THERMAL PERFORMANCE OF A FLAT PLATE SOLAR AIR HEATER BY USING METAL SCRAP MATERIAL

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Submitted by

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CERTIFICATE

This is to certify that the Project Report entitled **"THERMAL PERFORMANCE OF FLAT PALTE SOLAR AIR HEATER BY USING SCRAP MATERIALS"** being submitted by SAMOJU AJAY BABU (317126520167), VEMPATI SAI SRINIVAS (317126520177), BORRA AKHIL (318126520L26), CHENGALA GOPI VISWESH (317126520126), in partial fulfillments for the award of degree of **BACHELOR OF TECHNOLOGY** in **MECHANICAL ENGINEERING**. It is the work of bona-fide, carried out under the guidance and supervision of **MR.V.R. LENIN**, Assistant Professor, Department Of Mechanical Engineering, ANITS during the academic year of 2017-2021.

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CONTENTS

LIST OF FIGURES

ABSTRACT

In the solar-energy industry great emphasis has been place the development of "active" solar energy systems which involve the integration of several subsystems: solar energy collectors, heat-storage containers, heat exchangers, fluid transport and distribution systems, and control systems. The major component unique to active systems is the solar collector.

A precise and detailed analysis of a solar flat plate collector is quite complicated because of the many factors involved.

Efforts have been made to combine a number of the most important factors into a single equation and thus formulate a mathematical model which will describe the thermal performance of the collector in a computationally efficient manner.

This device absorbs the incoming solar radiation, converting it into heat at the absorbing surface, and transfers this heat to a fluid (usually air or water) flowing through the collector. The warmed fluid carries the heat and it is utilised for drying applications, this is one of the low-cost drying methods in the present scenario.

CHAPTER – 1

INTRODUCTION

The amount of paddy production in Andhra Pradesh is about 139.73 lakh tones in 2019-20. The drying of foods and crops (paddy...etc.) is a major operation in the food industry, consuming large quantities of energy. Dried foods are stable under ambient conditions, easy to handle, possess extended storage life, and can be easily incorporated during food formulation and preparation. The drying operation is used either as a primary process for preservation, or a secondary process in certain product manufacturing operations. Drying operations alone account for 10% to 25% of the total energy in the food processing industry. One of the main goals in designing and optimizing industrial drying processes is to reduce moisture at minimum costs. Presently, climate energy conservation plays a major role to make the process sustainable. Therefore, careful selection of drying techniques and the optimization of drying conditions play a significant role. Physical changes (such as deformation of shape and size, as well as color changes and microstructural changes) have a direct impact on consumer decisions in buying a product.

Agricultural crops are important for the human diet, depending upon their nature, including vitamins, mineral and fibers. Some crops are highly seasonal and are usually available in plenty. In the peak seasons, the selling price of crops becomes too low, leading to heavy losses for the grower. Furthermore, this leads to an unnecessary stock in the market, resulting in the spoilage of large quantities. Due to its seasonal nature, a need was felt to preserve crops over a period of time for use during off-seasons. Preservation of crops can prevent the huge wastage and make them available in the off-season at remunerative prices. Additionally, the seasonal nature of availability has led to efforts to extend the shelf life of crops by dehydration. Various drying methods have been practiced for dehydrating crops. These technologies need sophisticated equipment and skill training, the adoption of which appears difficult at the field or rural level.

There are many drying techniques are available. The most common technique is via air, in which heat is applied by convection, which carries away the vapor as humidity from the product. Examples of this include sun drying and artificial drying. Other drying techniques are vacuum drying and fluidized bed drying, where agricultural products are kept in vacuum conditions and water is used to evaporate and fluidize the material. These methods are suitable for heat sensible crops. Drum drying is another method, where a heated surface is used to provide energy; and spray drying that atomizes the liquid particles to remove moisture, like in milk powders. This shows that drying is one of the most important preservation techniques or methods for food crops. Among them there are several drying processes for paddy.

1.1 DRYING PROCESS:

Drying of products can thus be obtained by circulating air at varying degrees of heat through a mass of grains. As it moves, the air imparts heat to the grain, while absorbing the humidity of the outer most layers. In terms of physics, the exchange of heat and humidity between the air and the product to be dried is see in the following phenomena.

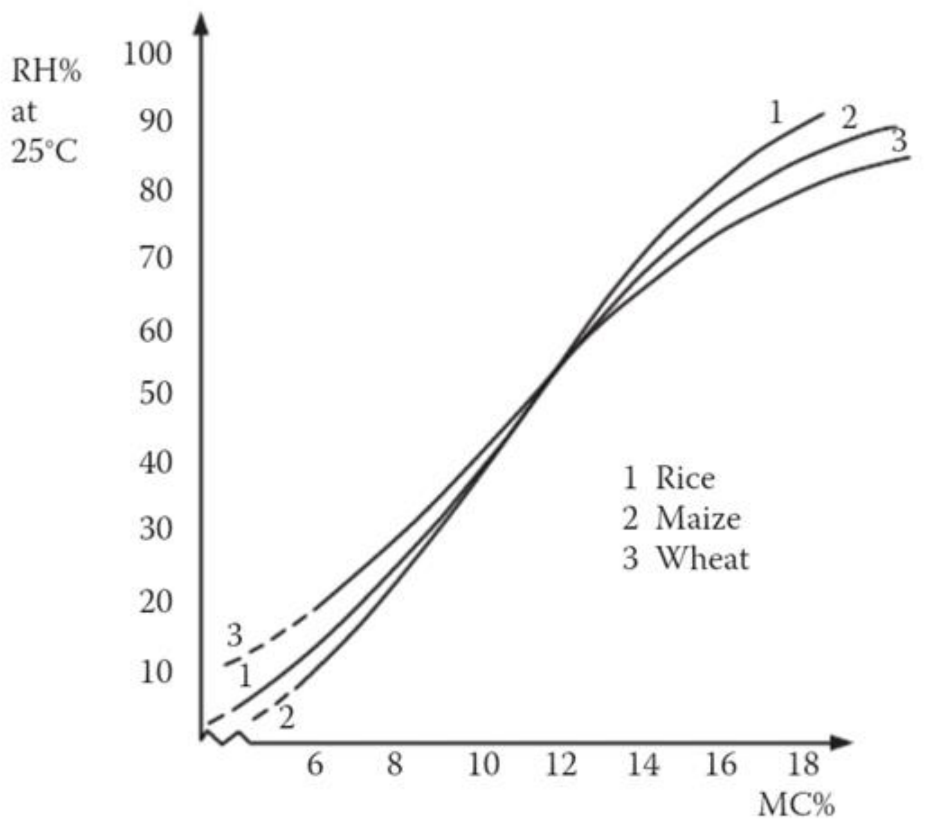


Fig (1.1): Moisture content vs Relative Humidity for various food products.

- Heating of the grain, accompanied by a cooling of the drying air.
- Reduction in the moisture content of the grain, accompanied by an increase in the relative humidity of the drying air. However, this process does not take place uniformly

The water present in the outer layers of grain evaporates much faster and more easily than that of the internal layers.

For drying grain, essentially two methods are used:

1.1.1 NATURAL DRYING:

The natural drying method consists essentially of exposing the high moist grain or legumes to the air (in sun or shade). To obtain the desired moisture content, the grain or legumes are spread in thin layers on a drying floor, where it is exposed to the air (in sun or shade) for a maximum of 10 to 15 days. To encourage uniform drying, the grain or legumes must be stirred frequently, especially if it is in direct sunlight.

1.1.2 ARTIFICIAL DRYING:

In order to satisfy the need for an increasing agricultural production, it is therefore necessary to dry the products in relatively brief periods of time, whatever the ambient conditions. Consequently, it is necessary to resort to artificial drying. This method consists of exposing the grain to a forced ventilation of air that is heated to a certain degree in special appliances called “dryers”

1.2 DRYING OF PARBOILED PADDY:

Paddy after parboiling contains about 35% moisture and it has to be dried to about 14%, which is the moisture level for proper milling and safe storage. The manner in which this excess moisture is removed is of considerable importance. If the moisture is removed at a very slow rate, the microorganisms will grow and spoil the parboiled paddy partially or fully. On the other hand, if drying is done rapidly and continuously, cracks may develop and rice will break during milling. However, if parboiled paddy is uniformly dried by any means (shade, sun, or by hot air) practically no breakage of rice will occur. However improper drying conditions may result in breakage as high as 100%.

1.2.1 SHADE DRYING OF PARBOILED PADDY:

Parboiled paddy could be dried under shade, but it would take a long time and is therefore not usually practiced. Due to the slow drying rate, the milling results of paddy dried under shade are best. Proper shade drying of raw paddy can yield excellent milling quality with less than 1% breakage.

1.2.2 SUN DRYING OF PARBOILED PADDY:

Figure (1.2) shows the sun drying and tempering of parboiled paddy. Sun drying of parboiled paddy is the most common practice, which is followed by big and small rice mills and individuals. The cost of sun drying per ton of paddy is the minimum. The main drawback in this method is that it is depend upon weather conditions. It cannot be carried out throughout the year and also the drying rate is too slow. Sun drying in a single stage causes considerable damage to the milling quality of paddy. The milling quality of paddy is not affected until the moisture content reaches 16%. Suspension of drying and tempering of paddy for about 2 hours by heaping the paddy and covering it with gunny, then drying in the second stage improves the milling quality considerably without adding much to the cost of drying. Sometimes the first stage of drying can be carried out in the day time and the second stage (with overnight tempering) on the next day. The cost of parboiling and drying is a very important consideration for popularizing a method of parboiling. While calculating the cost of parboiling and drying per unit quantity of paddy, many factors should be carefully considered. Cost of the equipment for any method should be considered as per present market prices.

Fig (1.2): Sun drying and tempering of parboiled paddy.

1.3 DRYING OF FRUIT AND VEGETABLES:

During the past decade, many advances in drying technologies have emerged with the goal of minimizing degradation of various quality attributes of food products during drying. Among an enormous number of foods that need to be dried, fruits and vegetables have received much attention as it has repeatedly been reported that these materials contain a wide array of phytochemicals, which are claimed to exert many health benefits, including antioxidant activity. In some cases, where extraction of bioactive compounds cannot be performed on fresh fruits and vegetables, drying is a necessary step that needs to be conducted to keep the materials for later use. It has been revealed that dried fruits and vegetables have also been regarded as alternative, fat-free snacks for health-conscious consumers. This implies that not only nutritional changes, but also other changes, including physical and microstructural changes, which are of importance and need to be optimized.

The drying of fruits and vegetables has been principally accomplished by convective drying. There are a number of studies that have addressed the problems associated with conventional convective drying. Some important physical properties of the products have changed such as, loss of color, change of texture, chemical changes affecting flavor and nutrients, and shrinkage. The high temperature of the drying process is an important cause for loss of quality. Lowering the process temperature has great potential for improving the quality of dried products.

In this case we can use flat plate solar air heater to drying purpose, because it will produce the air of temperature which is less than the 90-degree centigrade.

1.4 QUALITY CHANGES DURING DRYING:

There are several changes taking place in quality parameters during drying and storage. The extent of changes depends on the care taken in preparing the material before dehydration and on the process used. Major quality parameters associated with dried food products include color, visual appeal, shape of product, flavor, microbial load, retention of nutrients, porosity-bulk density, texture, rehydration properties, water activity, freedom from pests, insects, and other contaminants, preservatives. The state of the product (such as glassy, crystalline, or rubbery) is also important. Quality parameters of dried fruits and vegetable can be classified into four major groups:

i. Physical qualities ii. Chemical qualities iii. Microbial qualities iv. Nutritional qualities.

1.5 RECENT ADVANCES IN DRYING TECHNOLOGY:

The emergence of new research areas in recent years has seen many drying applications not only limited to food or crop materials. The drying of advanced materials in the manufacturing of superconducting materials or advanced ceramics, where novel spray drying technology has been developed, has obtained the desired electrical and magnetic properties. Another example is impingement jet drying of polymer solution on metal substrates to protect surfaces from corrosion. These are very well-controlled drying operations required by the market.

1.5.1 MULTI-STAGE DRYING:

The concept of multi-stage drying is based on the heat and mass transfer characteristics along the drying curve of the material, which shows distinct mechanisms requiring different conditions for optimal drying rates. As a result of this, each mechanism requires different equipment or operating conditions. Multi-stage drying allows for the better control of the entire drying process resulting in higher product quality. Multistage drying systems (MSDS) make it possible to use lower temperature inlet air flows into dryers than in one dryer case. Multistage drying systems make it possible also for the decreased mass flow of drying air into the drying system compared to one dryer case, when inlet temperatures of drying air are the same than in one dryer case. The multistage drying system enables remarkable savings in the energy costs of drying. It also offers the possibility to use secondary energy from a plant facility as the drying energy. The first advantage makes it possible to utilize low-temperature secondary energy flows in drying. This improves the efficiency.

1.5.2 SUPERHEATED STEAM DRYING:

Replacing hot air with superheated steam in drying was an idea generated long ago and has gained interest in the present day. This is a new, revolutionary technique, which has prompted changes in operational conditions. The addition of new devices and further necessary steps for heating and cooling of products are introduced. Furthermore, either pressure or vacuum process conditions are needed to introduce materials. The basic idea of the process is to increase drying rates by improving moisture mobility in the solid material.

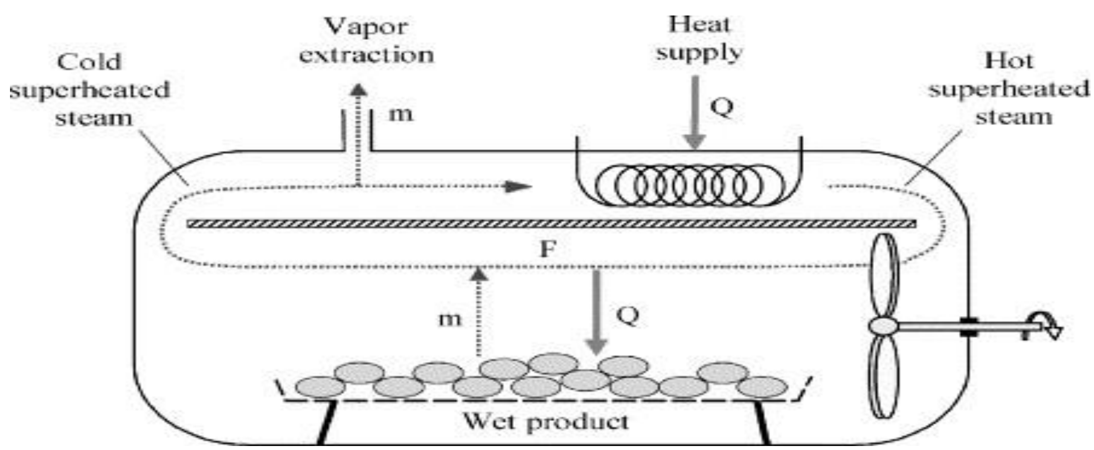


Fig (1.3): Superheated Steam drying process.

1.5.3 CONTACT-SORPTION DRYING:

In this drying method, wet material is in contact with heated particulate medium. In the case of an inert medium, the particle-particle heat transfer induces moisture evaporation and facilitates drying. In the case of highly hygroscopic heated medium, the generated chemical potential gradient between medium and material to be dried, facilitates moisture removal. Large particles in fluidized bed drying could be dried with the introduction of another sorbent material in addition to the hot air.

1.5.4 SPOUTED BED DRYING:

Spouted beds are modified fluidized beds for coarse particles belonging to Geldart's D group (larger and heavy particles). Particle movement is regular rather than random in fluidized beds. These beds have been very good for drying grains, but in recent times have been used for drying of slurries and pastes. A variation of the spouted bed emerged as the rotating jet spouted bed (RJSB). This method is recommended for drying heat sensitive particles in the falling rate period. RJSB consists of a flat-base cylindrical vessel fitted with slow rotating air distributor plates with one or several radially located spouting air nozzles.

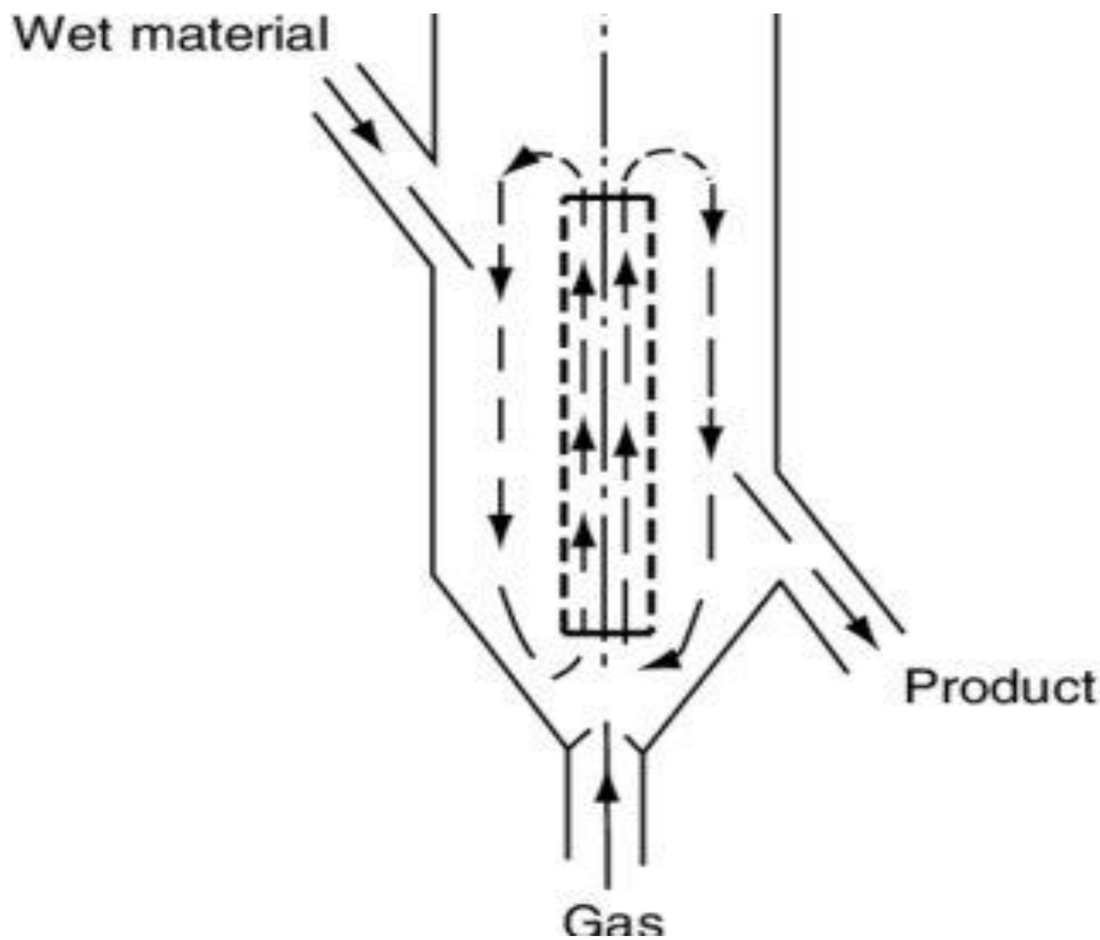


Fig (1.4): Spouted bed drying process.

Among them there is a solar drying method for reducing moisture in crops (i.e. paddy grains, fruits...etc.).

1.6 SOLAR DRYING:

Solar drying relies, as does sun drying, on the sun as its source of energy. Solar drying differs from sun drying in that a structure, often of very simple construction, is used to enhance the effect of the solar insolation. Compared to sun drying, solar dryers can generate higher air temperatures and consequentially a lower relative humidity.

The total solar energy absorbed by the Earth's atmosphere, oceans and land masses is approximately 3,850,000 exa (10^18) joules (EJ) per year. In 2002, this represented greater energy consumption in one hour than the world used in one year (2006).

The amount of solar energy reaching the surface of the planet is so vast that in one year it is about twice as much as will ever be obtained from all of the Earth's non-renewable resources of coal, oil, natural gas, and mined uranium combined. This is a huge source of energy and many applications that use solar energy, which is an abundant, clean and safe source, have been investigated. Solar technologies can be classified into two groups: passive and active heating.

Passive solar techniques include designing spaces according to natural circulation, locating buildings with reference to the Sun or selecting high thermal conductive materials.

On the other hand, active solar techniques include using solar panels, pumps or fans to convert solar energy into useful outputs.

There are several methods for solar drying one among them is solar air heaters. Solar air heaters are devices that utilize solar radiation for a variety of purposes. These devices are simple and can be constructed inexpensively. Mainly, Solar air heater consist of a transparent cover, an absorber plate and insulation material.

The air flow enters through the channel that is formed by the absorber plate and the transparent cover. Solar radiation absorbed by the absorber plate. The absorbed heat transferred to the air as it flows along the channel increases its temperature. This heated air can be used in several applications such as drying agricultural products, space heating and air conditioning, water heating and industrial process heating.

There are many advantages of solar air heater systems. Firstly, they are simple to maintain and design. After the set-up cost, a solar air heater system has no fuel expenditure. There is less leakage and corrosion when compared to the systems that use liquid. It is also an eco-friendly system which has zero greenhouse gas emissions.

The primary disadvantage of these systems is the low heat transfer coefficient compared to systems that use liquid as the working fluid. This is the result of low heat transfer coefficient between the absorber plate and the air.

Low heat transfer coefficients lead to low thermal efficiency of solar air heaters. For many years researchers have studied the enhancement of heat transfer coefficients of solar air heaters. To increase the efficiency of such a system, various configurations and designs have been proposed.

The efficiency of solar air heaters can be affected by various parameters such as collector length, number of channels, depth of channels, type of absorber plate, number and material of glass covers, air inlet temperature and air velocity.

CHAPTER - 2

2.1 Literature Survey:

K R Arun, G Kanal et al (2019) conducted an experiment on flat plate solar air heater to attain uniform and flexible solar drying by using a multi tray indirect mode solar cabinet dryer. The work considers unripe untreated banana and bitter gourd with an average initial moisture content of 180% (db.) and 1328% (db.), respectively. The present work tries to assess the influence of a tray-sequencing pattern on the drying behavior at different combinations of flake thickness (0.002 0.004 m), multi-tray spacing (0.1 0.15 m), tray mesh size (0.01 0.015 m), and mass flow rate (0.015 0.03 kg/s). For all the tested combinations, the proposed tray sequencing aided to achieve drying uniformity for banana flakes within 10 hours and bitter gourd by 18 hours.The results were 1. Among the different tested combination, for both banana and bitter gourd, and in all trays, as moisture content reduces with drying time, the moisture diffusion from the samples to the air reduces as well. 2. The products dried inside the MTISCD resulted in having the right color, excellent natural aroma and flavor, and retained uniformity in texture when compared to the open sun.

Samir A.Dhatkar et al (2015) carried out the major heat losses from a normal solar air collector are through the top cover which reduce the thermal efficiency, the low heat transfer coefficient between the air stream and the absorber plate is another reason of low thermal efficiency in solar air heaters. Thermal efficiency of double pass solar air heater with porous media is higher than single pass and double pass solar air heater without porous media. Many experiments have been carried out on the performance analysis of double pass solar air heater with porous media and solar air heater with extended surfaces. Effect of various parameters of porous media like pitch, number of layers , bed depth, porosity, thermal conductivity, pitch to wire diameter ratio have been studied. Also these studies includes the design of double pass solar air heater, heat transfer enhancement, pressure drop, type of flow. It is found that more increase in thermal efficiency in comparison with conventional solar air heater.

Kalogirou SA (2004) carried out the various types of collectors described include flat-plate, compound parabolic, evacuated tube, parabolic trough, Fresnel lens, parabolic dish and Heliostat field collector (HFC). The optical, thermal and thermodynamic analysis of collectors is also presented as well as methods to evaluate their performance. These include water heating, space heating and cooling, refrigeration, industrial process heat, desalination, thermal power systems, solar furnaces and chemistry applications. It should be noted that the applications of solar energy collectors are not limited. There are many other applications which are not described here either because they are not fully developed or are not matured yet. The application areas described in this paper show that solar energy collectors can be used in a wide variety of systems, could provide significant environmental and financial benefits.

Neeraj Kumar et al (2019) carried out an experiment on Absorber plates which are covered with a high absorbent coating. The top cover should be made of a maximum transmittance. The effectiveness of the flat plate air collector is highly affected by the losses through the top covering material and also due to the low heat transfer coefficient between the absorber plate and the air flowing through it. Most of the experiments and studies have shown that efficiency can be increased by using different types of solar collector which include double pass, a single pass with fins etc. Based on the experiments it has been found that most of the studies on the solar collector are done to increase its thermal efficiency by enhancing the rate heat transfer between air and the absorber plate by using rough surface on the absorber plate.

Jagadeesh D (2019) carried out experimented the thermal performance of a single pass solar air dryer is compared with a transient computational fluid dynamics studies for flat plate without fins, flat plate with fins and overlay composite absorber plate for two flow rates. Three configurations one with a flat absorber plate without fins, another with a flat plate with a vertical hollow fins placed below the absorber plate and third configuration with an overlay composite absorber plate of copper on the top and aluminium at the bottom are compared against each other for its performance improvement. Conducting Experiment providing the fins on the absorber plate there is an improvement in outlet temperature. With fin configuration is 25% more efficient than the without fin configuration, and there is a 10% enhancement in outlet temperature is achieved by varying the flow rate from 0.012 to 0.016 kg/s and Thermal efficiency increased from 40% to 51% for mass flow rates of 0.012 and 0.016 kg/s respectively.

Rajendra Karwa et al (2005) carried out investigation thermal efficiency of a solar air heater and the pumping power required to propel the air through the air heater duct are strong functions of the duct geometry and roughness, emissivity of the plate, air flow rate and the ambient conditions, such as solar insolation, wind velocity and temperature. It has been found that the iteration time is short even when the iteration is terminated for very close successive values of various temperatures and top loss. Results of sensitivity analysis are also presented to estimate the uncertainty of the results from the presented model.

Mohammad Ansari et al (2018) carried out the effect of repeated ribs on the thermal performance of a flat plate solar air heater is investigated. Thermal model of the air heater is developed based on the semi empirical heat transfer equations. The optimization is performed to meet two objectives, to attain higher thermal efficiency and to guarantee a desired temperature difference between the inlet and outlet of the air flow. It was found that employing ribs in a flat plate solar air heater improves the thermal efficiency by more than 9% under the low air mass flow conditions. In case of 20 K temperature difference between inlet and outlet air, the Re varied from 13656 to 28861.Based on the results of this study, the optimum values for the rib pitch ratio and the rib height ratio of a solar air heater are obtained to be 10 and 0.025 for a wide range of variations of other flow parameters.

Samir A. Dhatkar et al (2015) carried out The most important parts of flat plate solar collectors include- the absorber plate (black coloured), a transparent cover that allows solar radiations to pass (maximum transmittance), fluid to carry heat (air, antifreeze or water) from the absorber plate and heat insulating back. The fluid should have a high heat transfer coefficient. Flat plate solar air collectors can reach a temperature of around 50 to 70℃. Higher temperatures are feasible using special surfaces, reflectors, paint and good insulating casing .The absorber plate includes a sheet, which can be made of thermally stable polymers, aluminium or copper and on this sheet a coating of matte black colour or selective coating (chrome coating) is done.

Duffie JA and Beckman WA (2006) carried out Solar collectors of Flat Plate type is a thermal transfer device that absorbs solar radiation and converts it into heat, which is mainly used to increase the water temperature, heat and dryness, dryness of crops in the region, space heating and in industries where this hot fluid is required for many chemical reactions, and for applications requiring the temperature of the fluid to be less than 100°C. As non-renewable sources of energy are becoming depleted and will soon have the power crisis. The main components of the flat plate air collector are, absorbing plate, top covering plate (glass cover), insulating material and channel pipes covered with insulating material. Based on the literature survey it has been found that most of the studies on the solar collector are done to increase its thermal efficiency by enhancing the rate heat transfer between air and the absorber plate by using rough surface on the absorber plate.

Fatah. O. Al Ghuol et al (2015) carried out experiment on Solar collectors of Flat Plate type is a thermal transfer device that absorbs solar radiation and converts it into heat, which is mainly used to increase the water temperature, heat and dryness, dryness of crops in the region, Absorber plates are covered with a high absorbent coating. The top cover should be made of a maximum transmittance. The effectiveness of the flat plate air collector is highly affected by the losses through the top covering material and also due to the low heat transfer coefficient between the absorber plate and the air flowing through it.

Velmurugna P, et al (2013) carried out experiment on a solar air heater that is used by using solar collector. The efficiency of this is determined by using with and without using fins which are attached under the absorbing plate. By using fins the efficiency is increased and the efficiency is reduced without using fins. Generally the maximum efficiency is occurs at 0.012 and 0.016 kg/sec. The efficiency depends on the dynamic behaviour on the mass flow rate and the solar irradiation and geometry surfaces. Therefore the efficiency of the solar air heater is higher while the fins are used.

Fouded chabana et al (2013) carried out an experiment on solar air heater that is used by using solar collector. The efficiency of this is determined by using with and without using fins which are attached under the absorbing plate. By using fins the efficiency is increased and the efficiency is reduced without using fins. Generally the maximum efficiency is occurs at 0.012 and 0.016 kg/sec. The efficiency depends on the dynamic behaviour on the mass flow rate and the solar irradiation and geometry surfaces. Therefore the efficiency of the solar air heater is higher while the fins are used.

Velmurugan P et al (2016) carried out experiment on the energy performance of solar air heaters improved by using or employing double pass with different absorber surface. There is effect on various mass flow rate and solar intensity on temperature and pressure drop. Here the rise in temperature of air, thermal efficiency and the energy gain depends on the mass flow rate. From this we can learn that the mass flow rate is the important factor to determine the efficiency, temperature and the pressure drop. From this experimental study we can study that the energy and the energy performances of four types v-corrugated wire mesh double pass, finned plate double pass, roughened plate double pass, conventional flat plate single pass solar air heater. Here the efficiency of energy increases while the temperature rise decreases. So the surface geometries are influential in enhancing the performance of solar air heater.

G.Kalaiarasi et al (2020) carried out an experiment on flat plate solar air heater (SAH) has been designed to yield a good outlet air temperature irrespective of fluctuations in solar radiation. It was achieved with the help of a specially designed, integrated absorber plate cum storage unit, together acted as a single component. The integrated unit consists of a set of copper tubes with black painted copper foil, welded longitudinally on two main header tubes. High quality synthetic oil (Therminol-55) had been contained in those copper tubes, which acted as a sensible heat storage medium. It also concluded that sensible heat storage at the absorber plate improves the thermal output, therefore leads to a consistent performance.

Mohammad Ansari et al (2018) carried out investigation on the effect of repeated ribs on the thermal performance of a flat plate solar air heater. Thermal model of the air heater is developed based on the semi empirical heat transfer equations. The genetic algorithm is used to find the optimum set of parameters in an air heating application. An experimental test rig is designed and built not only to evaluate the validity of the semi empirical correlations, but also to extend the range of application of the equation. It was found that employing ribs in a flat plate solar air heater improves the thermal efficiency by more than 9% under the low air mass flow conditions. But, at the higher air flows or when negligible temperature difference is desired, the additional power required to overcome the pressure drop due to the ribs may decreases the performance of the air heater.

Hatami N et al (2008) carried out an experiment on natural convection heat transfer in a vertical flat-plate solar air heater of 2.5 m height and 1 m width, with one- and two-glass covers. Totally six cases of airflow (two for air heater with one glass cover and four for air heater with two-glass covers) were considered. These cases included states that air could flow within spaces between absorber plate and glass covers or air was enclosed in such spaces. Absorber plate temperature, back-plate temperature, glass cover temperatures, mass flow rates of air within channels and the solar radiation were measured.

Ho-ming yeh et al (1996) carried out investigation theoretically and experimentally on the effect of parallel barriers on the collector efficiency of flat-plate solar air heaters. The barriers were placed with uniform spacing and in parallel, there by dividing the air channel (collector) into parallel sub channels (sub collectors) of the same size. These sub collectors were connected in series so that air flowed through them in sequentially reversed directions. Experimental studies were performed for different locations of the barriers. The theoretical predictions agree reasonably well with experimental results. The optimal barrier location for maximum collector efficiency is the centre line of the collector. The collector efficiency increases theoretically as the number of barriers increases.

C.D. Ho et al (2005) carried out investigation on a device for inserting an absorbing plate into the double-pass channel in a flat-plate solar air heater with recycle. This method substantially improves the collector efficiency by increasing the fluid velocity. The results are represented graphically and compared with a downward-type single-pass solar air heater. Considerable improvement in heat transfer that is obtainable by employing recycle-type double-pass devices instead of single-pass devices or a conventional double-pass heater with the same flow rate. The absorbing plate location influence on heat-transfer efficiency enhancement and the hydraulic dissipated power increment is also discussed.

2.2 RESEARCH GAP:

There is a lack of information relevant to the study of scrap material used in solar flat plate collector to preheat the air, Every day lot of metal scrap is getting wasted all around the world, for example in united states alone, around 2.2 million tons of steel cans and other steel packaging waste were generated in 2018. We can increase the thermal performance of an air solar collector with an absorber plate made of recyclable aluminium cans.

Now a days worldwide most of the people are using this flat plate collector for several applications like space heating, drying agro-products etc. Here the problem is everyone using new aluminum or copper plates as absorber plates. As of now we are getting the same outlet air temperature. To minimize the meatal waste and used in an efficient manner. We can use metal scrap material like aluminum cans etc. to get the same output. This is one of the best method to utilize the waste metal scrap in domestic and agricultural purposes.

2.3 OBJECTIVE:

To ensure choice sources of energy that are clean, reliable steady and sustainable, solar power being rising major need in now a days among the technology of expensive fuels which is used to boil water for industrial and domestic cause. Solar water heaters are used all over the world. Particularly in sunny countries the place solar shine is abundant. We heat the fluid (air) with the help of solar radiation for further drying applications and etc. And compares the thermal efficiency of flat plate solar air collector using scrap material and actual solar flat plate collector.

Experiment objectives are

1. To conduct an experiment on flat plate solar air heater by using GI Sheet which is double coated with black paint acts as an absorber plate.

2. To conduct an experiment on flat plate solar air heater by reducing outlet area.

3. To conduct an experiment by using aluminum cans which are coated with black paint acts as an absorber plate.

4. To conduct an experiment by reducing height between tin top surface and bottom surface to 13cm.

CHAPTER – 3

METHODOLOGY

Solar water heaters are the collection devices which are usually accompanied to expose a dark surface to solar radiation so that the radiation is absorbed. The transparent cover used to allow the radiation to pass and prevents them from exiting, insulation used to resists back and rare side heat losses, a portion of the absorbed radiation is then transferred to a fluid, the system in which the series is achieved is called flat plate solar collector. It is simple in design and it has no moving components & requires less maintenance. It used in temperatures ranging from 40 degree centigrade to 100 degree centigrade.

3.1 Description of collector:

This Flat plate solar Air heater collector having dimensions 1.5mts, 0.67mts and 0.25mts length, width and height respectively. The collector volume is 0.25 m^3.9mm plywood we have used to construct the main body of the collector. 0.5-inch thermocol is used as insulation to avoid the escape of hot air. GI sheet of dimensions 1.5 m length and 0.64 m breadth is placed over the bottom over thermocol .A transparent glass cover with 5mm thickness is placed over the top portion of the collector.

We are doing this experiment at vizag location. It’s having latitude and longitude 17.6868°N and 83.2185°E respectively. To grab the maximum solar radiation, we inclined this flat plate collector to 17.686° top portion towards north and bottom portion towards south.

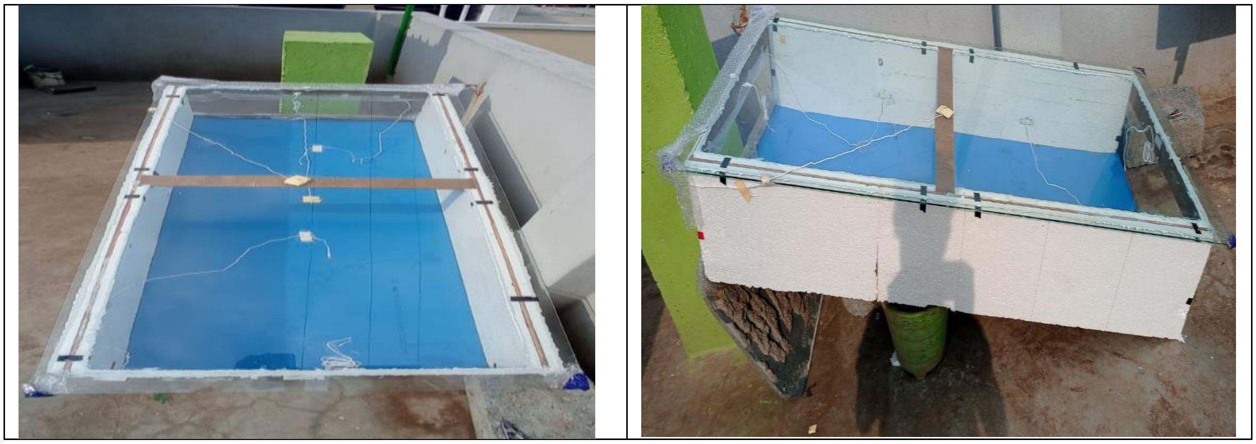
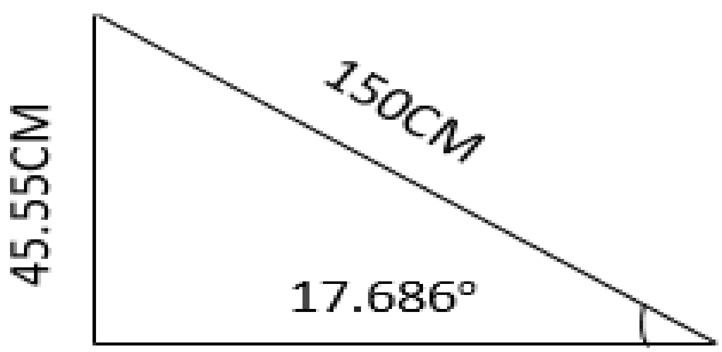


Fig (3.1): Flat plate collector using GI sheet.



Sin 17.686° = X/150

X=Sin 17.686° * 150

X= 45.55CM

Where X =Height

Fig (3.2): Calculation for inclination.

3.2 INSTRUMENTS USED:

3.2.1 Thermocouple:

Fig (3.3): Thermocouple.

Specifications: Temperature range: -50~ 110°C.Temperature measurement accuracy: ±1°C. Uses: To check temperature for indoor and outdoor purpose. In our experiment have used 7 thermocouples.

- The first on air inlet.
- The second on 50cm from air inlet
- The third on Glass surface.
- The fourth on 100cm from air inlet.
- The fifth on GI sheet surface.
- The sixth for atmospheric temperature.
- The seventh on air outlet.

3.2.2 Solar Power Meter:

Fig (3.4): Solar Power Meter.

Specifications: One-chip of micro-processor Lis circuit .Display: 13 mm (0.5") super large LCD display with contrast adjustment for viewing angle Dual function meter's display. Lux: 0 - 100,000 Lux, 3 ranges. Measurement and ranges Foot-candle (Fc):0 -10,000 Fc, 3 ranges. Sensor: The photo diode and colour correction filter, spectrum designed to meet C. I. E.

Units: W/m^2.

Uses:

- Solar Power Plant.
- Solar radiation measurements.
- Solar power research for location of the solar panels or solar water heater.

CHAPTER - 4

RESULTS AND DISCUSSION

4.1 Result and Discussion:

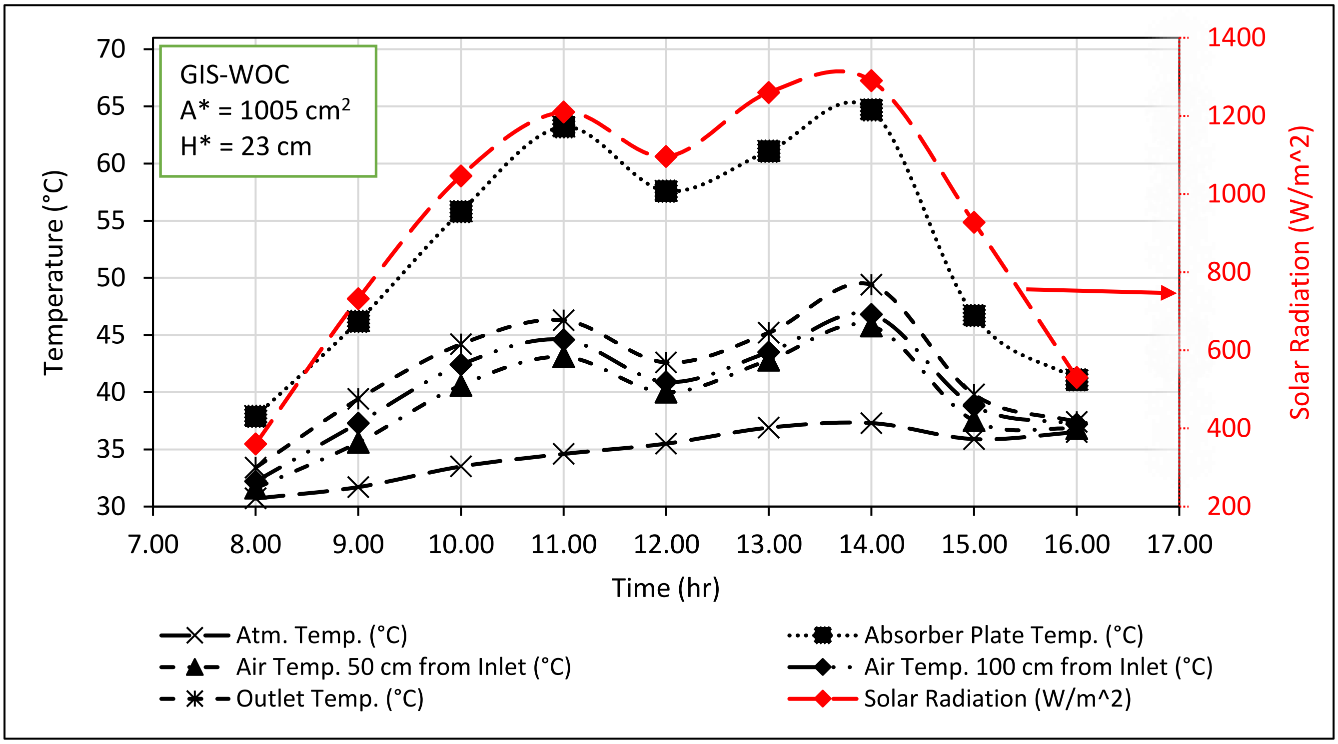


Fig (4.1): Graph for Experiment conducted using plane GI sheet which is not coated with black paint.

This was the graph obtained from the Experiment results on the experiment conducted on the flat plate solar air heater by using plane GI sheet. This was the basic and primary experiment conducted on this system.The distance between the top surfaces of the GI Sheet to bottom surface of the glass is 23cm.

The Fig (4.1) represents each and every temperature and solar radiation with respect to time from the primary experiment conducted on flat plate collector with plane GI Sheet which acts as an absorber plate.

The temperature of air at outlet is 49°C at 14.00 and solar radiation is approximately under 1300 W/m^2, the reason behind this outlet temperature is because of natural convective heat transfer from GI Sheet to Low dense air molecules.

The high density cold air enters into the system (flat plate collector) through the inlet portion and because of the temperature difference there is a transfer of heat from absorber plate and air molecules throughout the system heat in the mode of natural convection process.

The air heated up by absorbing the heat from the absorber plate throughout the system and escape from the outlet portion .Because of this outlet temp reached to 49°C at 14.00 and solar radiation is under 1300 W/m^2.

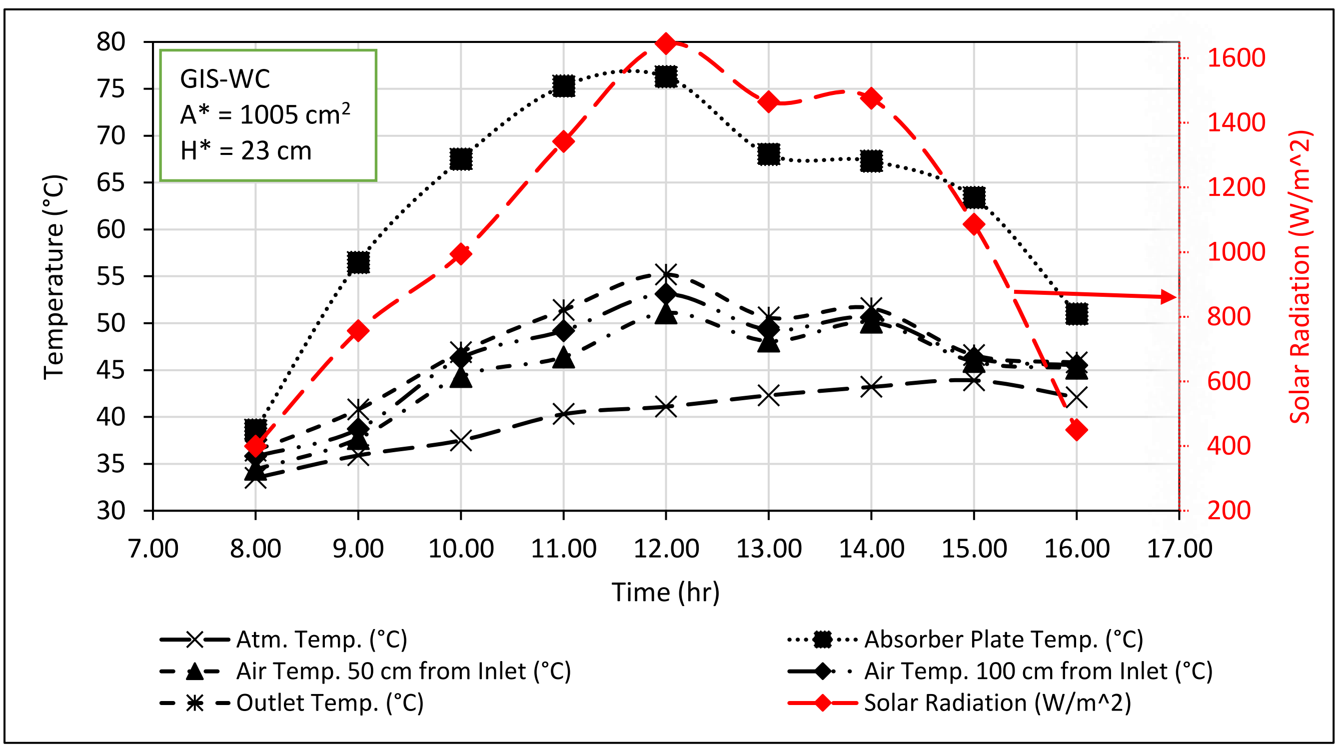


Fig (4.2): Graph for Experiment conducted by using GI sheet which is double coated with black paint.

This was the graph obtained from the experiment conducted on the flat plate solar air heater by using GI sheet which is double coated with the black paint. In this outlet and GI sheet temperature are more than previous plane GI sheet temperature.The distance between the top surfaces of the GI Sheet to bottom surface of the glass is 23cm.

The Fig (4.2) represents each and every temperature and solar radiation with respect to time from the second experiment what we have conducted on flat plate collector with the GI Sheet which is double coated with black paint acts as an absorber plate.

The temperature of air at outlet is 56°C at 12.00 and solar radiation is approximately under 1650 W/m^2, the reason behind this is in this experiment we have coated the GI sheet with black paint which absorbs the maximum solar radiation when compared to the plain GI sheet due to there is a high temperature difference between GI sheet and air molecules. So, there is an increase in air outlet temperature (i.e. 56°C) when we compared with the previous experiment.

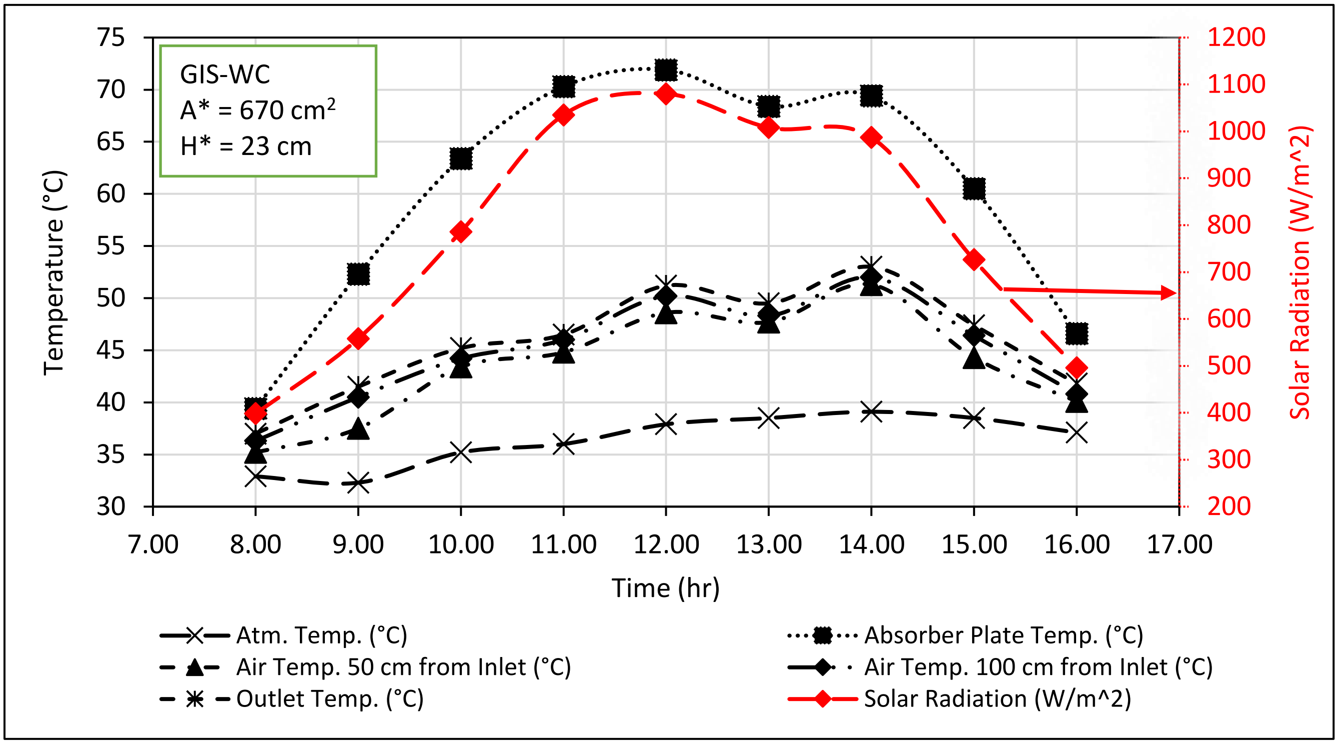


Fig (4.3): Graph for Experiment conducted by reducing outlet area to 670cm^2 using GI sheet which is double coated with the black paint.

This was the graph obtained from the experiment conducted on the flat plate solar air heater by using GI sheet which is double coated with the black paint. In this experiment outlet area got reduced to 670cm^2. Because of reducing outlet area, outlet temperature is increased. The distance between the top surfaces of the GI Sheet to bottom surface of the glass is 23cm.

The Fig (4.3) represents each and every temperature and solar radiation with respect to time from the third experiment what we have conducted on flat plate collector with the GI Sheet which is double coated with black paint acts as an absorber plate and reduces the outlet area to 670 cm^2.

Because of this restriction in outlet area, the air retains in the space in system and it has the time to absorb the maximum amount of heat energy. So, the temperature of air at outlet is 53°C at 14.00 and solar radiation is approximately under 1000 W/m^2.

When compared to previous experiment there is a decrease in air outlet temperature. The reason for this is because of the low solar radiation (i.e. 1000 W/m^2 solar radiation.).Though there is decrease in solar radiation up to 60% from the previous experiment there is a less decrease in air outlet temperature (i.e. 3°C).the reason behind this is due to reduction of air outlet area the air molecules retains within the system and absorbs maximum heat from absorber plate.

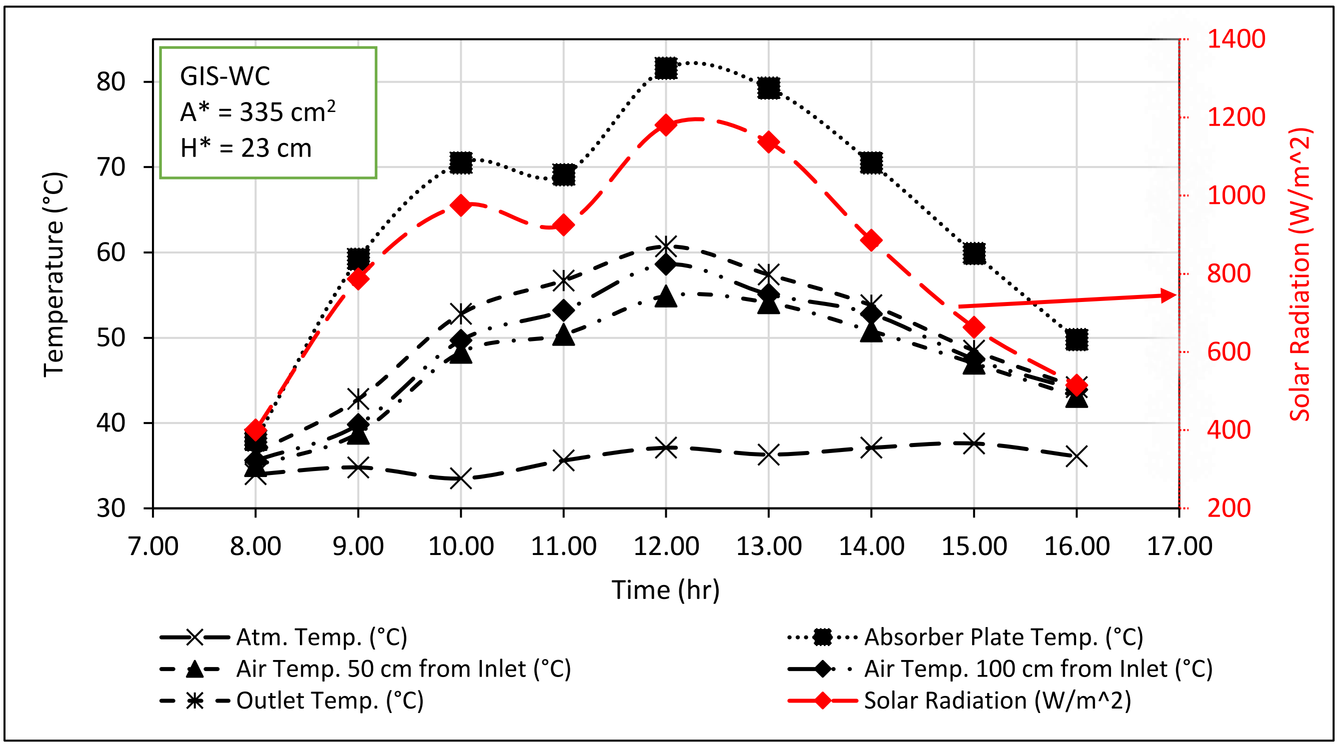


Fig (4.4): Graph for Experiment conducted by reducing outlet area to 335cm^2 using GI sheet which is double coated with the black paint.

This was the graph obtained from the experiment conducted on the flat plate solar air heater by using GI sheet which is double coated with the black paint. In this experiment outlet area got reduced to 335cm^2.This was giving the best results. That's why we taken this as reference.The distance between the top surfaces of the GI Sheet to bottom surface of the glass is 23cm.

The Fig (4.4) represents each and every temperature and solar radiation with respect to time from the fourth experiment what we have conducted on flat plate collector with the GI Sheet which is double coated with black paint acts as an absorber plate and reduces the outlet area to 335cm^2.

The air outlet temperature is 61°C at 12.00 and solar radiation is approximately under 1200W/m^2, the reason behind this outlet temperature is because of natural convective heat transfer from GI Sheet to high density air molecules and restriction in outlet area, the air retains within the system and it has maximum time to absorb the maximum amount of heat energy. So, in this experiment there is a maximum air outlet temperature and good thermal performance when compared with the other experiments.

This was the finalized outlet area to conduct the further experiments on flat plate collector with metal scrap material.

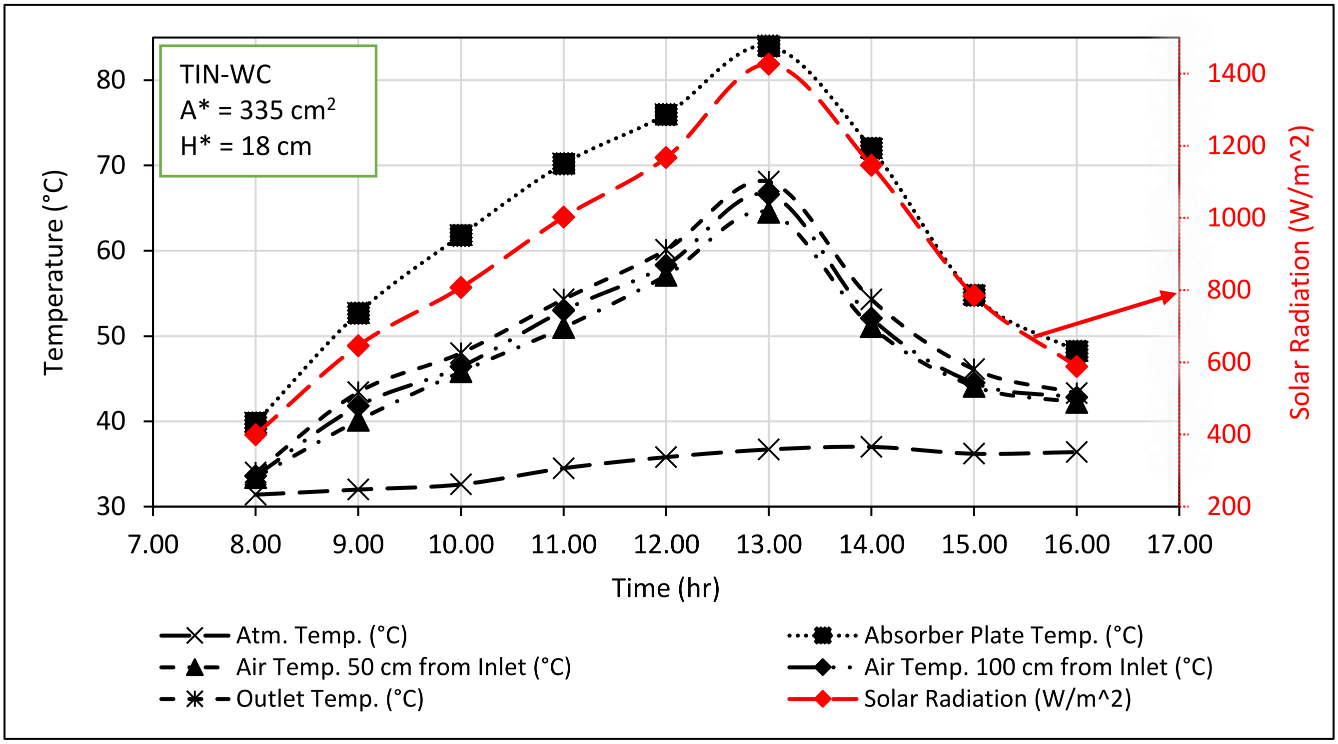


Fig (4.5): Graph for Experiment conducted by reducing outlet area to 335cm^2 using Tins which is double coated with the black paint with distance between Tins and Glass is 18cm.

This was the graph obtained from the experiment conducted on the flat plate solar air heater by using soft drink (250ml) tins which are coated with black paint instead of GI Sheet. The outlet area remains constant as 335cm^2 to get the maximum output. The symbols representing their respective temperatures. Here we can observe that the outlet temperature is more than the previous experiment where we used GI Sheet as an absorber plate. The distance between the top surfaces of the tin to bottom surface of the glass is 18cm. Before the height was 23cm, the height difference is one of the reason behind this increase in outlet temperature.

The Fig (4.5) represents each and every temperature and solar radiation with respect to time from the fifth experiment conducted on tins collector with soft drink aluminum cans (250ml) which are coated with black paint acts as an absorber plate.

After placing these aluminum tins the height between the top surface of the tin and the bottom surface of the glass is 18cm.

The temperature of air at outlet is 68°C at 13.00 and solar radiation is approximately under 1400W/m^2, the reason behind this outlet temperature is because of natural convective heat transfer from black paint coated aluminum tins to High density cold air and the surface area got increased because of these aluminum cans and at the same time rate of natural convective heat transfer also increases. Finally the air escapes from the outlet portion by absorbing maximum amount of heat energy and it results to the 68°C outlet temperature.

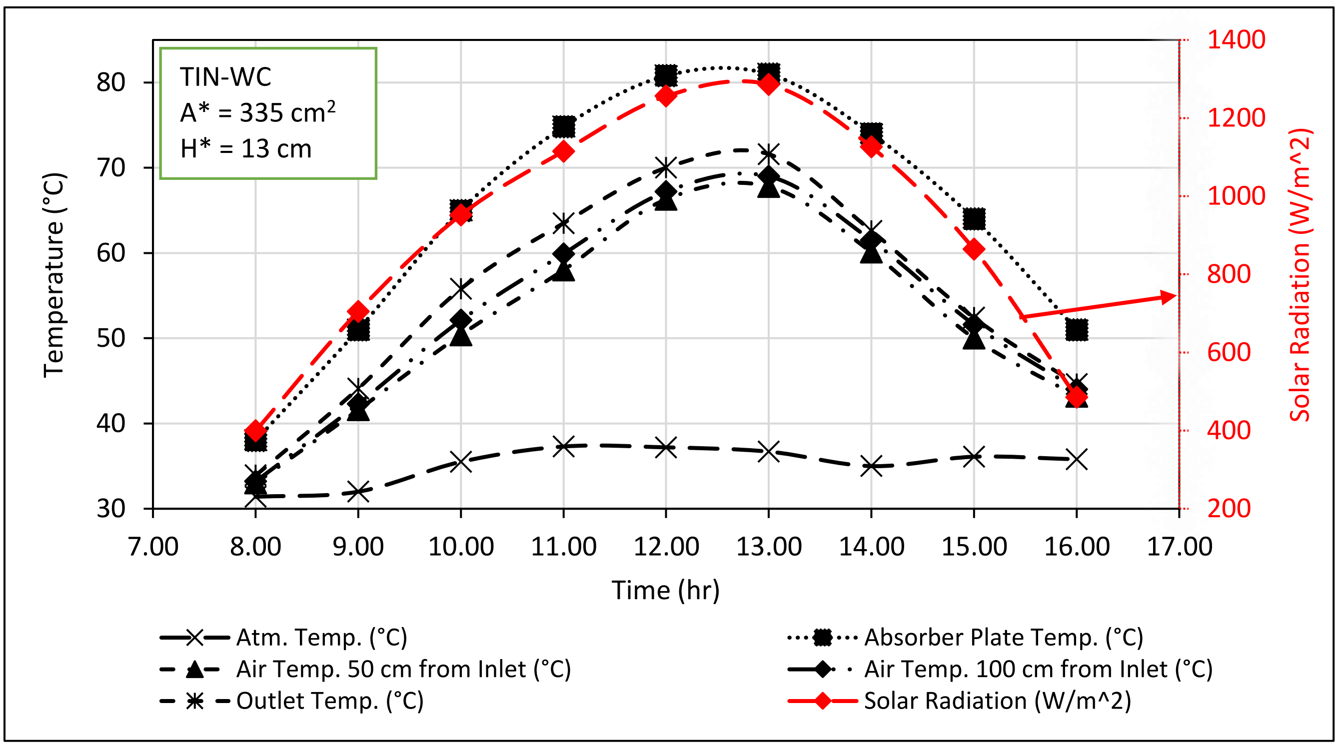


Fig (4.6): Graph for Experiment conducted by reducing outlet area to 335cm^2 using Tins which is double coated with the black paint with distance between Tins and Glass is 13cm.

This was the graph obtained from the experiment conducted on the flat plate solar air heater by using soft drink (250ml) tins which are coated with black paint instead of GI Sheet by reducing the height difference between the tin to glass. The outlet area remains constant as 335cm^2 to get the maximum output. Because of this reduction in height the air molecules above the absorber tins can absorb maximum heat energy and the air which is escaping from the outlet consists of more than the previous one temperatures. The distance between the top surfaces of the tin to bottom surface of the glass is 13cm. Before the height was 18cm.This was the final experiment we conducted on flat plate collector, here we got the maximum outlet temperature.

The Fig (4.6) represents each and every temperature and solar radiation with respect to time from the sixth experiment conducted on tins collector with soft drink aluminum cans (250ml) which are coated with black paint acts as a absorber plate and here we reduced the height between the top surface of the tin and the bottom surface of the glass to 13cm.

The temperature of air at outlet is 72°C at 13.0 and solar radiation is approximately under 1300 W/m^2, the reason behind this outlet temperature is because of natural convective heat transfer from black paint coated aluminum tins to High density air and reduction in height results in most of the chances to flow the fluid over the surface of the tins. Though there is a 7% decrease in solar radiation when compared to the previous experiment (i.e.100 W/m^2) but there is an increase in air outlet temperature because of the reduction in height there is the air molecules above the absorber tins can absorb maximum heat energy.

Because of this most efficient chances to flow the air over the surface results in more outlet temperature.

CHAPTER -5

5.1 CONCLUSION:

The present work attempts to address and resolve the main concern related to the wastage of metal scrap material and utilize it in flat plate collector. The study restricts itself and focuses on analyzing the experimental findings based on a comprehensive analysis of the flat plate collector by using soft drink aluminum tins instead of aluminum or copper plate as an absorber plate. The significant conclusions drawn from the results analyzed are:

1. The temperature of air at outlet is 56°C at 12.00 and solar radiation is approximately under 1650W/m^2 for the experiment conducted on flat plate solar air heater by using a GI Sheet which is coated with black paint acts as an absorber plate.

2. The temperature of air at outlet is 61°C at 12.00 and solar radiation is approximately under 1200W/m^2 for the experiment conducted on flat plate solar air heater by using a GI Sheet which is coated with black paint acts as absorber plate and outlet area reduced to 335cm^2.

3. The temperature of air at outlet is 68°C at 13.00 and solar radiation is approximately under 1400W/m^2 for the experiment conducted on flat plate solar air heater by using soft drink aluminum cans (250ml) which are coated with black paint acts as an absorber plate.

4. The temperature of air at outlet is 72°C at 13.00 and solar radiation is approximately under 1300W/m^2 for the experiment conducted on flat plate solar air heater by using soft drink aluminum cans (250ml) which are coated with black paint acts as a absorber plate and the height between the top surface of the tin and the bottom surface of the glass reduced to 13cm.

The outlet temperature of air is 61°C when GI Sheet is used as an absorber plate and after replacing this with metal scrap such as aluminium cans, outlet temperature of air increased to 72°C. Because of more convective heat transfer due to more surface area.

This clearly represents that the thermal performance of tins collector is more when using the metal scrap material. So, it is better to use metal scrap rather than the GI Sheet in flat plate solar air heater to reduce the cost and increase the thermal performance.

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