EXPERIMENTAL ANALYSIS OF FLAT PLATE SOLAR AIR HEATER

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IN

MECHANICAL ENGINEERING

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CERTIFICATE

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ABSTRACT

One of the most renewable energy sources is solar energy. In today's world, solar energy is regarded as one of the main important sources. It is more popular than other conventional fuels due to lower pollution and global warming, and its non-conventional nature. 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.

The work provides a brief overview of the thermal performance of flat plate solar air heaters. The main goal of this experiment is to produce the warm air with constant heat input by varying the height of the absorber plate, outlet area, inlet area of the flat plate and absorber material. This device absorbs the incoming solar radiation, converting it into heat at the absorbing surface, and transfers this heat to a air flowing through the collector. From this experiment it is noticed that the maximum air temperature can be obtained at the collector outlet is 64°C. The warm air carries the heat, and it is utilized for drying applications, this is one of the low-cost warm air generation methods in the present scenario.

CHAPTER 1

1.INTRODUCTION

1.1 Overview of Solar Energy

Solar power is the energy from the sun and without its presence, all the life on the earth would end. Solar energy has been looked upon as a serious source of energy for many years because of the vast amounts of energy that are made freely available. Harnessed by modern technology as shown in fig. Simple example of the power of the sun can be seen by using a magnifying glass to focus the sun's rays on a piece of paper. Before long the paper ignites to fames.

Figure: 1.1 Solar energy

The simplest and the most efficient way to utilize solar energy is to convert it into thermal energy for heating application. The most important and basic components of the system required for conversion of solar energy into thermal energy are called solar collectors.

Advantages

- Solar energy does not cause pollution.
- Solar energy can be used in remote areas where it is too expensive to extend the electricity power grid.
- Many everyday items such as calculators and other low power consuming devices can be powered by solar energy effectively.

Nature has given us energy in many forms and this energy plays a key role in the industrial and economic growth of a country. The continuous growth of population and rising industrialization need large amounts of energy to quench their thirst for energy. Environmental degradation with use of fossil fuels is very dangerous to the life on earth. In view of world's depleting non-renewable reserves and environmental threats, development of technologies which make use of renewable energy sources is important. Among many renewable energy sources, solar energy is a huge energy source for meeting the demand and is everlasting. The freely available solar radiation provides an infinite and non-polluting reservoir of fuel. The Earth receives 174 petawatts (PW) of incoming solar radiation at the upper atmosphere. Approximately 30% is reflected to space while the rest is absorbed by clouds, oceans, and land masses. The easiest way to utilize solar energy for heating applications is to convert it into thermal energy by using solar collectors.

Flat-plate solar air collectors are extensively used as low temperature energy technology which have attracted the attention of many scholars and scientists. Several designs of solar air heaters have been developed over the years in order to improve their performance. Generally, there are two types of flat-plate solar heating collectors (a). water heating collectors and (b) air heating collectors. The pace of development of air heating collectors is slow compared to water heating collectors mainly due to lower thermal efficiency. Conventional solar air collectors have poor thermal efficiency due to high heat losses and low convective heat transfer coefficient between the absorber plate and flowing air stream. Attempts have been made to improve the thermal performance of conventional solar air collectors by employing various design and flow arrangements.

Flat plate air collector is the key component of an active solar-heating system. It gathers the sun's energy and transforms its radiation into heat, then transfers that heat to the air. The heated air from the collector can be used for the application of space heating and crop drying and in chemical industries under forced mode of operation with air as a working fluid. There are generally 2 types of solar collectors. (1) Flat plate collector – The absorbing surface is approximately as large as the overall collector area that intercepts the sun's radiations. (2) Concentration collectors.

Solar air heaters (SAH) are one of the promising solar thermal technologies as they are simpler in design, easy to install and cheaper to operate. Unlike solar photo-voltaic, the SAHs produce heated air directly from solar radiation with no complex energy conversion. The main drawback of conventional flat plate SAHs is its poor thermal efficiency. It is mainly because of the low convective heat transfer coefficient between the absorber plate and the passing air medium, which leads to higher plate temperature and thereby causes thermal losses. Solar air heater (SAH) is a device which can harness solar thermal energy and transform it into usable form as hot air. SAH is an attractive option for low-temperature applications like drying. Residential space heating, requiring low temperature, provides enormous scope for solar air heater application. The lower seasonal requirement of SAH for space heating in some countries or regions can be compensated by using SAH in other hot air applications. SAH can provide flexibility in using solar heating, hot air can be used for several other residential applications like drying of clothes, fruits, vegetables and other agricultural or marine products, particularly in the low-temperature range. Thus, appropriate designs of solar air heaters can be effective means of using solar thermal energy for need-based applications and hence can significantly contribute to saving of fossil fuels as well as reduction in greenhouse gas emissions.

Residential space heating using solar energy can be achieved in many ways. Using solar passive architectures or building integrated systems are the most common methods. However, such methods are usually more appropriate for new constructions or otherwise extensive design data for the existing building as well as subsequent modifications are essentially required. Space heating energy is an important factor in residential energy consumption. The share of residential space heating energy varies from country to country depending on the climatic conditions. However, the share of conventional sources like fossil fuels for getting such energy remains almost stable for a particular region. Flat-plate solar collectors are designed for applications requiring energy delivery at moderate temperatures. They utilize both beam and diffuse solar radiation, and do not require sun tracking.

The solar air heater occupies an important place among solar heating systems because of minimal use of materials. Furthermore, the direct use of air as the working substance reduces the number of required system components. The primary disadvantage of solar air heaters is the need for handling relatively large volumes of air with low thermal capacity as working fluid. The primary applications are space heating and drying. Our design of a solar air heater has an extended heat-transfer area, arrangements for producing free convection and creation of air turbulence behind the heating surface as well as inclusion of strong forced convection. It is well known that the collector configuration influenced the fluid velocity and also the strength of forced convection. A simple procedure for changing the fluid velocity and the strength of forced convection involves adjusting the aspect ratio of a rectangular, flat-plate collector with constant flow rate the strength of forced convection may also be enhanced by placing parallel barriers on the flat-plate collector, thereby dividing the collector into several sub collectors. Flat-plate solar air heaters are no adiabatic radiative heat exchangers; they are essentially used on low temperature levels in air heating and drying systems. The use of air as a heat transfer medium instead of water in solar collectors reduces the risks of corrosion and freezing and helps to reduce weight and costs of collectors. However, the low density and low specific heat of air requires high volume flow rates that may lead to high friction losses. The low thermal conductivity causes increased heat transfer

1.2 Solar Air Heating

As the name suggests, Solar Air Heating is the conversion of solar radiation to thermal heat. The thermal heat is absorbed and calmed by air which is delivered to a living or working space. The transparent property of air means that it does not directly absorb effective amounts of solar radiation, so an intermediate process is required to make this energy transfer possible and deliver the heated air into a living space. The technologies designed to facilitate this process are known as Solar Air Heaters.

Solar Air Heaters operate on some of the most fundamental and simple thermodynamic principles:

Absorption of the solar radiation by a solid body result in the body heating up. In broad terms this solid body is known as the collector. Some bodies are better at absorption than others, such as those with black non-reflective surfaces. Convection of heat from the heated solid body to the air as it passes over the surface. Typically, a fan is used to force the air across the heated body, the fan can be solar powered, or mains powered. Different types of Solar Air Heater Technology achieve this process using the same basic principles but using different solid bodies acting as the collector. The fan that transfers the air across the heated surface is also used as part of a ducting system to direct the heated air into the dwelling space. In addition to heating the air within that space, the heat can further be absorbed by thermal mass such as walls boring, furniture and other contents. Such heat is effectively stored and slowly dissipates beyond sunlight hours.

1.2.1 Solar Air Heater Advantages

- The need to transfer heat from working fluids to another fluid is eliminated as air is being used directly as the working substance. The system is compact and less complicated.
- Corrosion is a great problem in solar water heater. And this problem is not experienced in solar air heaters.
- Leakage of air from the duct does not create any problem.
- Freezing of working fluid virtually does not exist.
- The pressure inside the collector does not become very high.

Thus, air heater can be designed using cheaper as well as lesser amount of material and it is simpler to use than the solar water heaters.

1.2.2 Solar Air Heater Disadvantages

- Air heaters have certain disadvantages also the first and foremost is the poor heat transfer properties of air. Special care is required to improve the heat transfer.
- Another disadvantage is the need for handling large volume of air due to its low density.
- Air cannot be used as a storage fluid because of its low thermal capacity.
- In the absence of proper design, the cost of solar air heaters can be very high.

1.3 APPLICATIONS

The benefits of Solar Thermal Air are often more than just heating

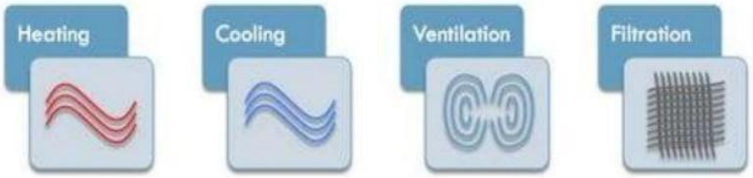

Fig.1.2 Applications

1.3.1 Heating

The primary function of a solar air heating system is to provide home heating. The heat generated is extremely energy efficient and as a result there are several significant benefits:

- Higher level of comfort
- Lower power bills
- Lower carbon emission

Space heating accounts for 38% of residential energy usage in Australia, with some states such as Victoria as high as 55% Although results vary, Case studies have shown some homes to reduce the heating component of their annual energy bill by around 50%, resulting in a total household reduction of around 20% per year. The amount of saving achieved depends on several factors:

- The size and type of Solar Air Heating System installed.
- The size and type of existing conventional heater.
- The habits of the occupants (e.g., thermostat setting).
- The thermal properties of the dwelling. (e.g., draft sealing cine)
- The local climate.

1.3.2Cooling

Many solar air heating systems can also be used to help cool homes by: Transferring cool outside air into the home, especially after sunrise during summer Expelling hot at out of the roof cavity to reduce the transfer of heat through ceiling to inside air. The cooling effect is often likened to an evening breeze bringing in cool air. The same fan that is used to transfer warm air so the home for heating can be used to transfer air v one of the methods above. The same ducting and thermostat control used to col the heating system can also be cured, often with no or very little additional hardware.

1.3.3Ventilation & Moisture Control

Modem Australian homes are designed and had to seal tight to meme the amount of heat loss for heat gain in summer) for the purpose of energy efficiency While this helps with heating and cooling bills, I can also introduce humidity related problems as I restricts the amount of fresh air entering the dwelling Moisture from showers, cooking and even breathing can become trapped and lead to condensation on internal surfaces and mount.

1.3.4 Filtration

Many Solar Thermal Air systems incorporate a high-grade air fire to ensure that not only is the incoming air fresh, but well filtered from dust, pollen and larger particles from wood fires and transport emissions. Most of the air enters the house in this controlled manner

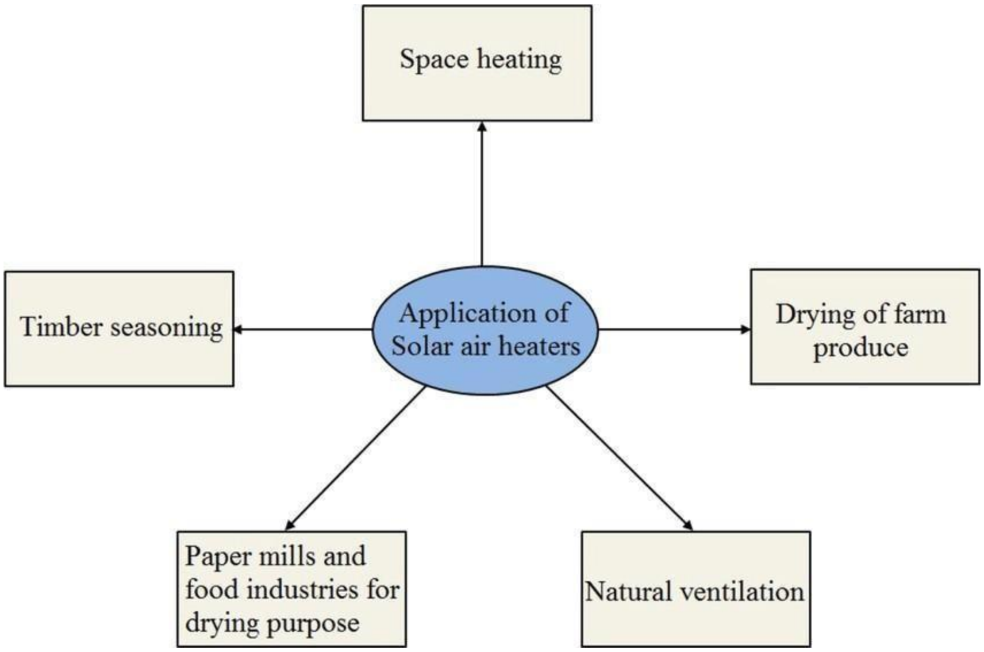

Fig: 1.3 Application solar air heater

1.4 Limitations

- Solal air heaters can only be utilized efficiently on sunny days.
- It also depends upon the geographic location.
- Need to have large volumes of air for efficient use of solar air heaters.
- Thermal losses like convection and radiation take place.

1.5 MOTIVATION

The motivation for doing this project was primarily an interest in undertaking a challenging project in an interesting area of research i.e., how to use solar energy more efficiently. The fact is that the sun is the source of life and energy to all living creatures on the earth for millions of years. Energy is a vital need in all aspects and due to the increasing demand for energy coupled with its inefficient consumption, the environment has been polluted either directly or indirectly. To prevent this from becoming a global disaster, it is inevitable to strengthen efforts of energy generation and utilization using sustainable means and progressively substituting fossil fuels for renewable sources of energy. Solar energy has experienced a remarkable development in recent years because of cost reduction due to technological development and this is what has led us to make flat plate air collectors. Although we are doing this project with just waste cardboard, coke tins, PVC pipes. By using this waste, we are producing some amount of heat and power. These types of systems can be used for:

- Active solar space heating
- Crop drying
- In HVAC industry
- Dryers

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Solar air heating is a solar thermal technology in which the energy from the sun, insolation, is captured by an absorbing medium and used to heat air.

Solar air heating is a renewable energy heating technology used to heat or condition air for buildings or process heat applications. It is typically the most cost-effective out of all the solar technologies, especially in commercial and industrial applications, and it addresses the largest usage of building energy in heating climates, which is space heating and industrial process heating.

2.2 Literatures

Kalaiarasi G et al. studied on analysis and comparison of flat plate solar air heaters with and without integrated sensible heat storage. 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 had been contained in those copper tubes, which acted as a sensible heat storage medium. To understand the characteristics of the novel SAH, a comparison study was made with a conventional SAH of similar dimensions experimented without any thermal storage. Both the SAH’s were tested for three different mass flow rates 0.017 kg/s, 0.02 kg/s and 0.028 kg/s at one of the hottest cities in India, Madurai. The results show that the novel SAH had operated at a maximum efficiency of 67.7%, when the mass flow rate was 0.028 kg/s, before the solar radiation started to decrease around 14:00 hour Indian standard time. And finally concluded this study, conducted the experiments on two types of SAHs and evaluated their performance. The tests were conducted for different mass flow rates, ranging from 0.017 kg/s to 0.028 kg/s of the hottest cities in India, Madurai. The results show that the novel SAH had operated at a maximum efficiency of 67.7% when the mass flow rate was 0.028 kg/s, before the solar radiation started to decrease around 14:00 hour Indian standard time. And finally concluded this study, conducted the experiments on two types of SAH’s and evaluated their performance. The tests were conducted for different mass flow rates, ranging from 0.017 kg/s to 0.028 kg/s. Of the hottest cities in India, Madurai. The results show that the novel SAH had operated at a maximum efficiency of

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Pradyumna Kumar Choudhury et al. studied on solar air heaters for residential space heating. He studies the potential of using solar air heaters in space heating applications. Associated critical issues like demand–supply mismatch, installation space constraint, annual utilization factor and undesirable variations in output temperature are highlighted. Further, current research trends toward improving applicability of solar air heaters are also briefly discussed. He concludes that AH works in a similar principle like the solar water heating system. Sluggish growth rate of SAH, in spite of ever-increasing energy demand for hot air application due to population growth and improved lifestyle, implies existence of critical issues which need more attention for resolving. Modular designs of SAH in standard variants in terms of efficiency or maximum output energy are necessary for catering the needs of users from different economic levels or regions. While designing SAH modules, region-specific traditional building designs should be considered in view of facilitating convenient installation and maintaining existing building aesthetics. Other secondary devices like heat store and control mechanism should also have modules with compatible designs with respect to building type, control system, heat store, auxiliary air heating devices and other secondary devices for hot air applications like drying can be expected to result in widespread use of SAH across the world.

HO-MING YEH et al. studied the efficiency improvement of flat-plate solar air heaters. He studied the effect of parallel barriers on the collector efficiency of flat-plate solar air heaters has been investigated theoretically and experimentally. The barriers were placed with uniform spacing and in parallel, thereby dividing the air channel (collector) into parallel subchannels 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 centerline of the collector. The collector efficiency increases theoretically as the number of barriers increases. He concluded that the theoretical prediction agrees reasonably well with the experimental results. We also found that the improvements in collector efficiency are achieved by placing a parallel barrier on the collector. With a constant collector length L and collector width B the collector efficiency increases when the barrier is placed at the center line of the collector. Therefore, the result of our study confirms previous work MS in which we indicated that with constant collector area, the collector efficiency increases when the collector aspect ratio (L/B) increases. We therefore believe that the more parallel barriers we place inside the collector with the same distance between any two of them, the higher the collector efficiency that will be obtained because increasing either the aspect ratio or barrier number decreases the cross-sectional area of the air duct and thus increases the velocity of air flow as well as the convective heat-transfer rate from the surface of the absorbing plate to the flowing air.

K. ALTFELD et al. studied the concept of net exergy flow and the modeling of solar air heaters. He tells ln solar air heating systems, the compression energy needed to overcome friction losses can reduce essentially the benefit from solar heat. Thus, the design of solar air heaters with high heat transfer rates and low friction losses is of particular interest. The net exergy flow as defined here is a suitable quantity for balancing useful energy and friction losses. By maximizing the net exergy flow the sum of exergy losses, including exergy losses by absorption of radiation at the absorber temperature level, is minimized and reasonably optimized designs of absorbers and flow ducts are found. Different types of solar air heaters have been modeled regarding thermal performance characteristics and to pressure drop for the calculation of net exergy flow. He concluded the net exergy flow is a suitable quantity for the second law optimization of flat-plate solar air heaters. The results of such optimizations are relevant not only from the thermodynamic but also from the technical point of view, because high thermal efficiencies in connection with low pressure drops (friction power) can be obtained.

Mohammad Ansari et al. studied on optimization of flat plate solar air heaters with ribbed surfaces. It shows 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. 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. However, 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 degrade the performance of the air heater. He concluded that thermal efficiency could be improved with an increase in the heat transfer inside the air heater channel. Using the genetic algorithm, an optimized set of parameters was specified for the design of a solar air heater. It was found that the ribs can improve the thermal efficiency and alter the thermal behavior of the heater. At lower air flow rates, when a higher temperature difference is desired, the ribs could improve the overall efficiency of the heater by more than 9%. The optimum value of e/dh increases as the air flow rate decreases. It simply implies that at higher temperature differences, taller ribs perform better. The optimum value of L/H increases by the increase of the temperature difference. The optimum value of W/H decreases with the increase of the temperature difference. The optimum values for the channel height and Re number do not alter widely with changes of other variables. The ribs height and spacing are however somehow interchangeable.

R.C. Wang et al. studied heat-transfer enhancement in double-pass flat-plate solar air heaters with recycle. It theoretically and experimentally investigates 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 of single-pass solar air heater. Considerable improvement in heat transfer is obtainable by employing recycled 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. He concluded that double-pass flat-plate solar air heaters were designed for increasing the inlet temperature using the premixing and recycle effects, leading to improved thermal performance. Recycle effect applications to flat-plate solar air heaters will enhance the convective heat transfer rate and reduce the driving force. This study showed that the desirable effect suppresses the undesirable effect in double-pass devices with recycle. The theoretical studies were accomplished for both flow patterns, one is the collector inlet flow passes above the absorbing plate and the outlet air passes below the absorbing plate, and the other is the inlet and outlet air flow in reverse order. It is concluded that suitable collector efficiency enhancement can be produced by increasing or decreasing the channel thickness ratio, D, and adding recycle at both ends. The solar collector efficiency enhancement is mainly due to an increase in the higher air velocity, as well as the heat-transfer coefficient, by recycle operation or by decreasing the equivalent diameter of the channel.

C.W. Yeh et al. studied on Improvement in device performance of multi-pass flat-plate solar air heaters with external recycling. It shows an absorbing plate and insulation sheet were inserted horizontally and vertically, respectively, into a parallel-plate channel to divide the open duct into four sub channels. The coupled nonlinear ordinary differential equations were derived and solved numerically. The theoretical results show that the new device of four-pass flat-plate solar air heater with external recycle can enhance the heat transfer rate compared with that in an open conduct-(Without the vertical insulation sheet inserted and the absorbing plate glued-on the bottom insulation plate, the so-called a downward-type single-pass solar air heater) under the same flow rate and working dimensions. The effects of inserting the absorbing plate and insulation sheet on the transfer efficiency enhancement as well as on the hydraulic dissipated power increment. He concluded that the desirable effect suppresses the undesirable effect in multiphase devices with external recycling, leading to improved thermal performance. The methods for improving the performance in solar collector devices are either in the double pass operation by inserting a horizontal absorbing plate or in multi-pass operation by inserting a horizontal absorbing plate and a vertical insulation sheet with negligible thermal resistance. The introduction of the recycle effect is a feasible way to increase the collector coefficient due to the increasing fluid velocity effect and may compensate for the decrease in temperature difference.

Santosh Vyas et al. studied thermal performance testing of a flat plate solar air heater using optical measurement technique. It shows thermal performance testing of flat plate solar air heaters with simulated solar radiation intensity; 600W/m2. A test cell of size 1m x 0.5m x 0.1m was fabricated. Three designs namely (i) plane absorber (ii) transverse V- porous ribs and (iii) inclined V-porous ribs of absorber are tested. All the experiments are conducted with artificial solar radiation and in natural convection. Performances of these three designs have been compared on the basis of overall thermal efficiency and thermal gradient along normal to the base. Thermal gradient has been determined by laser beam deviation method. PT-100 temperature sensors have also been used to validate the optical results of thermal gradients. The overall thermal efficiencies of these designs have been found as 14.91%, 17.24% and 20.04% respectively. It has also been seen that thermal gradient tends to reduce with increase in efficiency. The experiments are conducted with artificial and calibrated solar radiation and in natural convection condition. Performances of these three designs have been compared on the basis of overall thermal efficiency and thermal gradient along normal to the base at particular sections of the solar air heater. Thermal gradient normal to the absorber surface in the thermal flow field plays an important role in thermal performance of solar air heaters. Uniform distribution of temperature along the normal to the absorber surface increases air outlet temperature which results in increasing overall thermal efficiency.

Foued Chabane et al. studied on heat transfer and energy analysis of a solar air collector with a smooth plate. In energy and heat transfer analysis of a solar air collector with a smooth plate, this technique is used to determine the optimal thermal performance of a flat plate solar air heater by considering the different system and operating parameters to obtain maximum thermal performance. Thermal performance is obtained for different mass flow rates varying in the array 0.0108 – 0.0202 kg/s with five values, solar intensity: tilt angle and ambient temperature. We discuss the thermal behavior of this type of collector with new design and with my proper construction. An experimental study was carried out on a prototype installed on the experimental tests platform within the University of Biskra in Algeria. The effects of air mass flow rate, emissivity of channel plates and wind heat transfer coefficient on the accuracy of the criterion are also investigated. He concluded the solar collector type of the SAH has been introduced for increasing the thermal efficiency, leading to improved heat transfer. The optimal value of efficiency corresponding to mass flow rate equal 0.0202 kg/s is 58.30% at 13:15 h for all operating conditions. The current research works and an attempt has been made to optimize the thermal performance of flat plate solar collectors by using difference mass flow rate.

M.T. Baissi et al. studied thermal behavior in a solar air heater channel roughened with delta shaped vort. It shows friction factor and thermal enhancement factor of flow in a rectangular channel artificially roughened with two longitudinally curved delta-shaped baffles configurations. Two cases have been dealt with perforated and non-perforated baffles. This study encompassed for the range of Reynolds number (Re) from 2500 to 12000, relative longitudinal length of the obstacles on the absorber plate Pl/e from 3 to 5, relative transversal length of the obstacles on the absorber plate Pt/b from 0.6 to 1, relative roughness height (e/H=0.8) and single-attack angle (α=45°). The obtained results averred a significant augmentation in heat transfer and reduction in pressure drop. Whereas heat transfer (Nu) and in airflow friction (f) have reached 6.94 and 45.83 times more than smooth channel. However, the non-perforated LCD has reached a maximum of about 2.21. He concluded that perforated longitudinally curved delta shaped baffles a resistance to the flow was developed especially when Pl/e and Pt/b ratios became large. The correlations of Nusselt number and friction factor were developed as a function of roughness parameters and Reynolds number. The developed correlations predict the values of Nu and f with maximum deviation of ±12% and ±7% respectively.

Saket Kumar et al. studied on thermal and effective analysis of double flow packed bed solar air heaters. It shows the thermal and effective performances of a double flow packed bed solar air heater having wire mesh as porous packing in its upper duct. The experiment is encompassed with the variables like packing bed height, mass flow rate of air and the solar radiation intensity. Experimental data has been collected for a specified range of system and operating parameters to calculate the temperature rise parameter, thermal efficiency, effective efficiency, entropy generation and exergetic efficiency and to study the effects of system and operating parameters. Also, comparisons of packed bed solar air heaters with that of smooth solar air heaters of the conventional type have been presented. The results of experimental analysis on the performance of double flow packed bed solar air heaters with wire mesh packing in the upper duct can be useful in designing such solar air heaters. He concluded that the thermal efficiency and temperature rise parameter of a double flow collector having its upper duct packed with wire mesh absorber can be obtained up to 1.51 and 2.03 times respectively corresponding to a given height of packing and mass flow rate of air in the duct. Thermal efficiency, effective efficiency and second law efficiency (exergetic efficiency) strongly depends on the wire mesh packed bed height of a double flow packed bed SAH. The maximum value of thermal efficiency, effective efficiency, and exegetic efficiency are found as 60.11%, 54.8% and 2.75% at the bed height of 25 mm respectively. The increase in mass flow rate of air through the collector duct not only increases the thermal efficiency but also increases the pressure drop and thus reduces the effective efficiency. The entropy generation rate of the double flow packed bed SAH decreases with the increase in bed height for a given mass flow rate of air. It has the lowest value for a bed height of 25 mm corresponding to mass flow rate of 0.016 kg/s but it increases drastically beyond the mass flow rate of 0.025 kg/s. The double flow air heating collector with wire mesh packing in the upper duct has higher thermal efficiency than the double flow finned absorber and also than the single flow wire screen packed bed solar air heater as well as single flow smooth absorber plate solar air heater.

TONG-TSHIEN LIN et al. studied the effect of collector aspect ratio on the collector efficiency of flat-plate solar air heaters. It shows that The effect of collector aspect ratio of the collector efficiency of flat-plate solar air heaters has been investigated theoretically and experimentally. With constant collector area, the collector efficiency increases when the collector aspect ratio increases. He concluded that the theoretical values are generally lower than the experimental data, except for the highest aspect ratio (6:1). Perhaps the theoretical predictions are greater than the experimental results for higher aspect ratios because of the assumption we made that the loss coefficient Ub from the surfaces of edges and the bottom of the solar collector to the ambient is negligible. This assumption is obviously unreasonable when the collector aspect ratio is large since the surface area of the edges from which part of the energy is lost becomes large and this energy loss becomes significant although the surfaces are somewhat insulated. The collector efficiency increases when the collector aspect ratio increases. This result is obtained because increasing the aspect ratio decreases the cross- sectional area of the air duct and thus increases the velocity of air flow and also the convective heat-transfer rate from the surface of the absorbing plate to the flowing air. However, increasing the aspect ratio also increases the fan power and thereby leads to increased operating cost. Consequently, a proper increase of the collector aspect ratio should be economically feasible in the design of a solar air heater.

B. N. PRASAD et al studied artificial roughness on heat transfer and friction factor in a solar air heater. An investigation of fully developed turbulent flow in a solar air heater duct with small diameter protrusion wires on the absorber plate has been carried out and expressions for prediction of average stanton number and average friction factor have been developed. The results of these expressions have been compared with available data. The results have been found to compare with a mean deviation of 6.3% for friction factor and - 10.7% for the nusselt number. The effect of height and pitch of the roughness elements on the heat transfer rate and friction has also been investigated. Law of the wall similarity can be assumed for correlating heat transfer and friction data in an artificially roughened solar air heater duct. Geometrically similar rough nesses (for a given p/e, e/D) produce the same effect on heat transfer and friction. Increase in the relative roughness height results in a decrease of the rate of heat transfer enhancement although the rate of increase of friction factor increases. Increase in the relative roughness pitch results is a decrease in the rate of both heat transfer and friction factor. Small diameter protrusion wires can be utilized on the collector plates in the solar air heaters to double the heat transfer coefficient. However, this is found to cause a higher increase in friction factor, which effectively quadruples with use of the wires.

Irfan Kurtbas et al studied the efficiency and exergy analysis of a new solar air heater. In this study, five solar collectors with dimensions of 0:9*0:4 m were used and the flow line increased where it had narrowed and expanded geometrically in shape. These collectors were set to four different cases with dimensions of 1 *2 m. Therefore, heating fluids exit the solar collector after at least 4.5 m displacement. According to the collector geometry, turbulence occurs in fluid flow and in this way heat transfer is increased. The results of the

experiments were evaluated on the days with the same radiation. The efficiencies of these four collectors were compared to conventional flat-plate collectors. It was seen that heat transfer and pressure loss increased depending on shape and numbers of the absorbers. The conclusions can be drawn from the experimental study of the new collectors designed , and show the efficiency of the collector with increasing mass flow rates due to an enhanced heat transfer to the air flow. The efficiency of air collectors increases depending on the surface geometry of the collector and extension of the air flow line. When the surface roughness is increased, the heat transfer and pressure loss increase. The optimum slice number of the absorber can be determined for heat transfer and pressure loss changes the number of absorber slices in the collector. The exergy loss of the system decreases depending on the increase of the collector efficiency. There is a reverse relationship between dimensionless exergy loss and heat transfer, as well as pressure loss. The more important parameters to decrease the exergy loss are the collector efficiency, temperature difference (To-Ti) of the air and pressure loss.

2.3 Literature Summary

Increasing the aspect ratio decreases the cross-sectional area of the air duct and thus increases the velocity of air flow and also the convective heat-transfer rate from the surface of the absorbing plate to the flowing air. The increase in mass flow rate of air through the collector duct not only increases the thermal efficiency but also increases the pressure drop and thus reduces the effective efficiency.

The desirable effect suppresses the undesirable effect in multi pass devices with external recycling, leading to improved thermal performance.

The desirable effect suppresses the undesirable effect in double-pass devices with recycle.

2.4 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, everyday 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 wastes were generated as per recent studies. That can be used to increase the thermal performance of an air solar collector with an absorber plate made of recyclable aluminum cans.

Nowadays, worldwide most 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. To minimize the metal waste and use it in an efficient manner, it can be used for sustainable materials. This is one of the best methods to utilize the waste metal scrap for domestic and agricultural purposes.

2.5 Objective:

To ensure choice sources of energy that are clean, reliable, steady and sustainable, solar power is a rising major need nowadays among the technology or many domestic causes. Solar water heaters are used all over the world. Particularly in sunny countries where solar shine is abundant. We heat the fluid (air) with the help of solar radiation for further specific applications etc.

In order to achieving that the following objectives are defined:

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

3.To conduct an experiment on a flat plate solar air heater by varying the outlet area.

4.To conduct an experiment on a flat plate solar air heater by varying the height of the absorber plate.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

The absorber plate is made up of empty aluminium tins that have been black coated in order to absorb as much heat energy or radiation as possible from the source. The following formulas show the efficiency of the absorber plate, mass of air required for the moisture removal process, energy required for drying, and moisture content.

3.2 THEORETICAL FORMULAE

Nusselt Number :

$N_u = hL/k$

h = heat transfer coefficient

L = Length of the flat plate air heater

k = thermal conductivity

Reynolds Number :

$R_e = VL/\nu$

V = Velocity of air

L = Length of flat plate air heater

ν = Viscosity of air

Heat transfer coefficient :

$h = (Q_c)/(A(T_{pm} - T_{fm}))$

Q_c = heat transfer rate

T_{pm} = absorber plate average temperature

T_{fm} = air mean temperature

A = area of transparent plate

Flat plate collector efficiency:

$\eta = mC_p(t_c - t_i)/AG$

A = collector area (m^2)

C_p = specific heat capacity of air at constant pressure (J/kg^0C)

G = solar radiation incident on the collector (Wm^2)

m = air flow rate (kg/sec)

t_i = temperature of the inlet air(^0C)

t_c = temperature of the outlet air (^0C)

3.3 Components

3.3.1 Halogen Lamp

A halogen lamp is also called tungsten halogen, quartz-halogen, and quartz iodine lamp. It is an incandescent lamp consisting of a tungsten filament sealed in a compact transparent envelope that is filled with a mixture of an inert gas and a small amount of a halogen, such as iodine or bromine. The combination of the halogen gas and the tungsten filament produces a halogen-cycle chemical reaction, which redeposits evaporated tungsten on the filament, increasing its life and maintaining the clarity of the envelope. This allows the filament to operate at a higher temperature than a standard incandescent lamp of similar power and operating life; this also produces light with higher luminous efficacy and color temperature. The small size of halogen lamps permits their use in compact optical systems for projectors and illumination.,

Fig: 3.1 halogen lamp

3.3.2 Scaffolding clamps

Scaffolding clamps are used to secure pipe joints on a scaffold. A scaffolding clamp is a device used at a joint between pipes on a scaffolding structure to secure those pipes in place. The size, shape, and function of the scaffolding clamp will vary. Most clamps are made from high-quality, hardened steel, though sometimes an aluminum clamp may be used. Steel clamps are much stronger, however, and are less likely to crack or otherwise fail.

Fig: 3.2 clamps

3.3.3 PVC pipes

PVC pipes are commonly used for manufacturing sewage pipes, water mains and irrigation. Possessing very long-lasting properties, PVC pipes are easy to install, lightweight, strong, durable and easily recyclable, making them cost-efficient and sustainable. In this project we are using

PVC pipes to fix the halogen lamps. We used 3 PVC pipes of each length of 8feet. PVC pipes are generally categorized into four:

- PVC-U (plasticized PVC)
- C-PVC (chlorinated PVC)
- PVC-O (molecularly oriented PVC)

Fig: 3.3 PVC pipes

3.3.4 Stand

Here the stand is helpful for erecting the PVC pipes and the halogen lamp. PVC pipes are inserted inside the stand. This stand is made up of 3 iron pipes of 4feet of length. The stand is made in such a way that one is placed horizontally, and the other is placed vertically. The third rod is placed towards the upward direction.

Fig: 3.4 stand

3.3.5 Flat Plate Collector

Flat-plate collectors consist of a black flat-plate absorber which has high absorptivity, a transparent glass cover that reduces heat losses and allows the transmittance of solar radiations, a heat transport fluid to remove heat from the absorber, the fluid should have high heat transfer coefficient and a heat insulating backing. The absorber consists of a thin absorber sheet often backed by a grid or coil of fluid tubing placed in an insulated casing with a glass or polycarbonate cover which allows the radiation to fall upon the absorber plate. If the incident sunlight is increased using a reflector. Flat plate collectors easily attain temperatures of 40 to 70ºC. With very careful engineering using special surfaces, reflectors to increase th

Fig: 3.5 flat plate collector

3.3.6 Final Assembly of Experiment

3.4 Instrumentation

3.4.1 Solar Power Meter

A solar power meter is a device that can measure solar power or sunlight in units of W/m2, either through windows to verify their efficiency or when installing solar power devices. Solar meters accumulate PV yield production and local energy consumption to monitor and analyze PV plant performance. Solar energy is measured in kilowatt hours - or with large solar energy systems, in megawatt hours (1000 kilowatt hours).

Fig: 3.6 Solar power meter

3.4.2 Digital Thermocouple

A digital thermocouple thermometer needs two measurements to determine temperature. First, it has a sensor to measure the temperature where the thermocouple connects to it, this is known as cold-junction compensation (CJC). Secondly, it measures the mV signal from the thermocouple. In order to determine the temperature at the end away from the thermometer, it subtracts the CJC temperature from the hot end signal and then converts that voltage to temperature.

Fig: 3.7 digital thermometer

3.4.3 Infrared Thermometer

Infrared thermometers are one of the most popular types of thermometers as they help you read temperatures without the risk of transmitting germs. They use infrared rays to read the temperature of a person or an object from a certain distance and display the number in just a few seconds. Some of the advantages of an IR thermometer are its ease of operation, risk- free usage, quick response time, accurate readings, and light weight design. The primary use of infrared thermometers is in measuring the temperature of a subject from a distance. The device is beneficial in situations where it is difficult to reach the object to record the temperature.

Fig: 3.8 infrared thermometer

3.5 Construction of Flat Plate Solar Air Heater

The things that are required to make the flat plate collector are glass plates, wooden sheets, and coke tins. The glass plate should be 7mm thickness and 150cm length. Those coke tins are painted with black color because black is a good absorber of heat. Those coke tins are arranged inside the collector. The length of the flat plate collector is 150cm whereas its breadth is 64cm and its height is 25cm. We took 3 PVC pipes for holding the halogen lamps which will produce the solar radiation. The length of the pipes will be 8feet.Those pipes are arranged in such a way that one is vertical, other is horizontal and other is inclined. Halogen lamps are placed on the vertical pipe with equal distance between them. These pipes are joined with the help of scaffolding clamp. Scaffolding clamps are used for the adjustment for the pipes i.e., used to increase/decrease the height of the pipes. Stand is made to insert the pipes into it such that it will erect. Two halogen lamps are required to produce 1000w/m2 solar radiation. the specification of each halogen lamp is 1000w.The distance between two halogen lamps are 80cm.The distance from the glass plate and the halogen lamp will be 16cm.The flat plate collector will be inclined at 30 whereas the halogen lamps are inclined at 60.

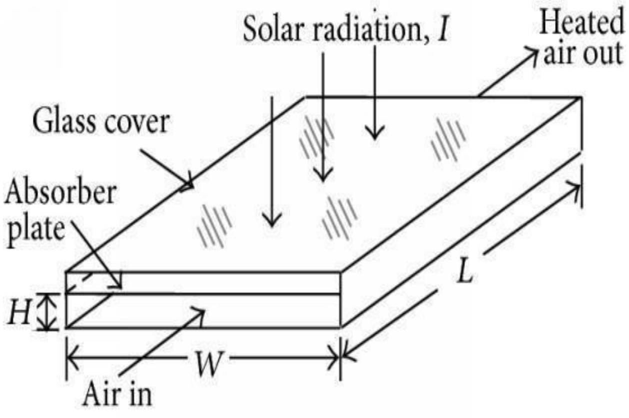


FIG 3.9 SCHEMATIC OF FLAT PLATE

3.6 EXPERIMENTATION

- Arrange the setup as shown in the above assembly figure.
- First of all, switch off all the lights and fans that are in the room.
- Now note down the initial readings of T1, T2, T3, T4 in atmosphere temperature conditions.
- Where T1 is room temperature, T2 is the average cans temperature, T3 is the outlet air temperature 5cm distance from the glass plate, T4 is the outlet air temperature at 10cm distance from the glass plate.
- Arrange the flat plate collector in such a way that inclination of 30.
- Arrange the halogen lamp setup parallel to the flat plate collector.
- Now insert the plugs of halogen lamp into the socket.
- Switch on the lights such that halogen lamp will glows.
- Now check the solar radiation at each and every corner of the flat plate collector produced by the halogen with the help of a solar power meter.
- Make sure that the solar radiation on the flat plate should be 1000W/m2.
- If the halogen lamps are unable to produce the solar radiation 1000 W/m2 arrange the halogen lamps setup in such a way that it will produce the desired solar radiation.
- After this arrangement for every 5 minutes note down the readings of T1, T2, T3, T4.
- This process should be continued until and unless T3 and T4 reaches a steady state.
- Once it attains the steady state switch off the lights of the halogen lamps and switch on the fans and lights available in the room.
- After that wait for 30 minutes until and unless T3 and T4 will come to room temperature reading.
- Once T3 and T4 attain the room temperature readings then continue the experiment with various factors like increasing and decreasing height and increasing and decreasing the outlet area.
- After conducting all the experiments with all the cases then find out the maximum reading of T3 and T4 and note it down.

TABLE 1

EXPERIMENTNUMBER	SOLAR RADIATIO N (w/m^2)	WITH CANS (OR) WITH OUT CANS	INLET AREA	OUTLETAREA	Distance between Absorber plate and glass top(mm)
1	1000	Without cans	64*15	64*5	21
2	1000	With cans	64*15	64*20	21
3	1000	With cans	64*15	64*15	21
4	1000	With cans	64*15	64*10	21
5	1000	With cans	64*15	64*5	21
6	1000	Without cans	64*15	64*15	19
7	1000	With cans	64*15	64*5	19
8	1000	With cans	64*15	64*10	19
9	1000	With cans	64*15	64*15	19
10	1000	Without cans	64*15	64*15	15

11	1000	Without cans	64*15	64*10	15
12	1000	Without cans	64*15	64*5	15
13	1000	With cans	64*15	64*5	15
14	1000	With cans	64*15	64*10	15
15	1000	With cans	64*15	64*15	15

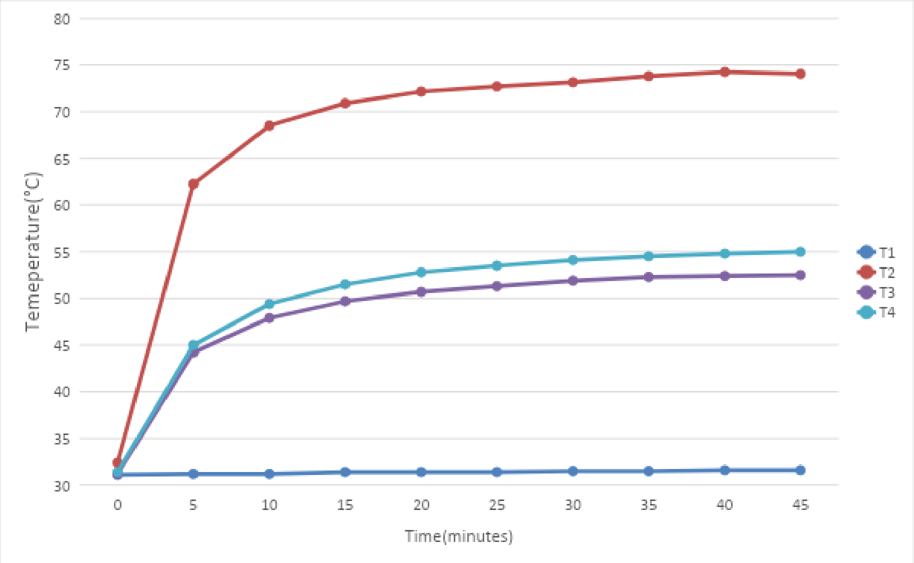
CHAPTER 4

4. Results and discussions

A Flat Plate Solar Heater was experimentally analyzed for its Thermal performance by varying outlet areas and Height of the absorber plate. The test was performed between 26/03/2022 and 01/04/2022 in the Spring months of Visakhapatnam. The SAH was installed at an inclination of 30° horizontally. The Incident radiation of 1000 watt was applied constantly, and temperature readings were observed at different places for every 5 minutes until the steady state of temperature. With maximum temperature reached for experimental setup where the outlet area is least and height of the absorber plate at maximum height.

The first experimental setup had an inlet area of 64cm X 15cm, outlet area of 64cm X 05cm. One setup used black cans as absorber media, others had black sheets as absorber media. They both are operated at 1000-watt radiation. The graphs drawn between temperature(°C) vs time in minutes. Fig 4.1 and Fig 4.2 shows variation of temperatures at different areas for these two setups. From these graphs it is observed with black sheets as absorber media had more outlet temperature compared to black cans as absorber media.

Fig: 4.1



T1 = atmospheric Temperature or Inlet Temperature T2 = Average Temperature

T3 = Outlet Air Temperature at 5 cm distance from glass plate

T4 = Outlet Air Temperature at 10 cm distance from glass Plate

Experimental setup specifications:

- Without Cans
- Inlet Area = 64 cm X 15 cm
- Outlet Area = 64 cm X 05 cm
- Inclination of the setup = 30 °

Height of Absorber Plate = 0 cm

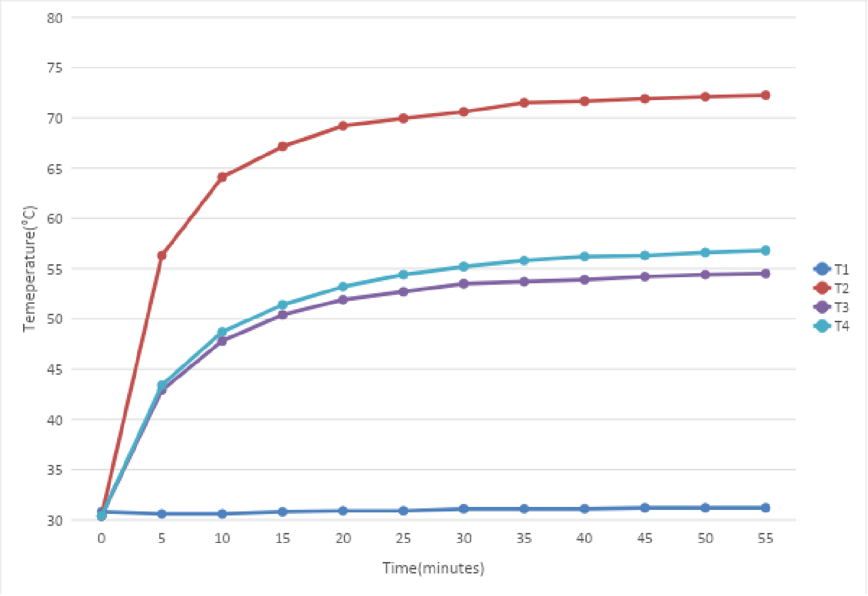


Fig:4.2

T1=Atmospheric Temperature or Inlet Temperature

T2 = Average Cans Temperature

T3 = Outlet Air Temperature at 5 cm distance from glass plate

T4 = Outlet Air Temperature at10 cm distance from glass plate

Experimental setup specifications:

- With Cans
- Inlet Area = 64 cm X 15 cm
- Outlet Area = 64 cm X 05 cm
- Inclination of the setup = 30 °
- Height of Absorber Plate = 0 cm

When we increased the height of the absorber raised by 15 cm for the setup with outlet area 64 cm X 05 cm with black cans as absorber media, we observed more outlet temperature. Graph is drawn between the temperatures and time observed in Fig 4.3.

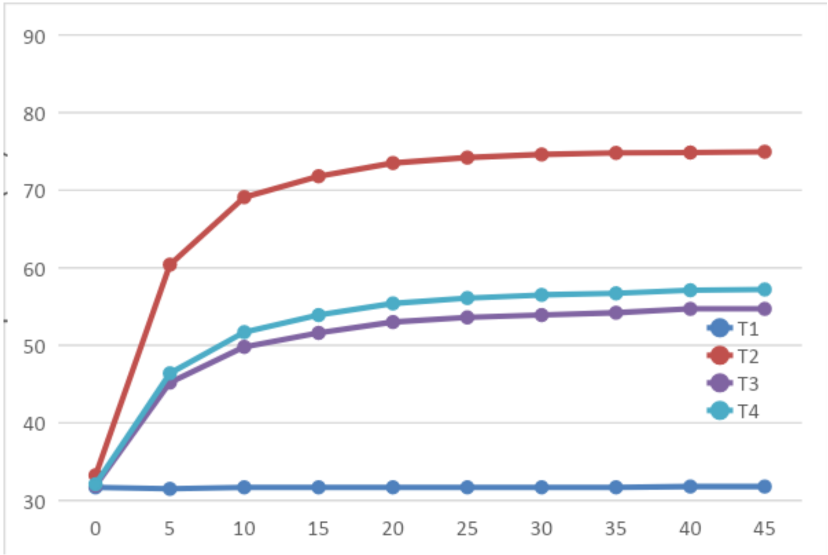


Fig: 4.3

T1 = Atmospheric Temperature or Inlet Temperature

T2 = Average Cans Temperature

T3 = Outlet Air Temperature at 5 cm distance from glass plate

T4 = Outlet Air Temperature at 10 cm distance from glass plate

Experimental setup specifications:

- With Cans
- Inlet Area = 64 cm X 15 cm
- Outlet Area = 64 cm X 05 cm
- Inclination of the setup = 30 °
- Height of Absorber Plate = 15 cm

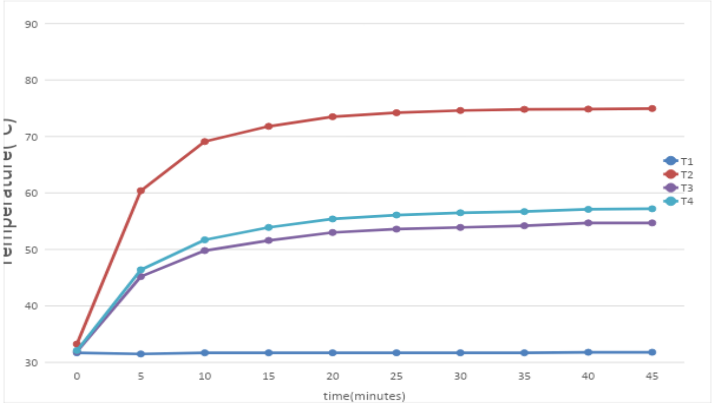


Fig:4.4

We had kept the outlet area constant i.e., 64 cm X 05 cm. we raised the height of the absorber media to 55 cm and values were taken with black cans and black sheet as absorber media and graphs were drawn Fig:04 and Fig:05. It is observed that black cans as absorber media produced more outlet temperature.

Graph-04

T1 = atmospheric Temperature or Inlet Temperature

T2 = Average Temperature

T3 = Outlet Air Temperature at 5 cm distance from glass Plate

T4 = Outlet Air Temperature at10 cm distance from glass Plate

Experimental setup specifications:

- Without Cans
- Inlet Area = 64 cm X 15 cm
- Outlet Area = 64 cm X 05 cm
- Inclination of the setup = 30 °
- Height of Absorber Plate = 55 cm

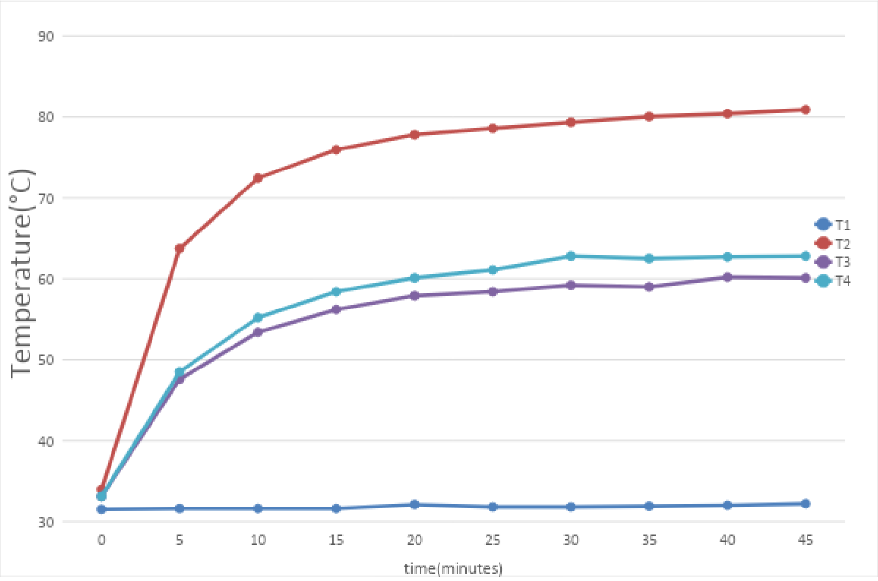


Fig 4.5

T1 = atmospheric Temperature or Inlet Temperature

T2 = Average Cans Temperature

T3 = Outlet Air Temperature at 5 cm distance from glass Plate

T4 = Outlet Air Temperature at10 cm distance from glass Plate

Experimental setup specifications:

- With Cans
- Inlet Area = 64 cm X 15 cm
- Outlet Area = 64 cm X 05 cm
- Inclination of the setup = 30 °
- Height of Absorber Plate = 55 cm

For the next setup we have increased the outlet area to 64 cm X 10 cm and different values of temperature are observed at different places while varying the height of absorber media and replacing the black sheet with black cans. Graphs are drawn

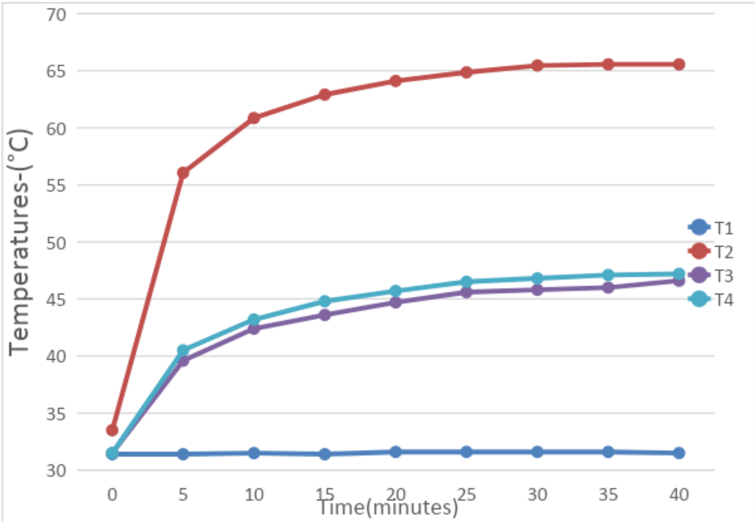


Fig 4.6

T1 = atmospheric Temperature or Inlet Temperature

T2 = Average Cans Temperature

T3 = Outlet Air Temperature at 5 cm distance from glass Plate

T4 = Outlet Air Temperature at10 cm distance from glass Plate

Experimental setup specifications:

- With Cans
- Inlet Area = 64 cm X 15 cm
- Outlet Area = 64 cm X 10 cm
- Inclination of the setup = 30 °
- Height of Absorber Plate = 0 cm

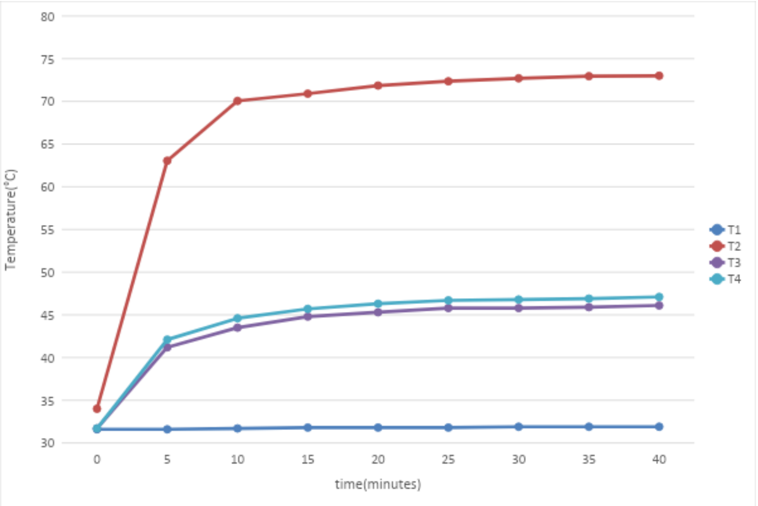


Fig 4.7

T1 = atmospheric Temperature or Inlet Temperature

T2 = Average Cans Temperature

T3 = Outlet Air Temperature at 5 cm distance from glass Plate

T4 = Outlet Air Temperature at10 cm distance from glass Plate

Experimental setup specifications:

- With Cans
- Inlet Area = 64 cm X 15 cm
- Outlet Area = 64 cm X 10 cm
- Inclination of the setup = 30 °
- Height of Absorber Plate = 55 cm

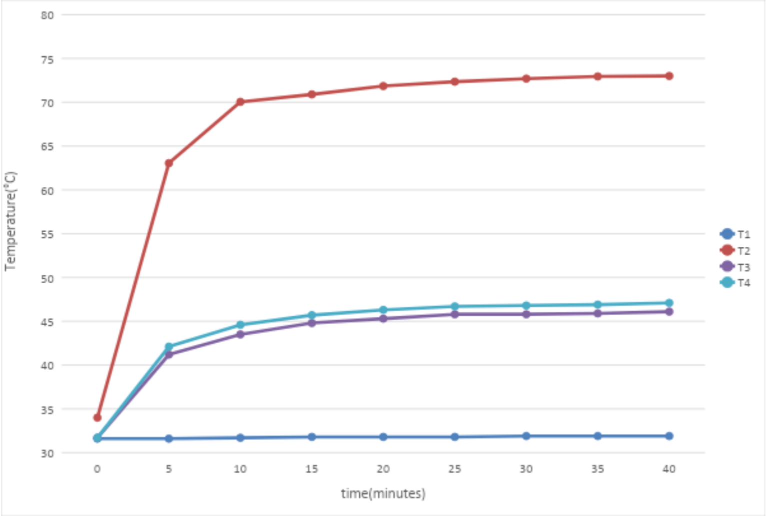


Fig 4.8

T1 = atmospheric Temperature or Inlet Temperature

T2 = Average Temperature

T3 = Outlet Air Temperature at 5 cm distance from glass Plate

T4 = Outlet Air Temperature at10 cm distance from glass Plate

Experimental setup specifications:

- Without Cans
- Inlet Area = 64 cm X 15 cm
- Outlet Area = 64 cm X 10 cm
- Inclination of the setup = 30 °
- Height of Absorber Plate = 55 cm

From above graphs we can observe that outlet temperature is high for outlet area 64 cm X 10 cm where absorber media is black cans where it is raised 55cm.

For the next setup we have increased the outlet area i.e., 64 cm x 15 cm. we have measured temperatures at different places by varying absorber media and increasing their height

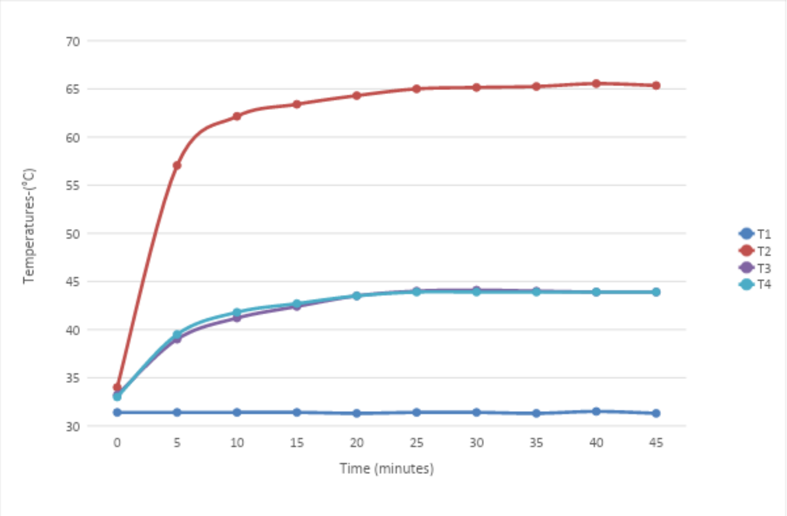


Fig4.9

T1 = atmospheric Temperature or Inlet Temperature

T2 = Average Cans Temperature

T3 = Outlet Air Temperature at 5 cm distance from glass Plate

T4 = Outlet Air Temperature at10 cm distance from glass Plate

Experimental setup specifications:

- With Cans
- Inlet Area = 64 cm X 15 cm
- Outlet Area = 64 cm X 15 cm
- Inclination of the setup = 30 °
- Height of Absorber Plate = 0 cm

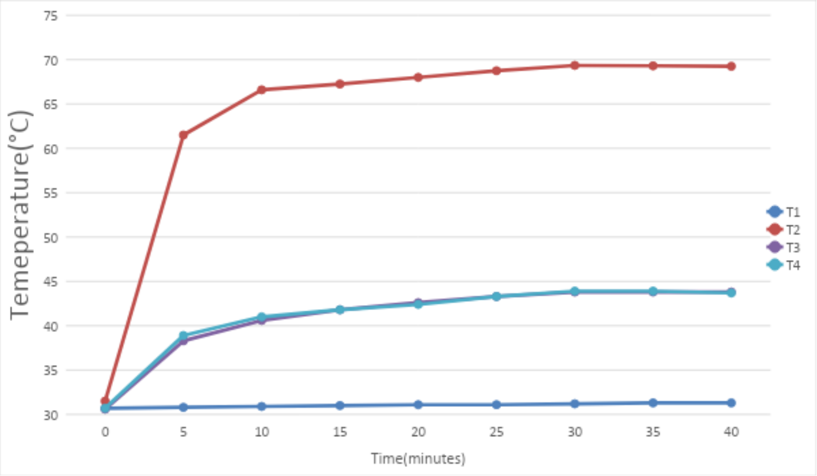


Fig 4.10

T1 = atmospheric Temperature or Inlet Temperature

T2 = Average Temperature

T3 = Outlet Air Temperature at 5 cm distance from glass Plate

T4 = Outlet Air Temperature at10 cm distance from glass Plate

Experimental setup specifications:

- Without Cans
- Inlet Area = 64 cm X 15 cm
- Outlet Area = 64 cm X 15 cm
- Inclination of the setup = 30 °
- Height of Absorber Plate = 15 cm

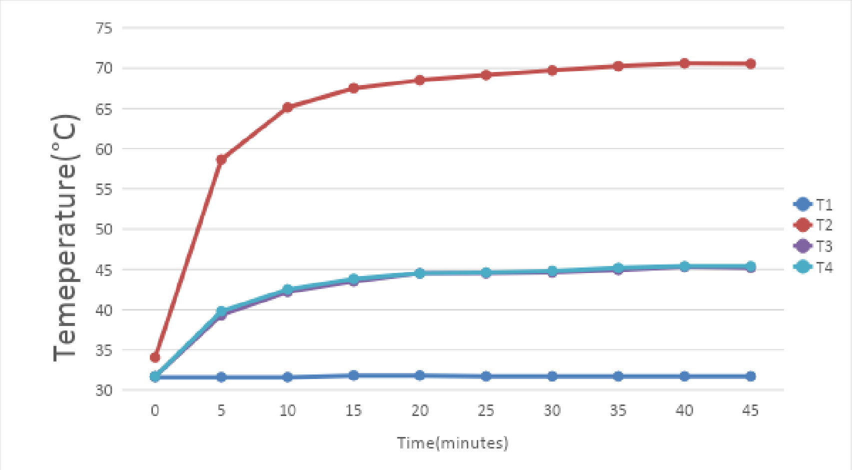


Fig 4.11

T1 = atmospheric Temperature or Inlet Temperature

T2 = Average Cans Temperature

T3 = Outlet Air Temperature at 5 cm distance from glass Plate

T4 = Outlet Air Temperature at10 cm distance from glass Plate

Experimental setup specifications:

- With Cans
- Inlet Area = 64 cm X 15 cm
- Outlet Area = 64 cm X 15 cm
- Inclination of the setup = 30 °
- Height of Absorber Plate = 15 cm

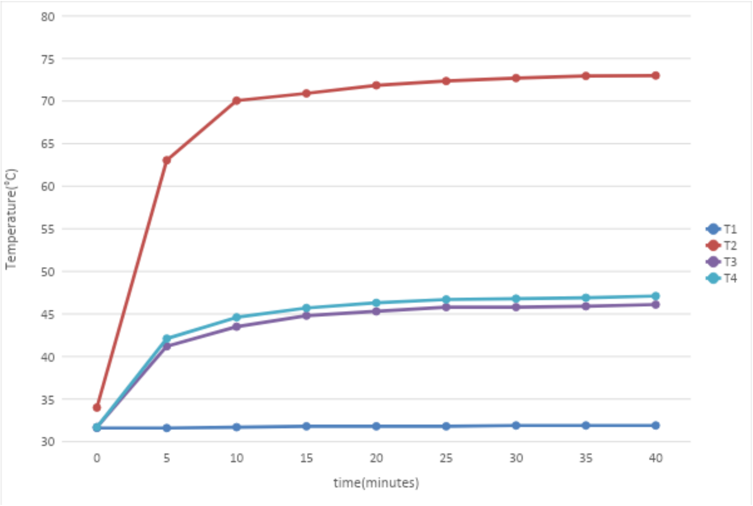


Fig 4.12

T1 = atmospheric Temperature or Inlet Temperature

T2 = Average Temperature

T3 = Outlet Air Temperature at 5 cm distance from glass Plate

T4 = Outlet Air Temperature at10 cm distance from glass Plate

Experimental setup specifications.

- Without Cans
- Inlet Area = 64 cm X 15 cm
- Outlet Area = 64 cm X 10 cm
- Inclination of the setup = 30 °
- Height of Absorber Plate = 55 cm

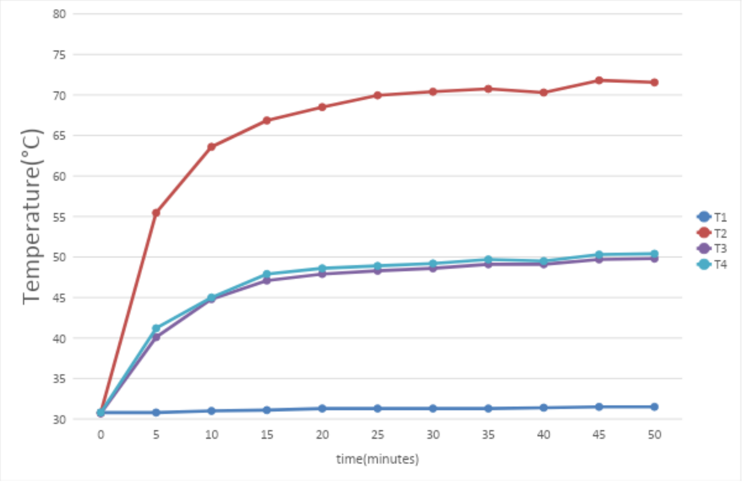


Fig 4.13

T1 = atmospheric Temperature or Inlet Temperature

T2 = Average Cans Temperature

T3 = Outlet Air Temperature at 5 cm distance from glass Plate

T4 = Outlet Air Temperature at10 cm distance from glass Plate

Experimental setup specifications:

- With Cans
- Inlet Area = 64 cm X 15 cm
- Outlet Area = 64 cm X 15 cm
- Inclination of the setup = 30 °
- Height of Absorber Plate = 55 cm

From above results it is observed that the outlet temperature is high for setup with black cans as absorbed media with raised height of 55 cm.

CHAPTER 5

Conclusion

This experimental study conducted on these different setups and evaluated and tabulated their values. The tests were conducted for different outlet areas and heights of absorber media. It was found that the outlet temperatures depend upon the outlet area and distance between the source and absorber. As the outlet area decreases the outlet area temperature increases and as distance between the source and observer decreases the absorber media absorbs more radiation which results in more outlet temperature.

From these results the black cans as absorber media absorbs more radiation resulting in an increase of heat absorption which increases air temperature at the outlet of the Solar Air Heater.

When the outlet areas are 64 cm X 15 cm, 64 cm X 10 cm and 64 cm X 05 cm the maximum air temperatures at outlet are 45 °C, 54 °C and 63 °C.

The maximum outlet air temperature is observed for the setup which has an outlet area of 64 cm X 05 cm and when the absorber is raised by 55 cm.

From the findings, the study concludes that flat plate solar air heater are useful for producing hot air which can be used for various purposes such as in process of removal of moisture, energy production etc.,

Future scope:

Highly efficient, innovative, and intelligent solar thermal energy systems providing hot water, space heating and cooling can be developed. For a widespread market deployment of solar thermal systems, it is necessary to store heat (or cold) efficiently for longer periods of time to reach high solar fractions, and therefore efficient and cost-effective compact storage technologies have to be developed.

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