

# REVIEW ON PERFORMANCE ANALYSIS OF SOLAR AIR-HEATER

<sup>1</sup>Tushar Kondhalkar, <sup>2</sup>Vivekanand Navadagi

<sup>1</sup>PG Scholar, <sup>2</sup>Assistant Professor,

<sup>1,2</sup>Department of Mechanical Engineering

<sup>1</sup>Dhole Patil College of Engineering, Pune, Maharashtra, INDIA

<sup>2</sup>JSPM's Imperial College of Engineering and Research Wagholi, Pune

**Abstract:** Given the geographical location, India has enormous scope to generate solar energy. This accounts to the fact that India is a tropical country and hence receives solar radiation throughout the year, which may be as much as 3,000 hours of sunshine equivalent to more than 5,000 trillion kWh. Approximately, 4-7 kWh of solar radiation per square meters is received by all parts of India, that being equivalent to 2,300-3,200 sunshine hours per year. This work deals with the energy and exergy analysis of solar air heater having absorber flat plate with force convection.

**Index Terms - Blower, Anemometer, K-type thermocouple, Acrylic glass, Aluminium plate**

## I. INTRODUCTION

Energy is a basic ingredient needed to sustain life and development. Energy is needed to in various forms to fulfil our day to day requirement. Energy consumption rate of the people are directly related to the preoperative or the standard of living. Two types of energy resources are available: conventional and non-conventional. Conventional energy resources such as fossil fuel (coal, crude oil and natural gas) are limited in amount. Total energy in recoverable conventional energy resources is estimated to be around 32-35Q (1Q=1018k) while the global energy consumption rate is roughly 0.4-0.5Q/year. Hence conventional energy resources are roughly estimated to last for 75-85years. This awareness of the limited nature of conventional energy resources gave rise to the search of alternative energy resources. Solar energy has the greatest potential among all the sources of renewable energy and even a small amount of this renewable source of energy is sufficient to meet the total energy demand of the world.

Solar air heating systems have been using globally for the past 20 years for a wide variety of multinational companies, schools, municipalities, military, agricultural application and commercial and industrial entities. As most solar air systems are made of metal, they are easily integrated to both new and retrofit buildings, and can be styled, shaped and design to accommodate any architectural style.

Most solar air heating systems are wall mounted, which allow them to capture a maximum amount of solar radiation in the winter. They are also fully building integrated and typically reduced between 20% to 50% of conventional energy used for heating buildings.

For a workable solar energy system, we should understand how the sun's energy reaches the earth and how this energy varies according to the time of year. The optimum climatic conditions for solar heating are based on bright sunshine on the coldest days of the year. A solar collector is then able to gather plenty of energy when is needed most. What is surprising is the amount of energy available even on cloudy days, which also tend to be not as cold. Clouds act as a blanket over the earth preventing some of its energy from radiating away. Solar radiation reaches solar panels in three ways: as direct, diffuse, and reflected radiation. There are three types of radiations are as mention below:

- Direct radiation consists of parallel rays coming straight from the sun. This type of radiation casts shadows on clear days.
- Diffuse radiation is scattered, non-parallel energy rays. This type of radiation makes the sky blue on clear days.

## II. PROBLEM STATEMENT:

Many experiments are done previously on solar air heater, but many of them uses only flat plate without blower because of that they get lower efficiency. Now we are going to use both flat plate as well as blower so that we will get maximum efficiency.

Although solar air heater has vast potential, it has not received much attention like the solar liquid collectors. Air type solar collectors have two problems, low thermal capacity of air and low absorber to air heat transfer coefficient, at the same time the most essential parameter of solar air collector design is the heat transfer coefficient between the absorber plate and the flowing air since the collector efficiency is strongly affected by this parameter, which is turn is dependent on collector type and operating conditions.

### III. OBJECTIVES:

1. Experimental study and comparison of heat transfer of flat plate and plate with fins by using forced convection in rectangular duct.
2. Experimental study and comparison of temperature variation of flat plate and plate having fins with respect to time of the day.
3. Experimental study and comparison of outlet temperature of flat plate and plate having fins with respect to time of day.
4. The experimental study and comparison of convective heat transfer coefficient of flat plate and plate with fins.

### IV. LITERATURE SURVEY

**D.V.N.Lakshmi** et.al, thermal and exergy efficiency of trapezoidal corrugated absorber solar air heater with sensible heat storage material (gravel) is experimentally investigated and compared with flat plate collector and trapezoidal corrugated absorber without sensible heat storage material. The energy and exergy analysis of solar air heater having absorber plate corrugated in the shape of trapezoid along with sensible heat storage material is carried out. Gravel is used as a sensible heat storage material and placed below the absorber plate. Thermal performance analysis of solar air heater with and without sensible heat storage materials is carried out and compared with flat plate solar air heater. The outlet air temperature of trapezoidal collector is more than the flat plate collector. [1]

**K. Mohammadi** et.al, studied that due to unfavorable thermo-physical properties of air, the rate of heat transfer between absorber plate and flowing air is low, which results in lower energy efficiency of solar air heaters. The performance of upward type single pass solar air heater with fins and baffles attached over the absorber plate is investigated. The parametric study of the fins and baffles is the main focus. Also effect of mass flow rate and solar radiation intensity are examined. [2]

**A.A. El-Sebaii** et.al, are perform the experiment and based on the results obtained from the experiments and theoretical models, the following conclusions have been drawn:(1) The outlet temperature of the DPVCPSAH is 5% higher than that of the DPFPSAH. (2) The DPVCPSAH is 11e14% more efficient than the DPFPSAH. (3) The thermal efficiencies of the DPFPSAH and DPVCPSAH increase with increasing until a typical value of 0.04 kg/s, beyond 0.04 kg/s, the increase in thermal efficiencies of the two systems are insignificant. (4) The increasing in pressure drop through the DPVCPSAH than that through the DPFPSAH is insignificant. [3]

**Atul Lanjewar** et.al, studied that the efficiency of flat plate solar air heater is low because of low convective heat transfer coefficient between absorber plate and flowing air that increases absorber plate temperature, leading to higher heat losses to environment. Low value of heat transfer coefficient is due to presence of laminar sub layer that can be broken by providing artificial roughness on heat transferring surface. Efforts for enhancing heat transfer have been directed toward artificially destroying or disturbing this laminar sub-layer. Artificial roughness in form of ribs and in various configurations has been used to create turbulence near wall or to break laminar sub-layer. Artificial roughness results in high frictional losses leading to more power requirement for fluid flow. Hence turbulence has to be created in region very close to heat-transferring surface for breaking viscous sub-layer. [4]

**Abdul-Malik Ebrahim Momin** et.al, the efficiency of flat plate solar air heater has been found to be low because of low convective heat transfer coefficient between absorber plate and the flowing air which increases the absorber plate temperature, leading to higher heat losses to the environment resulting in low thermal efficiency of such collectors. Several methods, including the use of fins, artificial roughness and packed beds in the ducts, have been proposed for the enhancement of thermal performance. it was found that the Nusselt number on the ribbed side wall having transverse ribs is about two or three times higher than the four-sided smooth channel values. [5]

**Atul Lanjewar** et. Al, air heaters form the major component of solar energy utilization system which absorbs the incoming solar radiation, converting it into thermal energy at the absorbing surface, and transferring the energy to a fluid flowing through the collector. Solar air heaters because of their inherent simplicity are cheap and most widely used collection devices. These have found several applications including space heating and crop drying. The efficiency of flat plate solar air heater has been found to be low because of low convective heat transfer coefficient between absorber plate and the flowing air which increases the absorber plate temperature, leading to higher heat losses to the environment resulting in low thermal efficiency of such collectors. Several methods, including the use of fins, artificial roughness and packed beds in the ducts, have been proposed for the enhancement of thermal performance. Use of artificial roughness in the form of repeated ribs has been found to be a convenient [6]

**Y. Raja Sekhar**. Et. Al, Flat Plate Collector (FPC) is widely used for domestic hot-water, space heating/drying and for applications requiring fluid temperature less than 100°C. The absorber plate of the FPC transfers solar energy to liquid flowing in the tubes. The flow can takes place due to thermosyphon effect or by forced convection. However, certain energy absorbed by the plate is lost to atmosphere due to higher temperature of the plate. The collector efficiency is dependent on the temperature of the plate which in turn is dependent on the nature of flow of fluid inside the tube, solar insolation, ambient temperature, top loss coefficient, the emissivity of the plate and glass cover, slope, etc. The objective of the present work is to evaluate top loss coefficient considering these aspects of the flat plate collector both theoretically and experimentally. A test setup is fabricated and experiments conducted to study these aspects under laboratory conditions [7]

**rvind Kumar Singh** et. al. AI, Energy in various forms has played an increasingly important role in worldwide economic progress and industrialization. In view of the world's depleting fossil fuel reserves, which provide the major source of energy, the development of non-conventional renewable energy sources has received an impetus. Sunlight available freely as a direct and perennial source of energy provides a non-polluting reservoir of fuel. The simplest and the most efficient way to utilize solar energy is to convert it into thermal energy for heating applications by using solar collectors. Solar air heaters, because of their inherent simplicity are cheap and most widely used collection devices. The main applications of solar air heaters are space heating; these can also be effectively used for curing/drying. The solar air heater occupies an important place among solar heating system because of minimal use of materials and the direct use of air as the working substance reduces the number of required system components. [8]

**Fabio Strucmann** et, al. In the solar-energy industry great emphasis has been placed on 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. 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 either directly to the hot water or space conditioning equipment or to a storage subsystem from which can be drawn for use at night and on cloudy days. 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. [9]

**Sunil K Amrutkar** et, al. In the solar- In the solar-energy industry great emphasis has been placed on the development of "passive" solar energy systems, which involve the integration of several subsystems: Flat Plate collectors, heat-storage containers, fluid transport and distribution systems, and control systems. The major component unique to passive systems is the Flat plate collector. This device absorbs the incoming solar radiation, converting it into heat at the absorbing surface, and transfers this heat to a fluid (water) flowing through the Flat plate collector. The warmed fluid carries the heat either directly to the hot water or to a storage subsystem from which can be drawn for use at night and on cloudy days. Since 1900, a large number of solar collector designs have been shown to be functional; these have fallen into two general classes: Flat plate collectors: in which absorbing surface is approximately as large as the overall collector area that intercepts the sun's rays. Concentrating collectors in which large areas of mirrors or lenses focus the Sun light onto a smaller absorber. Since of energy crisis, there has been effort to develop new energy sources as a way to solve energy problem and at of there, solar energy has received special attention. [10]

**S. Irfan Sadaq** et, al. Now a days the usage of natural resources are highly in progress because artificial resources such as electricity, gasoline, fuel etc are in declination stage and are very expensive. Solar radiation from sun is emitted and falls on earth surface this radiation is collected by using solar collectors. The present work is aimed to predict the performance of flat plate collector tested for 3 different days, using an application of water heating. The material used in the work is absorber plate, tube or pipe made of GI, casing and glass. The absorber plate material is mild steel and tube or pipe material is galvanized iron. Mild steel material have absorptivity is about 0.8 with black paint coated. The tube material is galvanized iron which is mild steel with coated with zinc for corrosion resistance. For this selection of material the maximum efficiency obtained was 9.75% at temperature 670 c [11]

**Foued Chabane** et,al. The thermal performance of a single pass solar air heater with five fins attached was investigated experimentally. Longitudinal fins were used inferior the absorber plate to increase the heat exchange and render the flow fluid in the channel uniform. The effect of mass flow rate of air on the outlet temperature, the heat transfer in the thickness of the solar collector, and the thermal efficiency were studied. Experiments were performed for two air mass flow rates of 0.012 and 0.016 kg s<sup>-1</sup>. Moreover, the maximum efficiency values obtained for the 0.012 and 0.016 kg s<sup>-1</sup> with and without fins were 40.02%, 51.50% and 34.92%, 43.94%, respectively. A comparison of the results of the mass flow rates by solar collector with and without fins shows a substantial enhancement in the thermal efficiency. [12]

**Santosh Vyas** et, al. Experimental test set up at laboratory scale has been developed for thermal performance testing of flat plate solar air heater with simulated solar radiation intensity; 600W/m<sup>2</sup>. 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 gradient. 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.[13]

**Anil Kumar** et, al. An artificial roughness on the heat transfer surface in the form of projections mainly creates turbulence near the wall or breaks the laminar sub-layer and thus enhances the heat transfer coefficient. In the present work the performance of a solar air heater duct provided with artificial roughness in the form of thin circular wire in V-shaped, Multi v-shaped ribs and Multi v-shaped ribs with gap geometries has been analyzed using CFD. The effect of these geometries on heat transfer and friction factor and performance enhancement was investigated covering the range of roughness parameters V-shaped, Multi v-shaped ribs, Multi v-shaped ribs with gap and working parameters. Different turbulent models have been used for the analysis

heat transfer and friction factor and their results are compared with Dittus-Boelter Empirical relationship for smooth surface. Renormalization k-epsilon model based results have been found in good agreement and accordingly this model is used to predict heat transfer and friction factor in the duct. [14]

**K. Mohammadi** et, al. This study investigates the influence of fins and baffles attached over the absorber plate on the performance

of the upward type single pass solar air heater. A steady-state mathematical model is presented and solved theoretically. The performance evaluation is studied in terms of different performance indicators, such as outlet air temperature, efficiency and effective efficiency. It is found that attaching fins and baffles effectively increases the outlet air temperature and efficiency in comparison to a simple conventional device. However, it is observed that increasing the number of fins and baffles parameters can reduce effective efficiency even less than a simple conventional device in some cases due to the high required pump work. It is found that there is no chance of introducing unique optimum number of fins and baffle parameters in all mass flow rates to achieve the highest performance in terms of effective efficiency, but it can be obtained in constant mass flow rate. The results reveal that the baffle width is a crucial parameter when the Reynolds number increases and the flow regime is turbulent. Increasing the solar intensity leads to achieve higher outlet air temperature and efficiency as well as lower difference between efficiency and effective efficiency [15].

### III. Experimental Setup:

Aim is to expose entire area of Aluminium sheet to the solar radiation. This is done by maintaining the proper angle of support stand by considering geographical consideration where we are doing the experiment.

The blower is connected to the inlet of the wooden duct. This passes the surrounding air over the Aluminium plate. This plate is exposing directly to the sunlight. Due to solar radiations, this plate is get heated and by convection phenomenon of heat transfer the air blown by the blower gets heated. This heated air can be further used for any application. The acrylic glass is used as cover of wooden duct. It protects the Aluminium plate as well as it entraps the solar radiation into the duct hence we get maximum amount of heat in the duct. Thermocouples are attached over the entire area of the plate so as to get the temperature at various points. With help of U tube manometer which is connected between inlet and outlet of the duct, the pressure drop can be found out in the duct.

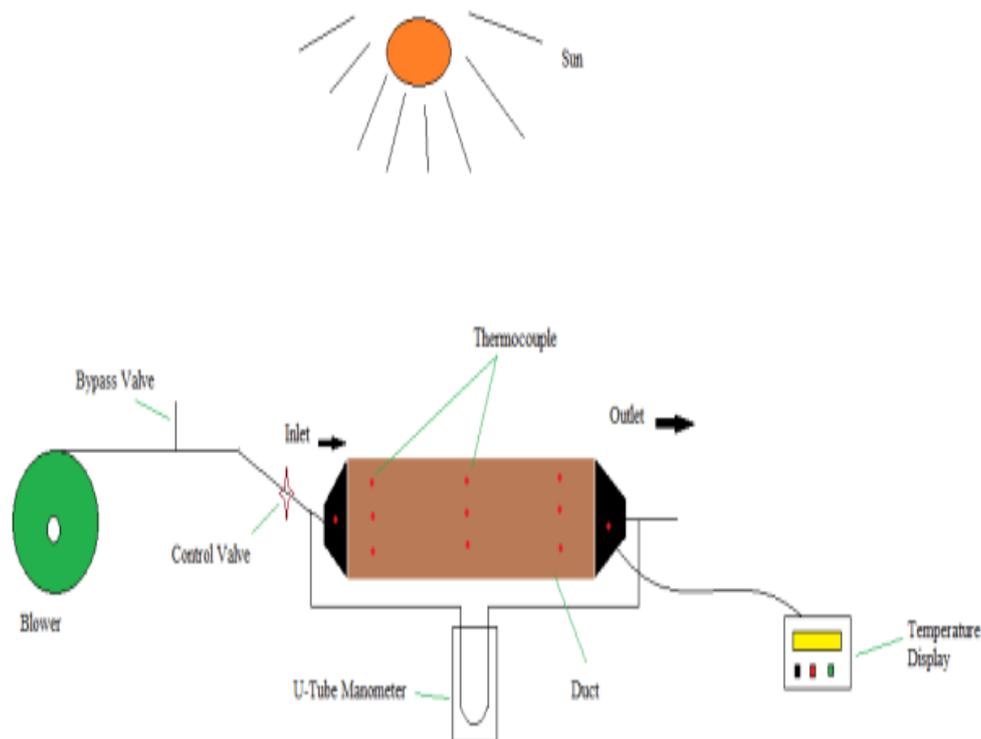


Figure 1. Schematic Diagram of Experimental Setup

### CONCLUSION:

The study of forced convective heat transfer from horizontal rectangular plate solar air heater has been studied experimentally by this research. We are studied five different types of parameter with respect to time of day.

These are like outlet temperature, temperature difference between inlet and outlet temperature, aluminium plate, Nusselt number and % change in heat gain of solar air heater

## REFERENCES:

- [1] D.V.N. Lakshmia, Apurba Layekb, P. Muthu Kumarc Performance analysis of trapezoidal corrugated solar air heater with sensible heat storage material". Energy Procedia 109 (2017) 463 – 470.
- [2] Abdul-Malik Ebrahim Momina, J.S. Saini b, S.C. Solanki Heat transfer and friction in solar air heater duct with V-shaped rib roughness on absorber plate International Journal of Heat and Mass Transfer 45 (2002) 3383–3396.
- [3] A.A. El-Sebaai a,1, S. Aboul-Enein a, M.R.I. Ramadan a, S.M. Shalaby b, B.M. Moharramb Investigation of thermal performance of-double pass-flat and v-corrugated plate solar air heaters. Energy 36 (2011) 1076e1086.
- [4] AtulLanjewar, J.L. Bhagoria, R.M. Sarviya Heat transfer and friction in solar air heater duct with W-shaped rib roughness on absorber plate Energy 36 (2011) 4531e4541.
- [5] K.Mohammadi a, M. Sabzpooshania, Comprehensive performance evaluation and parametric studies of single pass solar air heater with fins and baffles attached over the absorber plate Energy 57 (2013) 741e750.
- [6] Himangshu Bhowmik, Ruhul Amin Efficiency improvement of flat plate solar collector using reflector Energy Reports 3 (2017) 119–123.
- [7] Arvind Kumar Singh, Pushpendra Kumar Sharma, Harimohan Sharma Experimental Analysis on Solar Air Dryer ISSN: 2348 –3733, Volume-1, Issue-12, December 2014.
- [8] K. Mohammadi, M. Sabzpooshani, Comprehensive performance evaluation and parametric studies of single pass solar air heater with fins and baffles attached over the Absorber plate Energy 57 (2013) 741e750.
- [9] Sunil.K.Amrutkar, Satyshree Ghodke, Dr. K. N. Patil Solar Flat Plate Collector Analysis Vol. 2 Issue 2, Feb.2012, pp.207-213.
- [10] S. Irfan Sadaq, S. Nawazish Mehdi, Ishrath M.M, Afroz Mehar, Nbv. Lakshmi Kumari. Performance Analysis of Solar Flat Plate Collector, ISBN: 978-93-82702-74-0.
- [11] Sunil.K.Amrutkar, Satyshree Ghodke, Dr. K. N. Patil, Solar Flat Plate Collector Analysis, Vol. 2 Issue 2, Feb.2012, pp.207-213.
- [12] Fabio Struckmann, Analysis of a Flat-plate Solar Collector, 2008 MVK160 Heat and Mass Transport May 08, 2008.
- [13] Arvind Kumar Singh, Pushpendra Kumar Sharma, Harimohan Sharma, Experimental Analysis on Solar Air Dryer, ISSN: 2348 –3733, Volume-1, Issue-12.
- [14] Y. Raja Sekhar, K. V. Sharma and M. Basaveswara Rao, Evaluation of heat loss coefficients in solar, flat plate collectors, ISSN 1819-6608, Vol. 4, no. 5.
- [15] Abdul-Malik Ebrahim Momin, J.S. Saini , S.C. Solanki, Heat transfer and friction in solar air heater duct with V-shaped rib roughness on absorber plate, International Journal of Heat and Mass Transfer 45 (2002) 3383–3396.
- [16] Prof. C.Shriramshastri, Vivekanand Navadagi, "Performance analysis of solar collector with Inline and perforated W shape rib roughened absorber plate for air heating applications", International Engineering Research Journal, Pages-170-178, 2016/6.
- [17] Prof. C.Shriramshastri, Pramod Biradar, Vivekanand Navadagi, "Thermal performance investigation of solar flat plate collector integrated with latent thermal energy storage system", International Engineering Research Journal, Pages- 162-169, 2016/6.
- [18] prof. vivekanand navadagi, "performance analysis of double-pass flat plate solar air heater with porous media", International journal for science and advance research in technology, Volume-1, Issue-10, 2015/10.