INVESTIGATING THE DIFFERENT PROCESS PARAMETERS OF SOLAR AIR HEATER

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***Abstract*: Conventional resources of energy are depleting very rapidly due to their heavy use for the generation of energy. To over come this and to save the natural resources, researchers are working to find the substitute of conventional fuels which is renewable and abundant in amount. Solar energy is one of the most promising which can replace or shorten the heavy use of conventional fuels. Solar air heater is one of the most efficient equipment which convert solar energy in to thermal energy. So, in order to increase the efficiency of the system, it is necessary to identify the different process parameters of the solar air heater. This paper includes the complete review of solar air heater and their different process parameters.**

***Keywords*: Solar air heater, review, heat transfer, efficiency, process parameter**

1. Introduction

Energy demand depends on five different factors, including country status, climate and year-round climate, population, energy and energy conversion technology. Rising global energy demand is being largely reduced by the habit of renewable energy resources such as fossil fuels (oil, gas and coal) and nuclear power. The use of these non-renewable energy resources contributes to environmental degradation such as acid rain, greenhouse gas emissions, global warming and depletion of natural resources. Global energy demand is strongly influenced by global population growth, estimated at 1.23% per year for 2000 to 2015 (World Bank 2017). This increased energy demand can be recognized by the growth of economic growth and modern luxury lifestyle among the population, as well as technological advances. Fossil fuels (fuel, natural gas, and coal) are typically burned for power generation and power plants. Combustion fuels produce carbon dioxide, which is considered to be the main greenhouse gas emitted into the atmosphere. This growing energy demand, if it relies solely on fossils, will be a huge burden on the environment, requiring the shifting of environmentally friendly energy resources. With pollution and a steady decline in oil reserves, renewable energy sources are the solution to clean energy and future competition. Today, solar power plants are one of the major candidates for remarkable amounts of clean electricity: Kaygusuz, K et.al (2012)

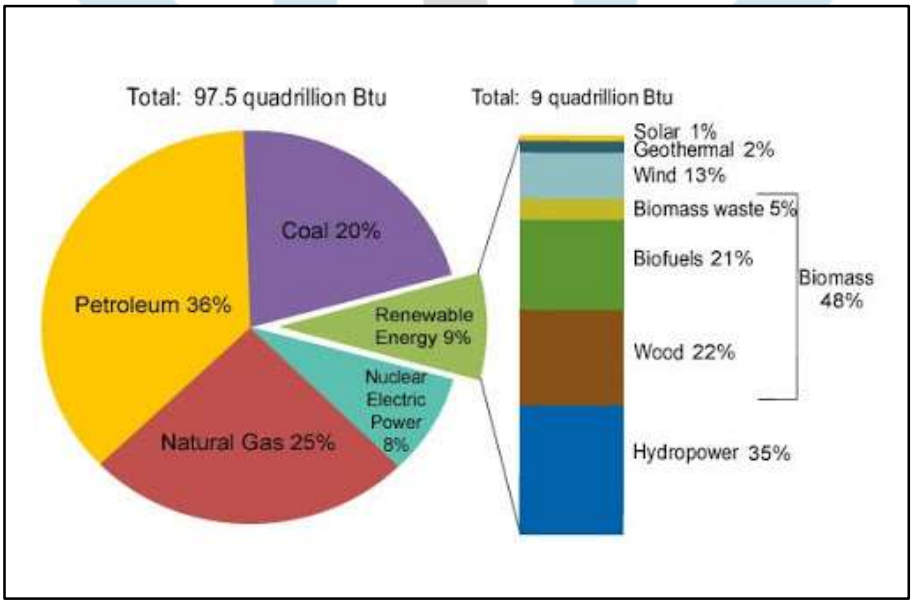

Figure: 1.1 Percentage consumption of various energy resources

2. Solar Energy Collection

Currently, solar heating systems are the most economical technology for large-scale solar energy recovery. Heat collectors, or solar panels, are devices used to generate solar energy. Solar collectors are a special type of heat exchanger that converts the flow of sunlight into the internal energy of a fluid that is used as a means of transport. Solar collectors are an essential component of any solar recovery system. In a solar collector, the incoming sunlight is absorbed by the suction plate and converted into thermal energy, which is then transferred to a circulating fluid (usually air or water). The circulating fluid flowing through the engine acts as a means of transport. The heat converted from the liquid can be used directly for water heating or for air conditioning, or can be stored

in a suitable heat storage tank, which can be used at night or on a rainy or cloudy day. Solar collectors can be broadly classified into two types, collectors and non-collectors. Non-concentrated collectors have the same openings for receiving and absorbing sunlight, while the concentrated surface of the openings is used to receive and concentrate the solar flux over a smaller absorption area. Increase the amount of radiation for the same collection area. The main characteristics of the different types of collectors are given below in Table 1.1.

Table 1.1 Important features of different solar collectors

Motion	Type of collector	Type of Absorber	Concentration Ratio	Range of temperature
Stationary	i. Flat Plate Collector (FPC) ii. Evacuated Tube Collector (ETC) iii. Compound Parabolic Collector (CPC	Flat Flat Tubular	1 1 1-4	30-80 40-200 60-250
One-axis tracking	iv. Linear Fresnel Reflector (LFR) v. Parabolic Trough Collector (PTC) vi. Cylindrical Trough Collector (CTC)	Tubular Tubular Tubular	10-40 15-50 10-60	60-250 50-300 65-300
Two-axes tracking	i. Parabolic Dish Reflector (PDR) ii. Helistat Field Collector (HFC)	Point Point	100-900 100-1550	100-550 100-1100

Solar heaters are the simplest solar devices used to heat air using the sun's radiant light. Mainly solar fan heaters include a parallel suction plate or a plate forming an air flow channel. The transparent cover is usually glass attached above the suction plate and the system is thermally insulated from the edges and rear. Fan use is based on design [Patil et.al (2012)]. The major parts of flat plate type solar air heater are: Absorber Plate this is the most vital component of unit. It collects the heat of the sun that is transferred to air traveling across it. It is painted with black to maximize absorption of solar radiation. Transparent Cover it is situated at upper side of the unit, which receives the sunrays and then fall over the absorber plate then build up the interior temperature. It also minimizes radiation and convection losses. Insulation it provided on lower and lateral walls of unit that reduce the conduction losses. Fluid Tube in this fluid is flowing, and absorber plate gives the heat to that fluid. In solar air heater except fluid tube there is a duct in which air is flowing.

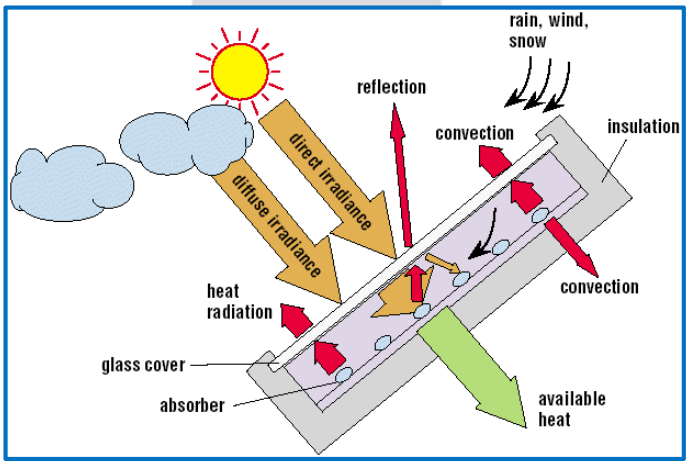

Fig. Cross section of a basic flat plate collector [Patil et.al (2012)]

3. Existing work

1. **Inderjeet Singh *et.al* (2018)** computationally investigated the heat transfer and fluid flow analysis for non-uniform cross-section transverse rib of square wave profile (using ANSYS fluent). The research has been proposed with the following objectives:
   - To study the effect of roughness and flow parameters on Nusselt number and friction factor in non-uniform cross-section square wave profile transverse rib roughened solar air heater duct.
   - To determine optimum roughness and flow parameters based on thermo-hydraulic performance.

The investigation covered the parameters range as relative roughness pitch from 4 to 30, relative roughness height from 0.015 to 0.043 and relative roughness width from 10-310 and Reynolds number from 3000-15000. It was found that with the increase in Reynolds number, the Nusselt number value augments while the friction factor declines for all values of investigated roughness parameters. Nusselt number and friction factor both increases with the increase in relative rib height for the considered range of Reynolds number.

2. **Yuen Zheng et.al [2018]** This research work had focused on enlightening the efficiency of the collector of inclined SCPP through the usage of underneath air-vents. The study engaged numerical method employing a Computational Fluid Dynamics software, Star-CCM+. In the system modelling and simulation, radiation modelling principles were adopted under condition of steady state. The study discovered that with the usage of underneath air-vents, there was 4.25% and 4.64% reduction in convection and radiation heat transfer respectively from the collector cover to the ambient at 1000 W/m^2. It was also pragmatic that the air mass flow rate was augmented by 210% and consequently the power output of the plant enhanced by 60%. The study exposed that for a 100 m^2 inclined collector used in the study, 15 number of air-vents were obligatory for optimum performance enhancement. The study also revealed that the system without chimney could operate but with reduced efficiency as compared with the system incorporated with chimney.
3. **Xu Haoxin et al. (2017)** Proposed the purpose of the method to evaluate the material in the heat not yet clearly visible in the heat storage facility to use the waste heat. He developed a detailed and systematic approach to evaluating PCM for non-existent thermal energy production, which included classification and object-based objective analysis based on multi-criteria decision tools. First, a large number of candidates are selected from a well-defined list. Solar heating materials are classified using hierarchical process analysis and favorable techniques similar to the ideal solution. Three different target functions are proposed, clearly evaluating the efficiency of the phase transition of the raw material. Pareto's decision at the highest point should be an additional tool in studying performance goals. A good consensus for solar heaters was observed between the evaluation results and the building for the simulation of thermal comfort in the results of the validation literature and the first proposed method of evaluating the performance of the results. Of phase material exchange with the method must be applied storage system for unseen heat of thermal energy for waste heat utilization in practice in a cogeneration plant. The efficiency of the pre-cut PCM is evaluated and the results provide a clear quantitative indicator in the classification which will provide high confidence in selecting the most efficient material in the design phase.
4. **Ayadi et.al [2017]** The purpose of this work is to study and improve the characteristics of the chimney (SPP) using numerical and experimental methods. Numerical simulations were simulated using Ansys Fluent commercial CFD codes. The effect of the height of the collector ceiling on the performance of the solar flue is known. The local characteristics of air flow in SPP systems are expressed and analyzed as: temperature, velocity, pressure and turbulence characteristics. The results confirm that the height of the collection roof is very influential for SPP optimization. In fact, an increase in the generated energy is reported while the height of the collector roof is reduced. The optimization of the flue equipment is limited by the high cost, this document can be a solution to improve the energy generated by the existing solar flue system.
5. **Hans *et.al* (2017)** By experimenting, evaluate the heat transfer characteristics and fluid flow of a damaged solar heater. The study considers the parameters of the ribs as a relative roughness pitch of 4 to 12, a relative width of between 0.5 and 2.5, a position between 0.2 and 0.8, a relative roughness of 0. 022 to 0.043 and an arc angle of 15˚75 ˚ for the Reynolds 2000-16000 range. The improvements obtained in the numerical number and the values of the coefficient of friction, respectively, are 2.63 and 2.44 times corresponding to the geometric parameters such as the relative roughness step 10, the relative width of the air gap 1.0. , Arc angle 30 m, relative position of gap 0.65 and relative roughness height 0.043.
6. **Singh and Singh *et.al* (2017)** Digitally estimated channels for rough solar air heaters with uneven toothed ribs of cross section. 3-D CFD studies cover a range of parameters such as Reynolds numbers from 3000 to 15000 and relative roughness steps from 4 to 30. . The Nuselt number and the coefficient of friction are the maximum at the relative roughness level of 16 for the range of Reynolds numbers studied. The maximum increase in the number of nodes and the coefficient of friction on the smooth channel is 2.18 and 3.34, respectively, at 15,000 rhododendrons and the relative roughness step.
7. **Mekhail et.al [2017]** In this study a very small model of the chimney height of 6 m was installed, the collector diameter of 6 m and the chimney diameter of 0.15 m. The mathematical model, based on the thermodynamic analysis of the flow within the SCPP, was used to predict its performance. The city of Aswan is one of the hottest and sunniest cities in the world. These climatic conditions make the city an ideal place to generate electricity for the Solar Chimney power plant (S.C.P.P). The experimental performances and the theorems calculated by the mathematical model were in good agreement. This model was used to predict the production of a larger model of chimney height 20 m, collector 30 m 2 and chimney diameter of 1 m, which is still under construction. The results revealed that the largest model can produce a theoretical power of about 600 times the smallest. This study helps to select the power of the generator for the largest model.
8. **Vieira et.al [2017]** This research project aims to study the influence of geometric parameters on the usable capacity of solar power plants (APP) by the project. The effect of different soil temperatures (mimicking the effects of different sunlight on the collector) on optimal shape was also evaluated. The geometry faces three obstacles: the turbine collector area and the exhaust pipe. In addition, three degrees of freedom are considered: R / H (ratio between radius of curvature and inlet height), R1 / H2

(ratio between radius and height of chimney) and H1 / H (ratio between height of main manifold and height). Of the chimney). Insert sensor) fixed (H1 / H 10.0). On average, the conservation of momentum and power equations (RANS) was solved numerically using the quantitative method (FVM). The standard k-e model was used to model the turbulence. The results show a strong influence of the geometry of the flue and of the collector on the available energy. In addition, the geometric parameters of the collector and the stack must be evaluated in combination. It has also been observed that soil temperatures are very sensitive to resilience and geometric effects.

9. **Okoye et.al [2017]** The purpose of this article is to raise awareness of whether solar power plants (SPPs) are an acceptable and sustainable option in rural communities with limited or no electricity. The study took into account hourly weather data for specific locations to assess SPP feasibility in seven regions of Nigeria. Theoretical models for power generation, cost savings (LCOE) and CO2 avoidance predictions have been developed. In addition, the effects of the seasons on sunlight, ambient temperature, and energy were investigated. The results show that a 600m diameter SPP and a 150m high chimney per day under Nigeria conditions will provide an average of 154 to 181 kW of power. In 40 years, the price of electricity was between 0.216 and 0.254 EUR / kWh vs. 0.563 R / kWh for the most widely used diesel generators. CO2 emissions are between 162 and 191 tons. The analysis also shows that the proposed SPP will improve the social, economic and environmental development of the region.
10. **Ghalamchi et.al [2016]** In this work, a test plant was built to study the temperature region and obtain the latest experimental data. The collector roof is 4m sodium welded glass. And a black aluminum plate is placed on the absorber. In this work, temperature and velocity distributions in different driver sizes and instrument materials are described and compared. Finally, the optimum condition is reached, the maximum speed of the fluid at the inlet of the flue is 1.7 m / s, and the optimum data on the temperature of the absorber and the fluid are 353.78 and 329.1. K. I noticed. Reducing the internet size has a positive effect on the operation of the solar flue, but this reduction has the best range and the best number is 6 s. For this configuration. The diameter of the chimney is the most influential geometric parameter in the operation of the solar chimney.
11. **Pandey *et.al* (2016)** The thermal characteristics of the roughened elements of the absorbing plate were analyzed. The findings based on the results show a good increase of the nucleation when using this type of rough configuration. The maximum gain obtained at Nu and f is 5.85 and 4.96, respectively. The maximum gain for ny is found at the Reynolds numerical value of 21000 for the geometric configuration (g / e = 1, d / x = 0.65, W / w = 5, e / D = 0.044, P / e =. 8 and α = 60 equator A statistical equation for the nucleus and the coefficient of friction as a function of various geometric and flow parameters is established.
12. **Kabeel A.E. *et.al* (2016)** Attempts to study the thermal characteristics of SS with flat and angular boards, with and without PCM as heat storage devices. In this study, he directly studied the SAA, with its flattened, flattened, and lettered SP shape, with HPS combined as the thermal energy of the storage material. SAH together with PCM is 12% higher than Paraguay, higher without PCM, it is also 15% higher and 21.3% higher than below value when flat plate is used with and without PCM when mass flow 0.062 kg. G / s respectively.
13. **Kumar and Kim *et.al* (2016)** Performed 3D CFD analysis of various V-shaped ribs such as V-shaped ribs, V-shaped convex ribs, V-shaped ribs and V-shaped ribs combined with a single groove in the 500 digital range. - 20,000. The constant parameter is the relative roughness height 0.040, the relative roughness step 10 and the attack angle 60 °. They concluded that V-ribs with a combination of grooves resulted in maximum thermal processing compared to the other V-rib profiles investigated in this study.
14. **Hanna et.al [2016]** In this study, they built a 10-day experimental plant in Aswan, Egypt to evaluate the operation of the lamp plant turbine. However, ambient temperature is considered to play an important role in influencing solar energy generation. More importantly, the efficiency of the solar oven is proportional to the air temperature of the solar collector, especially between 1:00 and 3:00 p.m. Based on the results, it can be estimated that the fan speed can be selected at 1650 rpm, with an average fan efficiency of 57%. The conclusion is that this digital model is the right basis for the system to generate solar thermal energy, and the simulation model can be easily used to predict the efficiency of the solar system. The results and test results are good. Finally, the maximum output of the solar power plant in the study was said to be higher than the previous work, according to an ongoing website in Aswan, Egypt.
15. **Driss et.al [2015]** In this work, a numerical study was carried out to study the turbulent flow around the unusual wind turbine of Savannah. This study compares different rocket designs defined by blowing angles of 60 °, 75 °, 90 ° and 130 °, while other geometric parameters are kept constant. Under these conditions, the third case involves a normal wind turbine rotor. The results showed that the blower design had a direct effect on the local property. In particular, it is believed that the area of depression increases as the angle of the bucket nose increases. Large depressed areas appear with ψ = 130º. It is located in the parallel surface of the blade and along the rotor chain. The acceleration zone in which the maximum velocity value is recorded is generated on the convex surface of the blower and increases with the increasing angle of the blower arc. The posterior property of the maximum turbulence is more informative as the ade angle increases.
16. **Azawie et.al [2014]** In this work, the conversion capabilities of six different raw materials available in Malaysia were investigated experimentally and numerically. Experimental equipment for recording measurement data was constructed. In the FLUENT software office, digital models are designed to model and simulate power conversion processes. Selected materials include ceramics, black chalk, scotch, black wood (DGPS), sand and gravel. The experimental results showed good agreement with the experimental results regarding air flow and energy conversion efficiency. Ceramic and black stone proved to work better than other materials. Due to its availability, black stone has been introduced as an absorbing material in solar chimneys in Malaysia and other countries in the region.

Conclusion

The performance of solar air heater depends on different process parameters like heat flux available on the absorber plate, thermal conductivity of the materials that are used for the manufacturing of heat sink, velocity of working fluid, flow behavior of working fluid and many others. In most of the cases forced convection is used to transfer heat from solar air heater to working fluid. Many researchers have optimized the different process parameters of solar air heater. People basically worked on forced convection type solar air heater, very few people have worked on natural convection solar air heater. Here in this work, heat transfer and efficiency of natural convection solar air heater was enhances using ribs inside the convex shaped solar air heater.

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