 4.27 shows that an increment in the mass flow rate soars the daily efficiency. Moreover, it also shows that the daily efficiency is 1.13-1.47 times higher in Copper Wire Mesh solar air heater than in v-Corrugated Plate solar air heater.

4.8.6 Efficiency Curves at various flow rates

Optical efficiency (F_R α_P τ_g) is obtained at the intersection of the lines of best fit with the vertical axis. Also, the slopes of the lines (negative) as shown in Fig. 4.28 – 4.32 are corresponding to the overall heat transfer coefficient of the gatherer (U_l). According to Kabeel [13] et al, it is seen that the efficiency curves are likely to decrease as the mass flow rate soars. Thus, the higher the mass flow rate, the lesser the overall loss. Moreover, it is deduced that the loss coefficient is higher in v-Corrugated plate solar air heater than in Copper wire mesh solar air heater.

CONCLUSION

The solar air heater was tentatively researched under two setups of absorber plates, i.e. Copper Wire Mesh and v-Corrugated to monitor the optimum activity and the performance of the heater under a wide scope of mass flow rates and working conditions. From the results obtained experimentally, the following conclusions can be made:

- The Copper Wire Mesh solar air heater was established to be efficient between the two solar air heaters.
- The increment in mass flow rates increased the instantaneous thermal efficiency of the solar air heaters. The thermal efficiency of Copper Wire Mesh solar air heater was 1.10-1.41 times better than that of v-Corrugated Plate solar air heater.
- The outlet temperature difference among the two solar air heaters was found to be elevated at lower mass flow rates of air and the outlet temperature of Copper Wire Mesh solar air heater was always higher than the v-Corrugated Plate solar air heater at all mass flow rates.
- The convective heat transfer coefficient in Copper Wire Mesh solar air heater in contrast to v-Corrugated Plate solar air heater was 1.53 and 1.38 times higher at m=0.03589 kg/s and 0.00582 kg/s respectively.

- The daily efficiency was 1.13-1.47 times higher in Copper Wire Mesh solar air heater than in v-Corrugated Plate solar air heater.
- The thermal efficiency curves were likely to lessen with the increment in mass flow rate.
- The loss coefficient in v-Corrugated Plate solar air heater was elevated than Copper Wire Mesh solar air heater.

Considering this experiment, it is deduced that the Copper Wire Mesh solar air heater is an efficient device than v-Corrugated Plate solar air heater due to its higher thermal conductivity, increased surface area and higher turbulence of air inside the collector box. However, both the solar air heaters can be positively utilized for drying implementations according to the operating and economic conditions.

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