INVESTIGATING THE DIFFERENT PROCESS PARAMETERS AND THEIR EFFECTS OF SOLAR ENERGY

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***Abstract*: Now a day world is moving toward the renewable source of energy for generating power, especially focusing on solar energy. Solar energy is the most reliable and everlasting source of energy which fulfil the demand of power, though the initial cost of setup is high but it is compensate in the long. Because the running cost of solar system is very low. Solar energy can be utilized mainly in heat generation and electricity production. International energy agency (IEA) shows, in a comparative study on the world energy consumption that in 2050 solar arrays installation will provide about 45% of world energy demand. So, it is necessary to focus of research in the field of solar energy, many researchers have already working and get the useful data. So, in the same manner, here in this paper review of research in the field of solar energy was done.**

***Keywords:* Solar air heater, Review, heat transfer, process parameters, methods, mechanism**

1. Introduction

Energy demand is dependent on five different factors which include wealth status of a nation, the statistics of weather and climate conditions throughout the year, human populations, the efficient consumption of energy resources, and the energy conversion technologies. The growing energy demand of the globe has mainly been mitigated by the habit of non-renewable energy resources such as fossil fuels (oil, gas and coal) and nuclear energy. The use of these non-renewable energy resources contributes to environmental degradations such as acid rain, greenhouse gas emission, global warming and the depletion of natural resources. The global energy demand has been greatly influenced by the global human population growth which was rated at 1.23 % per year for the years between 2000 and 2015 (World-Bank 2017). This growing energy demand can be attributed to the increased economic growth and advanced lifestyles of luxury among individuals as well as technological advancements. Renewable energy has long been the interest quest in the field of electricity power generation. Considering the various renewable sources of energy, solar energy is considered the Earth's predominant source of energy but time and location dependent. The radiant heat as well as light approaching from the Sun can be converted directly or indirectly into different forms of energy. However, it is known that the solar power is being disadvantaged by the low efficiencies of the energy conversion systems. One of the drawbacks of solar power systems is the initial investment cost which restrains the masses from investing into the energy system. The economic disadvantage is associated with the increased costs of the installation of solar energy technologies while producing only a relatively small amount of energy related to other conventional energy system, thus characterized of low efficiency. As a result, the solar power still remains considerably a high cost energy option when compared to conventional energy sources such as the fossil fuels, nuclear and hydropower.

In recent years, there has been an increasing interest in utilizing the solar energy for electricity generation and various reviews have stated that the advantages of the solar technologies outweigh their disadvantages. For examples, some of the benefits of solar energy embrace free and abundant supply, and its environmentally friendly nature. Solar energy also is inexhaustible in supply which has recorded 1.8 × 1014 kW/hr interception on the earth surface out of the total 3.8 × 1023 kW/hr emitted by the Sun. The unlimited source of solar energy makes it a promising option to provide continuous supply of electricity to meet the global energy demand. Asian countries receive a reasonably high volume of solar radiation throughout the year. Even though the Asian countries receive higher solar radiation from the Sun with longer sunshine duration as compared to other temperate countries, solar energy is yet to be effectively harnessed in this region. Solar energy can be converted directly and indirectly to electrical power using different energy conversion systems.

The construction of solar energy-based power generating plants could prove to be beneficial in the long term, as initial investments on the solar power plants would serve to provide sustainable energy future for both urban and technologically less developed areas. Extensive researches have been supported out to improve the cost effectiveness of solar technologies for electricity production to allow the possibilities for the development of commercial solar power generation plants in the near future.

2. Solar Energy Collection

Presently, solar thermal systems are the most economical solar utilization technologies on a large scale. Solar thermal collector or solar collectors is a device which is used for the utilizing the solar energy. Solar collector is special type of heat exchanger that converts the incoming solar flux into the internal energy of the fluid that is used as a transport medium. Solar collector is the main component of the any solar utilization system. In a solar collector, the incoming solar flux is absorbed by the absorber plate and converted into heat energy that is then next transferred to the circulating fluid (usually air or water).

The circulating fluid flowing through the collector acts as a transport medium. The converted heat energy from the circulating fluid can be directly used to heat the water or space conditioning or it can be stored in a proper thermal storage tank from which it can be used in nights or during rainy or unclear days. Solar collectors can be broadly classified into two type's namely non-concentrating and concentrating collectors. A non-concentrating collector has same aperture area for receiving and absorbing solar flux, whereas in case of concentrating solar collector, concave aperture surface is used to receive and focus the solar flux to a smaller absorbing area, thereby increasing the amount of radiation for the same area of collector. The important features of different types of collectors are given below in Table 1.1

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

3. 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 generate high 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.

The current renewable energy technologies employed to adapt solar energy into heat and electricity. According to energy needs and conditions farms, this energy carrier has three operating sectors of the energy and can be represented by the diagram in Figure1.1.

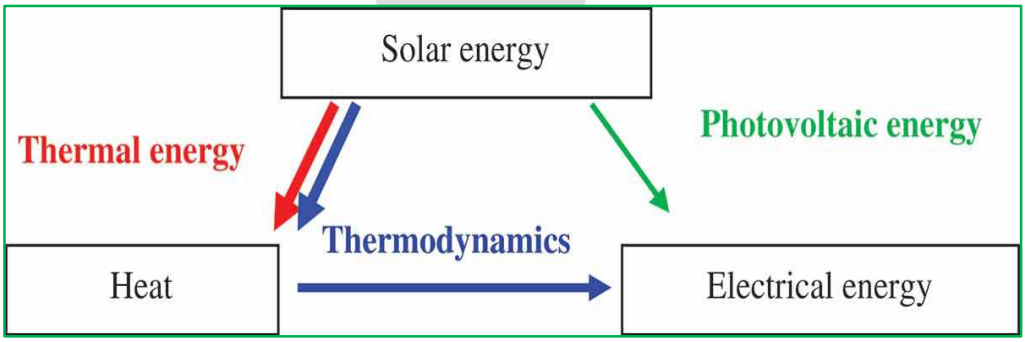

Figure:1 Conversion Types of solar energy Ref [2]

4. Existing Research work

Experimental as well as theoretical methods have been widely used for analysis of SAHs by many researchers in 20th century. However, with availability of high-speed computers new trend of CFD simulation in this field is becoming popular. At present CFD, simulation has major limitation regarding validation of its sample results with experimental investigations. However, it can be seen from literature CFD simulation results could be a substitute for extensive experimental investigations.

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 improving the efficiency of the collector of inclined SCPP through the use of underneath air-vents. The study employed numerical method using 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 revealed that with the use 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 observed that the air mass flow rate was increased by 210% and consequently the power output of the plant improved by 60%.

3. **Xu Haoxin et al. (2017)** have suggested the purpose of material assessment methodology in latent heat in thermal energy storage for the waste heat recovery purpose. He has made a details and systematic methodology of a PCM's assessment for the Latent Heat Thermal Energy Storage fabrication, which comprises the prescreening, ranking and performance objective examination based on Multi-Criteria Decision-Making tools. Firstly, a large candidate pool is pre-screened with the crucial boundary constraints. The material of solar air heater is then ranked by employing the Analytical of Hierarchy Process & Techniques for Order Preference by the Similarity to Ideal Solutions. Three distinctive objective functions are to suggested by explicitly evaluate the performance of Phase Change in Materials. Pareto solutions at top points are to be additional tools in the performance objective examination.

4. **Ayadi et.al [2017]** The objective of this work was to study and optimize the characteristics of a chimney power plant (SCPP) using numerical and experimental methods. The numerical simulations were simulated using the Ansys Fluent commercial CFD code. The effect of the collector ceiling height on the performance of the solar chimney is realized. The local characteristics of the airflow within the SCPP system have been presented and analysed, such as; the characteristics of temperature, speed, pressure and turbulence. The results confirmed that the height of the collector roof is very influential in the optimization of the SCPP. In fact, an increase in the power generated is recorded while the height of the roof of the collector is reduced. Since the optimization of the chimney device is characterized by high costs, this document could be a solution to improve the power generated by an existing chimney solar system.

5. **Hans *et.al* (2017)** experimentally evaluated the heat transfer and fluid flow characteristics of broken arc rib roughened solar air heater duct. The investigation considered rib parameters as relative roughness pitch from 4 to 12, relative gap width from 0.5-2.5, relative gap position from 0.2-0.8, relative roughness height from 0.022-0.043 and arc angle from 15˚-75˚ for Reynolds number range of 2000–16000. The enhancement obtained in Nusselt number and friction factor values were 2.63 and 2.44 times respectively corresponding to geometrical parameters as relative roughness pitch of 10, relative gap width of 1.0, arc angle of 30˚, relative gap position of 0.65 and relative roughness height of 0.043.

6. **Singh and Singh *et.al* (2017)** numerically evaluated the solar air heater duct roughened with non-uniform cross-section saw tooth rib. The 3-D CFD investigation encompassed the parameter range as Reynolds number from 3000-15000 and relative roughness pitch from 4- 30. The relative roughness height and saw-tooth angle were taken as 0.043 and 45° respectively. Both the Nusselt number and friction factor were maximum at relative roughness pitch of 16 for the investigated Reynolds number range. The maximum Nusselt number and friction factor enhancement over smooth duct was 2.18 and 3.34 respectively at Reynolds number of 15000 and relative roughness pitch of 16.

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. 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 aimed to examine the influence of geometrical parameters on the available power of stacked solar power plants (SCPPs) by design. The influence of different soil temperatures (mimicking the effect of different solar influences on the collector device) on the optimal shapes is also appraised. The geometry is subject to three limitations: sensor zones, turbines and chimneys. In addition, three degrees of freedom are taken into account: R / H (ratio between the bend radius and its entry height), R1 / H2 (ratio between the radius and the height of the chimney) and H1 / H (ratio between collector base height and sensor entry height) constant (H1 / H 10.0).

9. **Okoye et.al [2017]** The purpose of this paper was to raise awareness that Stacked Solar Power Plants (SCPPs) are a viable and sustainable alternative in rural communities with limited or no access to the grid. The study considered site-specific hourly meteorological data to assess the feasibility of SCPP in seven selected areas of Nigeria. A theoretical model has been developed for the power output, the electricity cost paid (LCOE) and the avoided CO2 emissions forecasts. In addition, the effects of seasonality on solar radiation, ambient temperature and energy were investigated. The outcomes revealed that the SCPP with a collector diameter of 600 m and a stack height of 150 m on a typical day under Nigerian conditions would yield an average power of 154 to 181 kW.

10. **Ghalamchi et.al [2016]** In this work, a pilot plant was built to study the temperature fields and obtain new experimental data. The sensor roof was made of 4 mm soda-lime glass and black aluminium foils were applied to the sensor absorber. In this work the temperature and velocity distribution in different pilot sizes and collector materials was described and compared. Lastly, the best condition was achieved and the maximum velocity of the fluid at the inlet of the chimney was 1.7 m / s and the best data with respect to the temperature of the absorber and the fluid were each 353.78 and 329.01 K. It has been noticed that reducing the size of the inlet has a positive effect on the performance of the solar fireplace, but this reduction has an optimum range and this optimum number is 6 cm for this configuration.

11. **Pandey *et.al* (2016)** Thermo-hydraulic characteristics of gapped multiple-arcs shaped roughness elements on absorber plate were analyzed. Conclusions on the base of results indicated good augmentation in *Nu* using this type of roughness configuration. Maximum augmentation achieved in *Nu* and f is 5.85 and 4.96 respectively. The maximum increment for Nu was found at Reynolds number value of 21,000, for geometric configuration (g/e = 1, d/x = 0.65, *W/w* = 5, *e/D* = 0.044, *P/e* = 8 and α = 60 °. Statistical equations were developed for Nusselt number and friction factor as function of various geometric and flow parameters.

12. **Kabeel A.E. *et.al* (2016)** Made an attempt to investigate the thermal performance of flat and vcorrugated plate SAH with and without PCM as medium of thermal energy storage. In this research he has carry out a practical investigation of flat & v-corrugated plate SAH with built in PCM as thermal energy of storage material. The integrated SAH with PCM was 12% more than the parallel ones without using the PCM , it is also 15% & 21.3% higher than the consequent values when the flat plate was used with & without PCM when mass flow rate is 0.062 kg/s, respectively.

13. **Hanna et.al [2016]** In this research study, they had constructed a experimental setup for ten run days in Aswan, Egypt to appraise the operation of the turbine inside the lantern factory. It has been perceived that ambient temperatures, however, play a vital part in the effect on the production of electricity for solar energy. Most importantly, the efficiency of the solar cooker is proportional to the temperature of the air from solar collectors, especially in the range of 1:00 to 3:00. Based on the result, it can be judged that the rotational speed of the fan can be chosen at 1650 rpm, with the average fan efficiency of 57%. The conclusion is that this digital model is a valid basis for the system to generate solar thermal output and the simulation model can easily be employed to predict the efficiency of any solar exhaust system.

14. **Driss et.al [2015]** In this work, numerical studies were carried out to investigate the turbulent flow around Savonius' unconventional wind rotors. This study compares various rotor designs characterized by blade elbow angles equal to 60 °, 75 °, 90 °, and 130 °, while the other geometric parameters are kept constant. Under these conditions, the third case concerns a conventional Savonius wind rotor. The results revealed that the design of the blade had a direct impact on the local properties. In particular, it has been perceived that the depression areas increase with increasing nose angle of the bucket. The large depression zone appears with $\psi = 130^{o}$. It is positioned in the concave surface of the blade and downstream of the rotor.

15. **Al-Azawie et.al [2014]** In this work, the conversion capacity of six different base materials that may be available in Malaysia has been investigated experimentally and numerically. An experimental device was built to record the measured data. In the FLUENT software environment, a numerical model was created to model and simulate the energy conversion process. The materials chosen were ceramics, black chalk, sawdust, dark green lacquered wood (DGPW), sand and pebbles. The results of the simulation showed good agreement with the experimental results in terms of air flow rate and energy conversion efficiency. Ceramic and black stone showed better performance on other materials. However, due to its availability, black stone is recommended as absorbent material in the solar chimney in Malaysia and the countries of 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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