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Analysis of Solar Air Heater – A Review

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Abstract: The primary purpose of a solar air heater is to heat water or air by harnessing solar radiation. Different designs of solar air heaters were created in order to increase the rate of heat transmission. A large number of studies have adjusted various process parameters, with the majority using ribs in flat plate solar air heaters to increase the rate of heat transmission. In order to promote heat transmission by natural convection in solar air heaters, Singh et al. have employed convex and concave profiles. Their research indicates that a convex shape profile with a 50-degree curve exhibits a greater heat transfer rate.

Keywords: Solar, Air Heater, Ansys, CHD.

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I. INTRODUCTION

Renewable energy has long been of interest in electricity generation. Considering the different sources of renewable energy, solar energy is considered to be the main energy source on earth, but it depends on time and place. Radiant heat, as well as light approaching the sun, can be returned directly or indirectly in various forms of energy. However, solar energy is known to have disadvantages due to the low efficiency of the energy conversion system. One disadvantage of solar energy systems is the initial investment cost, which limits the amount of money many people invest in energy systems. The economic disadvantage is accompanied by an increase in the cost of installing solar energy technology, while the less energy produced, which is associated with other conventional energy systems, is therefore characterized by lower yields. As a result, solar energy is still a very expensive alternative to conventional energy sources such as fossil fuels, nuclear power and hydropower.

Solar conversion systems are used to generate electricity indirectly from solar energy. Solar heating systems can be classified as low temperature or high temperature solar systems. High-powered solar heating systems include solar collectors, parabolic, solar towers (paralysis), parabolic reflectors, linear transformers, solar panels, food absorbers, and more. Discover its origins. Solar energy is considered a form of pure energy that can be used to generate electricity without harming the environment.

The construction of solar power plants can be beneficial in the long run, as the initial investment in solar power plants will ensure a sustainable energy future for less urban and technologically underdeveloped areas. Extensive research is being supported to increase the profitability of solar power generation technologies to support future solar power plant development. In addition, since the intensity of radiation varies depending on the location of the country receiving the amount of solar radiation, there will be no problems with the reliability of the power supply.

Conversion of Solar Energy

Converting solar energy into electricity is possible by either using a solar photovoltaic device or by converting the solar energy into thermal energy and subsequently converting the thermal energy into electric power. The later technology is known as solar thermal technology. A solar thermal technology can either be

(i) A concentrating technology or

(ii) A non-concentrating technology.

The concentrating technologies employ powerful collectors that are able to generatehigh temperature thermal energy to initiative either steam turbines or gas turbines to produce power. The parabolic trough, the dish technology, and the heliostat are examples of concentrating power technologies simply put as CSPs. The non-concentrating technology oppositely employs collectors that are unable to concentrate the solar radiations i.e. they capture both the direct and diffuse solar irradiation. Invariably they are unable to attain very high temperatures. The solar chimney power technology to be investigated in this literature review falls under the non-concentrating power technologies.

Renewable energy technology is currently being used to adapt solar energy to heat and electricity. Based on the energy requirements and conditions of the farm, this energy vector has three active energy sectors and can be represented by the diagram

Solar Collectors

Solar collectors work as a special type of heat exchanger that converts solar radiant energy to thermal energy, which then take by flowing medium. Solar insolation has low density (1 to 0.1 kW/m2) [Zhu *et.al* (2009)]. Hence, it is collected by covering a large ground area by solar thermal collectors. It takes heat from the sun and transfers this heat efficiently to the transport medium. To utilize this heat in the subsequent stages of the system, it is mandatory to take heat from the transport fluid and then store it in thermal storage tank/boiler/exchanger.

It is mainly classified as:

- Stationary Compound Parabolic collectors
- Evacuated tube collectors
- Flat plate collectors
- Concentrating type Collector

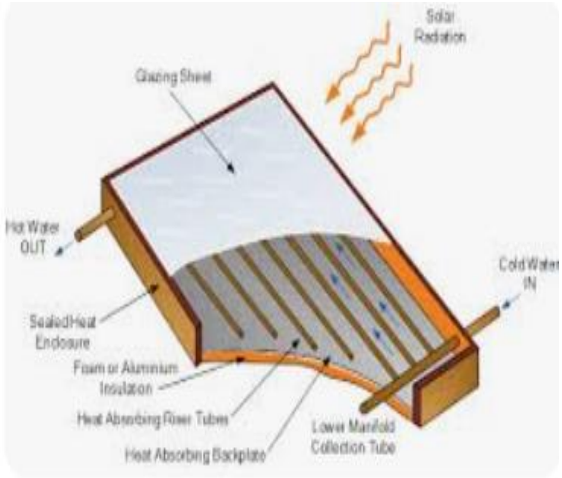

Figure 1: Components of Flat Plate Collector

Solar Air Heater

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 The major parts of flat plate type solar air heater are:

(a) 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.

(b) 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.

(c) Insulation it provided on lower and lateral walls of unit that reduce the conduction losses.

(d) 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.

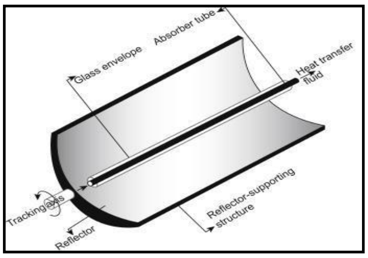

Figure 2: Concentrating collector

Types of Solar Air Heaters:

These are categorized in two ways. The first one is considering channel flow design for increment in system efficiency. The different configurations are; (a) single flow single pass (b) double flow single pass (c) single flow double pass and (d) single flow recycled double pass.

The second one is associated with the air channel design. It also enhances the system efficiency. These are expressed in three sub categories such as; (a) flat plate (b) extended surface (c) porous media.

ASA is a device by which solar energy is transferred into the air. It is a normal task to properly allocate SS. There are many models and different methods of construct testing They can be explained on the basis of the model as active, passive and hybrid. Here, SA depends on the power storage device, such as SSM, the number of glass covers, the magnification area shown in the figure below. Power storage devices such as PCM are inserted into the active SS to generate worm air during shutdown hours. The passive SAS type can be applied during the day.

Advantages of Solar Air Heaters:

1. The system is compact and less complicated because fluid used is air and it can be used directly as the working substance.

2. Rust is a major problem with solar water heaters, and this problem is not related to solar heaters.

3. Air leakage from the solar air heater does not produce any problem.

4. As air is used as working fluid, problem of freezing of working fluid is eliminated.

Disadvantages of Solar Air Heaters:

1. Larger volume of the air is to be handled because of the low density of the air.

2. Due to the lower value of the thermal capacity of the air, working fluid air cannot be used as a storage fluid.

3. Due to the weak thermal characteristics of the air, special care is needed to improve the heat transfer.

II. LITERATURE REVIEW

Kabeel A.E. *et.al* (2024) 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.

Hamdan et.al [2022] In this paper, a mathematical thermal model for stationary air flow in a solar power plant with altered Bernoulli equations influencing water droplets and fine gas equations is presented. The study evaluates the utilization of the constant density assumption of the solar stack and compares it to a more realistic mathematical model that allows for density variations across the stack. The results show that the use of constant density assumptions in solar tubes can shorten the analysis pattern but predict electricity generation. The results also show that the height of the radiator flue of the solar collector and the turbine head are important parameters for the design of the solar fireplace. It is considered that the maximum power depends on the turbine head and the connection is not monotonic.

Kaygusuz et.al (2021) Recognize that lack of energy can hinder the achievement of goals. This study shows that sustainable energy security and a sustainable environment require more efficient and economical use of clean energy technologies. He also noted that the lack of consumer awareness and indifference to clean energy equipment are barriers to using energy differently.

Sami *et.al* (2019) In the present work, an experimental study was carried out to find the maximum height of the air gap for a rectangular water heater. To carry out the solar test, four solar beams with different heights in the air gap were designed and constructed. Each heater is 200 cm long. M and width 50 cm. M. The height of the air gap studied was 3, 5, 7 and 9 cm. The results showed that the highest air temperature difference was found for the air gap height of 3 cm i.e 57.5 ° C, air gap 3 cm. Leading to the highest discharge temperature of the entire study period. The highest mass flow rate and therefore the highest heating is 9.0 g / s at 9 cm and 1:00 min. High mass flow rate leads to high efficiency, viz. 57.3% at 9 p.m. And 10:00 a.m. The large airflow and efficiency of solar heaters show a slight increase when the air gap height exceeds 5 cm.

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.

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.

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.

Yadav et.al (2013) Advantages - A study of the heat transfer in the rectangular shape of the triangular beam at the edge of the absorber plate using CFDs. The effects of Reynolds and Nuselt numbers were studied. Calculations based on the low-volume method using the SIM card solution were performed for air flow against 3,000 to 18,000 rhododendrons. The ANSYS 12U Limited Commercial Package is used to analyze and visualize the nature of the flow through solar panels. The results of the CFD simulation agree well with the experimental results and the standard theoretical methods. Nusselt's numbers were found to increase as Randall rose.

Satya Prakash Nayak et.al (2012), CFD studies have used digital simulation software to improve turbulent heat transfer. Current CFD analysis of heat transfer and flow patterns with artificial roughness in the form of different rib types, heating walls of rectangular channels for turbulent flow with Reynolds number (3000–15000) and for rib length / Height ratio p / e. (5 to 20) is achieved. The k-was turbulence model was selected by comparing the projections of the different turbulence models with the experimental results available in different literature. This study evaluates the connection point, heat transfer, and fluid flow behavior in a rectangular channel with several rough ribs mounted on a main wall (solar panel) using CFD software. 3.26 Software). The results were validated by comparison with existing experimental data.

Pakdaman et.al (2011) Constructed a convex-shaped solar heater with a rectangular rib absorber plate. They developed a practical model and demonstrated the calculation of design parameters that characterize the thermal behavior of the system. Exercise analysis was performed and the optimal conditions in which the system had the highest performance were reported.

Sozen et.al (2010) Introduced a new ANN technique for determining the efficiency of solar collectors and explained that system design parameters, operating conditions and temperature differences have a significant impact on the efficiency of solar collectors. This study shows that ANNs are used instead of mathematical models that benefit from speed, simplicity, and the ability to learn from examples.

III. CONCLUSIONS

After going through the literature survey following problems were identified. 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.

REFERENCES

[1] Kabeel A.E. et.al (2024) Thermo-hydraulic performance enhancement of convex- concave natural convection solar air heaters. Solar Energy, 183, 146–161. doi:10.1016/j.solener.2019.03.006.

[2] Kaygusuz ,Alessandro Romagnoli, Jia Yin Sze, Xavier Py ,(2021) "Selection of Phase Change Material for Thermal Energy Storage in Solar Air Conditioning Systems", Energy Procedia 105 (2017) 4281 – 4288, doi: 10.1016/j.egypro.2017.03.898.

[3] Ahmed Ayadi Singh, Abdallah Bouabidi, Zied Driss, Mohamed Salah Abid [2021, "Experimental and numerical analysis of the collector roof height effect on the solar chimney performance", Renewable Energy (2021), doi: 10.1016/j.renene.2017.08.099.

[4] Hans, V S, Gill R S, and Singh S (2020) Heat transfer and friction factor correlations for a solar air heater duct roughened artificially with broken arc ribs. Exp Therm and Fluid Sci 80: 77-89.

[5] R.S. Vieira, A.P. Petry, L.A.O. Rocha, L.A. Isoldi, E.D. dos Santos [2017], "Numerical evaluation of a solar chimney geometry for different ground temperatures by means of constructal design", Renewable Energy 109 (2017) 222e234.

[6] Chiemeka Onyeka Okoye, Onur Taylan [2017], "Performance analysis of a solar chimney power plant for rural areas in Nigeria", Renewable Energy (2017), doi: 10.1016/j.renene. 2016.12.004.

[6] Mehrdad Ghalamchi, Alibakhsh Kasabian, Mehran Ghalamchi, Alireza Hajiseyed Mirzahosseini [2016], "An experimental study on the thermal performance of a solar chimney with different dimensional parameters", Renewable Energy 91 (2016) 477e483.

[7] Pandey, N.K., Bajpai, V.K., Varun, 2016. Experimental investigation of heat transfer augmentation using multiple arcs with gap on absorber plate of solar air heater. Sol. Energy 134, 314–326.

[8] Yadav A and Bhagoria J L (2013) A CFD (computational fluid dynamics) based heat transfer and fluid flow analysis of a solar air heater provided with circular transverse wire rib roughness on the absorber plate. Energy 55: 1127-42.

[9] Satya Prakash Nayak, Priti Shukla & Satyashree Ghodke 2012, „CFD Analysis of Solar Flat Plate Collector Heat Transfer and Fluid Flow Analysis of Roughness Rib in Solar Air Heater Duct by Computational Fluid Dynamics (CFD)Simulation", International Journal of Advanced Research in Science, Engineering and Technology, vol.01, no.03, pp.15-20.

[10] Patil, A.K., Saini, J.S., Kumar, K., 2012. A comprehensive review on roughness geometries

and investigation techniques used in artificially roughened solar air heaters. International Journal of Renewable Energy Research 2 (1), 1-15.

[11] Mohammad O. Hamdan [2012], "Analysis of solar chimney power plant utilizing chimney discrete model", Renewable Energy 56 (2012) 50e54.

[12] Kaygusuz, K 2012, 'Energy for sustainable development: A case of developing countries', Renewable and Sustainable Energy Reviews, vol. 16, pp. 1116-1126.

[13] Panwar, NL, Kaushik, SC & Kothari, S 2011, 'Role of renewable energy sources in environmental protection: A review', Renewable and Sustainable Energy Reviews, vol. 15, pp. 1513-1524.

[14] Fakoor Pakdaman M, Lashkari A, Basirat Tabrizi H & Hosseini R, „Performance evaluation of a natural convection solar air heater with rectangular-finned absorber plate‟, Energy Conversion and Management, vol.52, pp.1215-1225.

[15] Karmare SV & Tikakar AN 2007, „Heat Transfer and friction factor correlation for artificially roughened duct with metal grit ribs‟, International Journal of Heat Mass Transfer, vol.50, pp.4342-4351.

[16] Adnan Sozen, Tayfun menlik & Sinan Unvar 2010, „Determination of efficiency of the plate solar collector using neural network approach‟, Expert Systems with Applications, vol.35, pp 1533-1539.

[17] Deniz Alta, Emin Bilgili, Ertekin C & Osman Yaldiz 2010, „Experimental investigation of three different solar air heater: Energy and Exergy Analysis‟, Applied Energy, vol.87, pp.2953-2973.

El-Sebaii AA & Al-Snani H 2010, „Effect of selective coating on thermal performance of flat plate solar air heater‟, Energy, vol.35, pp. 1820-1828.