

## Review Study on Solar Air Heater

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### ABSTRACT

Solar air heater is used efficiently in renewable energy heating technology. Since the era of thermal technology arose the need of solar air heater has been increased. By analyzing all the consequences and issues solar air heater has been developed which are now available in new design and also in cheap amount. This device used the unbendable energy solar irradiances and converts it into thermal energy. With different surface geometry, low cost of maintenance, converting the unbendable energy into useful form this device has been used as profitable appliances. In this review total coverage of working of solar air heater, its profits and demand has described in a simple way. Many problem can be tackled by used of solar air heater like energy storage its leakage, decreased in convective flow of air current etc. which has been discussed and also with their solution.

**Keywords:** Air Heater, Solar energy, Heat transfer, Nusselt number, Thermal efficiency.

### 1. INTRODUCTION

Solar energy; the unendable and remarkable energy which can be use in a way to create new path to introduce thermal energy in magnificent and renewable way. For this solar air heater is used commonly as heat exchanger. Air heating is the major solar application used in many ways. Nowadays use of conventional energy is going to decrease due to its high cost in place of this the use of solar energy is preferred which is unending and of low cost. Solar air heater have been in use for many year. In past decade many scientist has work on the concept of solar air heater like Ekechukwu and Norton. Many scientist has also classify the solar air heater in number of ways like it had classified based on mode into active, passive, and hybrid, also according to basis of tracking axis, energy storage, extended surface and number of covers and also classified on the basis of number of air passes into single pass and double pass. Two type of solar heater are there first is passive and second is active. In passive solar air heater hot air is generated and in active the storage material is utilised to generate hot air. They are also used at different time like passive is used in day time and active solar air heater is used in off day time. Considering its anatomy it consists of absorber plate, air flow duct and thermal insulation of low thermal conductivity on the side wall (to reduce the heat loss). In this context of this review paper the use, profit, new design, working, and the things in the consideration of solar air heater are discussed for its unsurpassed conceivable performance.

### 2. BRIEF HISTORY OF SOLAR HEATER

Solar air heater had been in views from the past decades. Daniels and Duffie had reported the use of heat stored in the iron in 1877. In 1881 the first design of solar air heater was established and also it was produced by E. Morse which works purely on convection. Many solar heating home were developed in past decades. At present a technology known by the name of phase change material and has lots of application in all over the world has been established between 1946-1949 by the two residence Massachusetts who have introduced the new way by using the chemical compounds that absorbs and release heat for solar air heating. This research was continued unto 1978 by building three more houses in MIT. A modern research in solar air heating was begins at Massachusetts which was marked by Scientist named Cabot (1938). Baymond (1949) defined a solar home at dover. The main objective of this system was to carry the total heating load. A fully solar heated device was developed in Arizona desert by Bliss

(1955). An overlapped transparent glass plate type solar collector Lof (1959) had designed the solar heating system. He also investigated the all over performance of this solar air heater for year. In Australia an another solar air heater used for limited heating of laboratory was described by Close et al (1968). Since further decade and unto 1970 many designs of solar air heater are introduced which had been in practice for many years. Many different design of European ‘solar combisystem had been discussed by Weiss (2003).

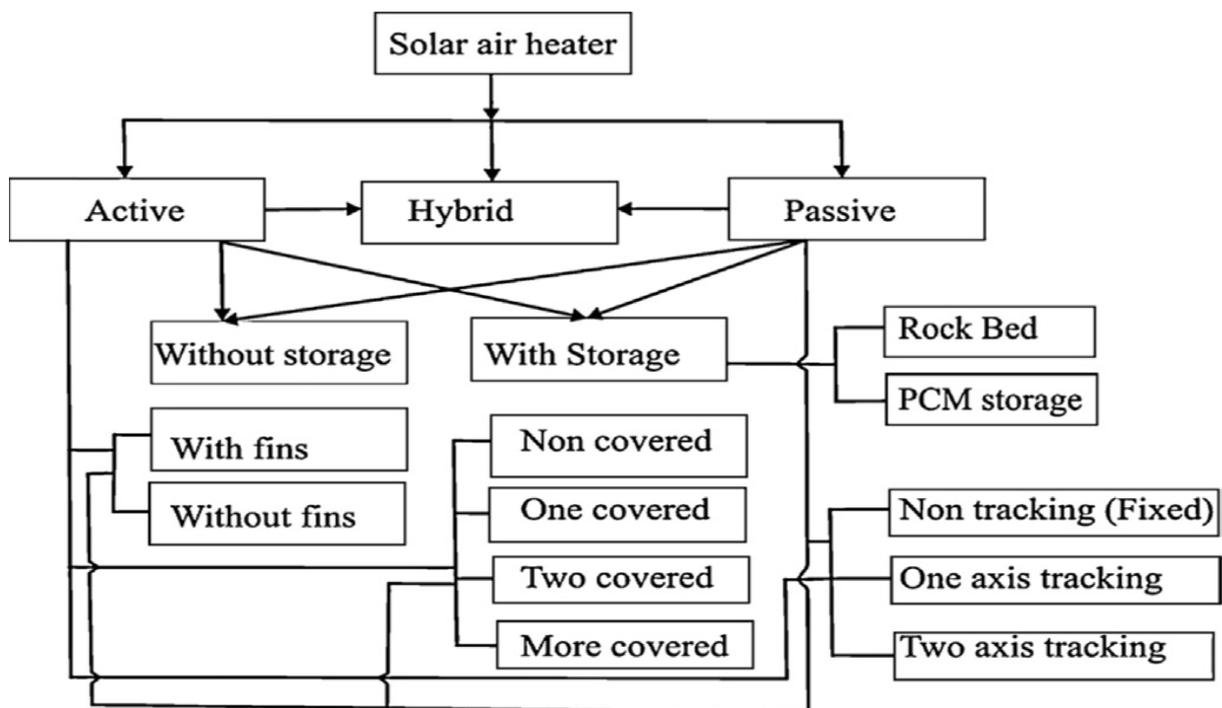
**3. SOLAR AIR HEATER**

Solar air heater works by use of solar energy which is collected and use in many ways.

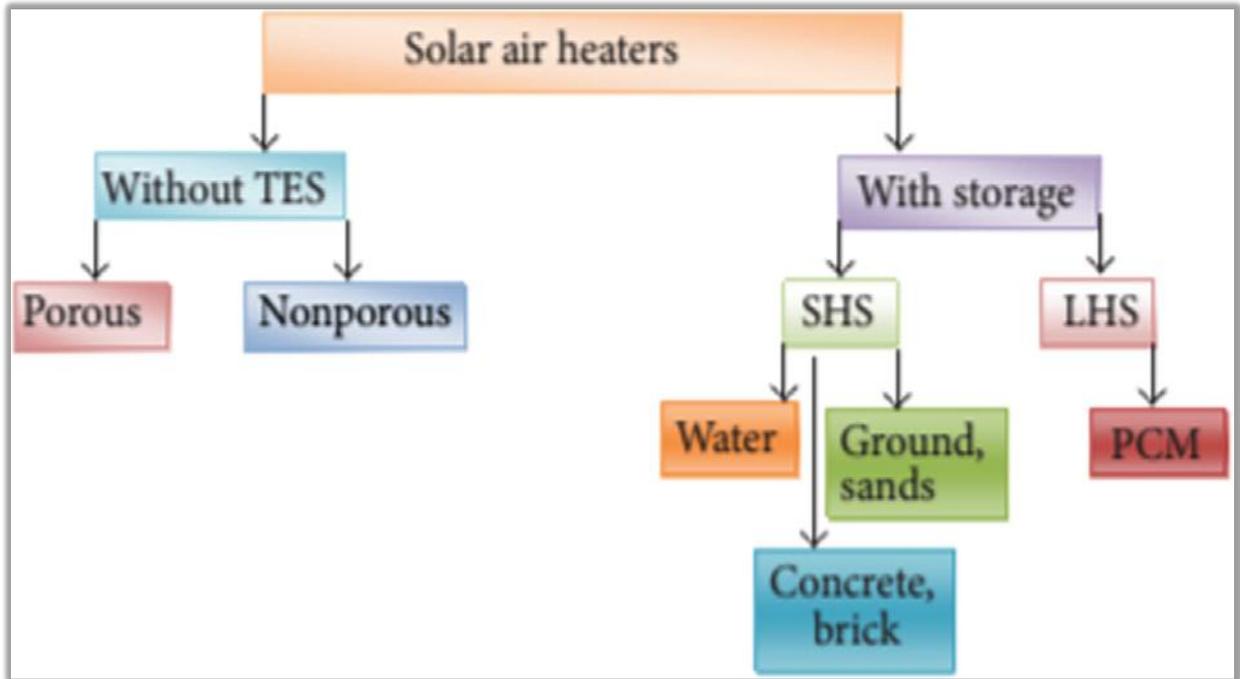
When the absorbing surface of the solar air heater is exposed to the solar energy or the irradiance of the sun, the irradiance of the sun get absorbs and get transferred to the collecting system which can be fluid like air or water flowing through the tube. The most commonly used fluid is water. The fluid filled in this does not get freeze even at the temperature lower than zero degree. The bottom is presented with stiff roughness and provided various shape to enhance the heat transfer. The leakage of heat is prevented by the insulation present on bottom and sides which is economically very important point.

**4. CLASSIFICATION OF SOLAR AIR HEATER**

Numerous classification has been done of solar air heater. First on the bases of passes into single pass and double pass. In single pass the air is blown in one way direction either below or above from the absorber plate but in double pass solar air heater the air passes from the two passage. It has also been classify into active and passive. In active solar air heater storage materials are utilised to generate hot air and in passive solar air heater hot air is generated and directed to use.



**Fig.1.** Classification of the SAHs



**Fig.2.** Classification of solar air heaters on the basis of TES

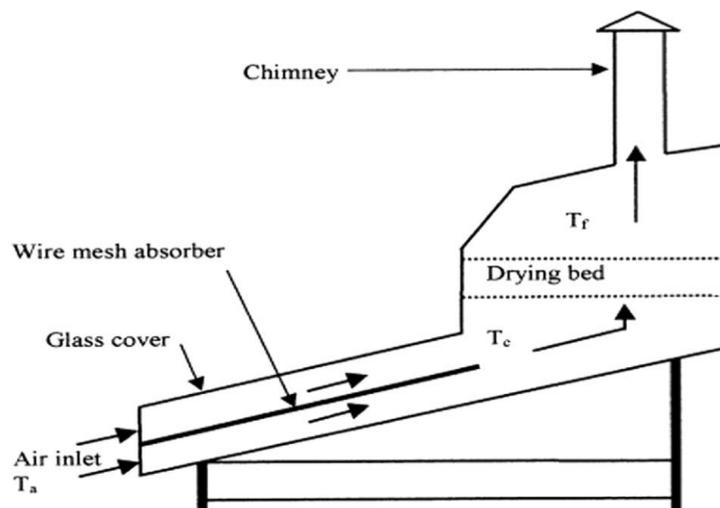
### 5. VARIOUS TYPE OF SOLAR AIR HEATER

Basically all solar air heater are classified into two category

1. Air heater porous absorber plate
2. Air heater with nonporous absorber plate.

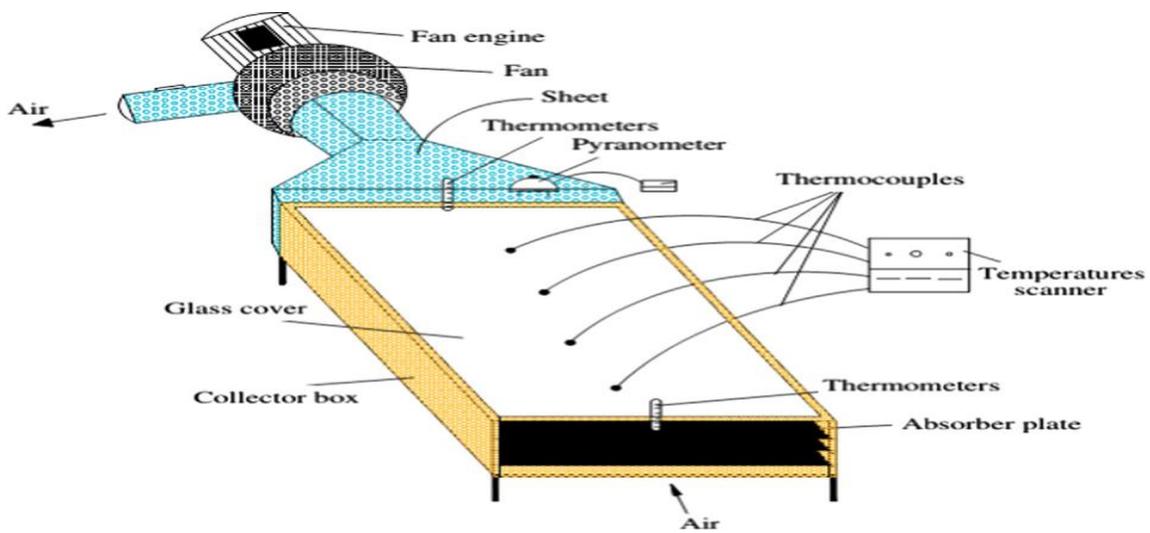
### 6. VARIOUS DESIGN OF SOLAR AIR HEATER

There are numerous type of solar air heater. In which first is focusing type solar air heater in which mirror and lenses are used to focus the solar energy into a small zone. In another design of flat plate collector (FPC) the fluid first get heated with the commerce of the surface than that fluid is get heated with solar radiation.

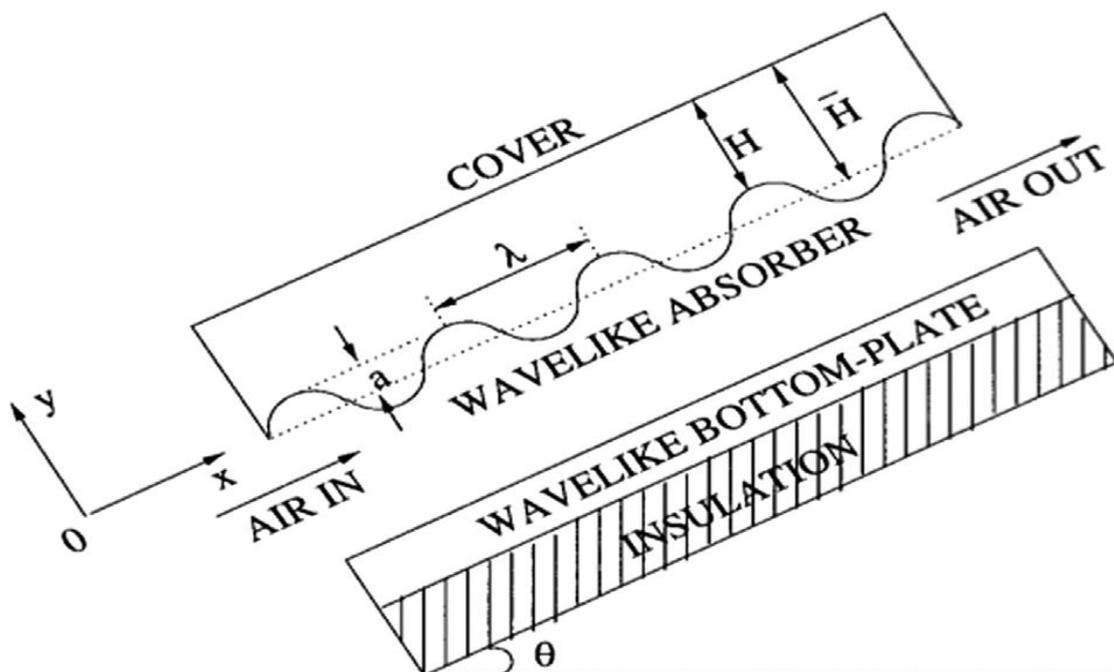


**Fig.3.** Simple design solar dryer for agriculture crop aeration

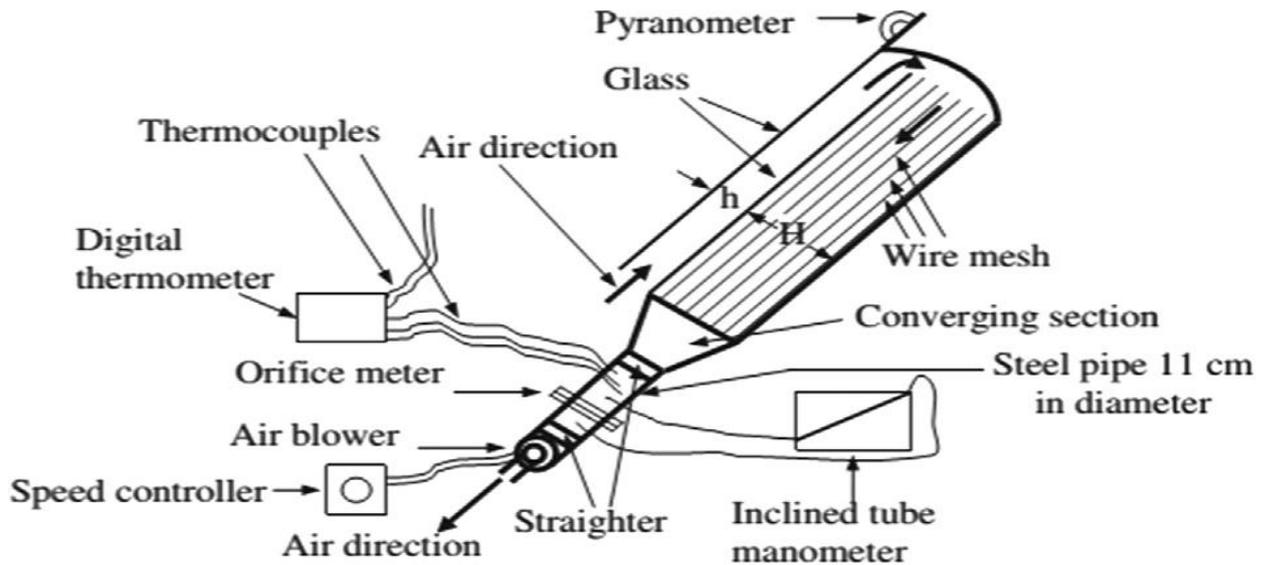
Another is air type solar heater which has a great application in agriculture work i.e. used in agricultural aeration. The main advantage of the air type is that leakage is very low which is best point economically diagrammatic representation of air type has been shown in Fig.3. A scientist named Chau et al. had also designed an inflated plastic solar air heater. Other scientist namely Singhal and Bansal have designed the fabricated matrix solar collector. They had used the broken glass pieces by supposing that they are thermally efficient and economically cheaper. Ranjan et al. other scientist who had developed the heat transfer model which is very much useful in predicting the transient response. In order to the performance of duct type solar air heater garg et. al had provided rectangular fins in the air passage between the absorber and rear plate. Two scientist have studied the five modals or design of solar collector. In this design flow line upsurges in narrow section and lengthened geometry. \*Different solar air heater designs have been shown below-



**Fig.4.** Schematic of a double-flow SAH having different obstacles on absorber

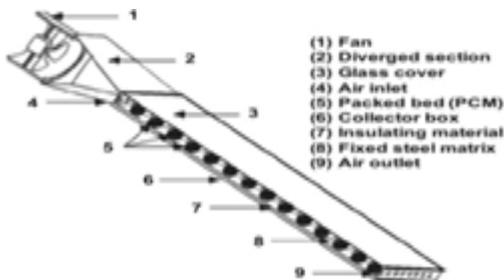


**Fig.5.** Schematic diagram of the cross corrugated SAH



**Fig.6.** Schematic diagram of the experimental setup of a single and double pass SAH

In passing decades the designs made by the scientist had improved the efficiency of the solar air heater. The 11-14% increased efficiency than double pass conventional solar air heater the double pass v-corrugated plate solar air heater was come in knowledge. To express the thermal behaviour of solar air heater of double pass counter flow and double pass counter flow Quinonez had developed the two different analytical models. The analytical expressions which are developed are useful important tool to be included in computational code. The other design is artificially roughened surface, the thermal performance and experimental results in heat transfer had represented by Prasad. Bouadila et al. want to study the performance of solar air heater with latent storage collector so he has constructed the test rig. Considering its anatomy it has made up of packed bed absorber which was made up of spherical capsule with dark coating. Krishnanath and Kalidasa, fabricated a design in which the outlet and inlets are made up of conical section for uniform flow, the heater of this counter flow double pass solar air heater is coated with dark colour and in addition to this it was integrated with paraffin waxes in six aluminium capsules.



**Fig.7** SAH with latent storage material [13]



**Fig.8.** Cross-sectional view of the experimental test-rig

Many scientist has given forth the various designs various experimental data, researches have been made

## 7. HYBRID SOLAR AIR HEATER

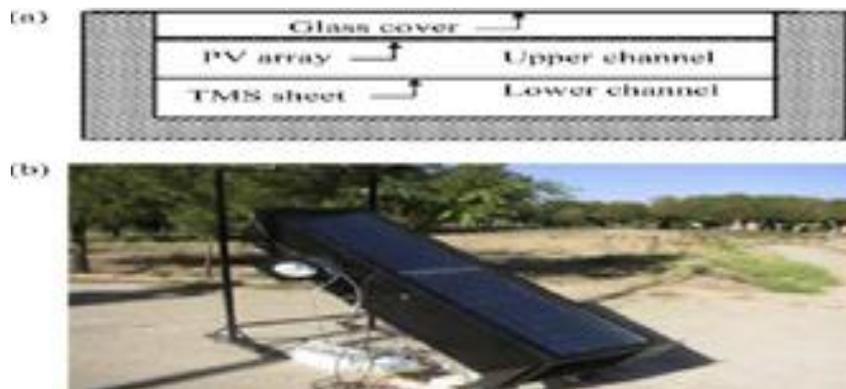
To enhance the performance of the solar air heater hybrid of solar air heater is prepared. Hybrid system has provided a additional system that not only have greter efficeincy but also has the long time performance. A scientist hughes et al had two type of off-peak solar energy system. The advantage of this system was that the sufficient

amount of energy will inside the system. With effective heat storage and necessary haet recovering facilities, Forsstbm and



**Fig.9.** A prototype PV/T air collector

Lund, these scientist had developed had developed the simple model of solar air heater this has been provided by the auxillary power. By creating the air turbulance and by outspreading the heat transfer area Yeh and Ting, using the stuffing of iron fillings in the middle of the absorber plate and glass plate had improven the performance of solar air heater. By developing the mathematical model bhargava had analysed a hybrid system cosisting of solar air air heater with PV solar system. A lenear relation was used to calculate the variation of ‘ $\eta$ ’ of solar cell with temperature. By seeing the low cost, cheap plastic was used by Misra who have developed three hybrid solar air heater the present hybrid system was fabricated with plastic air heater. Garg and Adhikari had analysed the performance of a conventional photovoltaic/thermal (PV/T) air heater. A simple diagrammatic representation of PV/T shown in fig.9. Two scientist (Shahsavari and Ameri) had developed a new model in a hybrid form PV/T solar air heater. In this system a new concept was applied in this the dual panels are associated in parallel which were equestrian on the air panel beneath which a thin aluminium sheet is positioned. This aluminium sheet is used advance the heat abstraction, ultimately due to which the heat and electricity amount produced are also upsurge. Experimenting proved that its efficiency surges due increase in air mass flow and thus the heat transfer coefficient upsurges



**Fig.10.** (a) Cross-sectional view of studied PV/T air collector. (b) Photograph of experimental Setup

For single glass and double glass configurations various parameter of performance are calculated. CPC used to increase the intensity of the falling solar irradiance. Taking this system advantage Othman had designed the prototype. The absorber of this system consists the array of the cell due to which the falling radiation are also used to produce the electricity. Heat transfer is also the part of solar air heater so to increases the heat transfer the fins are also used in this system at the back side of the absorber plate. Results were obtained by using the energy balance equation. An Integrating model of thermal solar water/air and PV heating system was developed by Tiwari and Sodha. As a functions of climatic and design parameter an analytical expression for solar temperature and water and overall  $\eta_{\text{therm}}$  of the system was derived. Dubey a scientist had derived the expression of N hybrid PV/T air collector which were connected in series. The two different cases are considered that are the air collector are fully covered with the PV module and the air flow below and above the absorber plate. This system is very beneficial because it is very much practicable to accomplish the requirement of hot air for aeration purposes and also for the generation of electricity concurrently. By many scientist the experimental and mathematical validity of the different was carried out in detailed.

## 8. METHOD OF ENHANCEMENT IN SOLAR AIR HEATER PERFORMANCE

In past decade many scientist had came and smear there effort for the advancement in the performance of solar air heater. Many method are apply many parts are arranged to improve the performance of the solar air heater. Many configuration are remove and many configuration are added for there improvement some of them are discussed in brief below

**First is the the use of fins:** the objective of the use of fins is to increase the efficiency so these are used to increase the area of heat transfer hence if the heat transfer increases the productions of electricity and the efficiency of the solar air heater also increases. Several types of fins are used which are as folow: longitudinal fins, corrugated fins, attaching baffels.

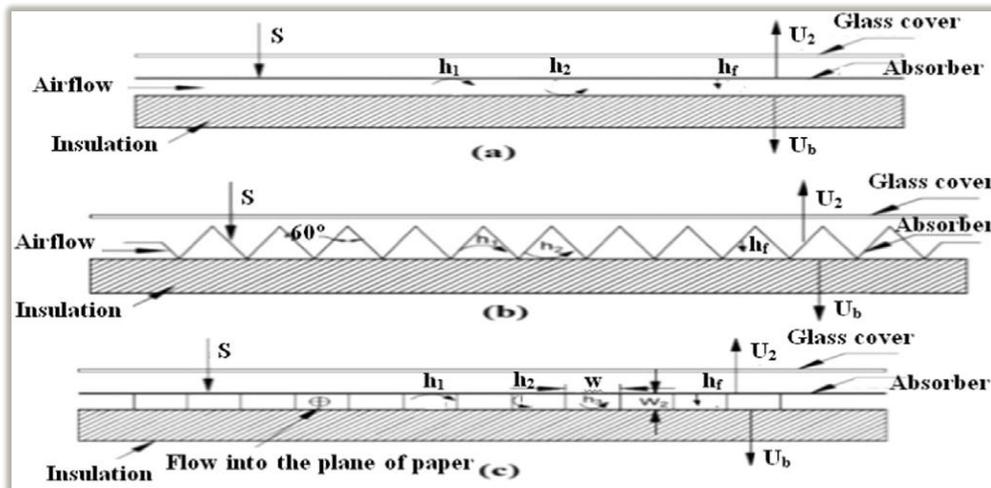
**Longitudenal fins :** the influence of fins number, height and fin arrangement has also result in the increase in the efficiency of the solar air heater. Longitudenal fin results in the increases in the height. Paisarn a scientist who had the predict the effesct of height and number of fins on the heat transfer by creating a mathematical model. He witnessed that the performance and the entropy generation has get double.



**Fig.11.** Photo for the experimental test rig

**Attaching baffles:** as discussed up Bayrak et al. had designed the test-rig to the performance and efficiency theoretically and experimentally. two different air mass flow rate are considered that are 0.016 and 0.025kg/s. It was observed that lowermost and the maximum efficiency and temperature growth of air are reached by the heater at respective air flow rate.

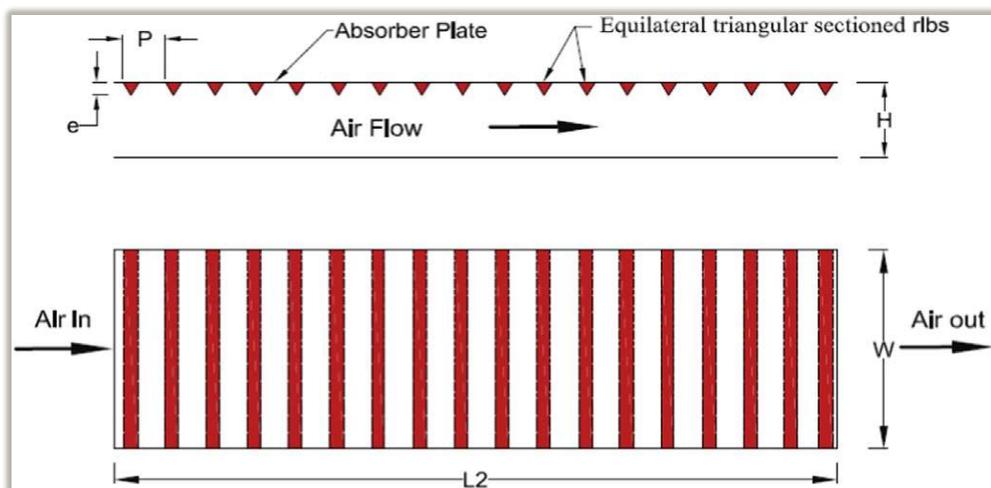
**Corrugated fins:** experimentally and theoretically flat plate, finned and v-corrugated solar air heater was studied by the two scientist named Karima and Hawlader, it is was shown that these are 5-11% and 10-15% more effectual in double pass and single pass mode correspondingly. Fig. below shows layout of the tested collectors.



**Fig.12.** Layout for a- Flat plate solar air collector, b- V-groove air collector and c- Finned collector

As investigated by the El-Sebaai et al. double pass v-corrugated plate solar air heater is 9.3-11.9% more efficient than double pass finned plate solar air heater by studying the effect of air mass flow rate on pressure drop.

**Second the effect of artificial roughness:** turbulent flow was required at the transfer surface for the enhancement of forced convection heat transfer flow, for this the artificial roughness was created on the surface of the heat transfer thus to increase the thermo-hydraulic performance of solar air heater.

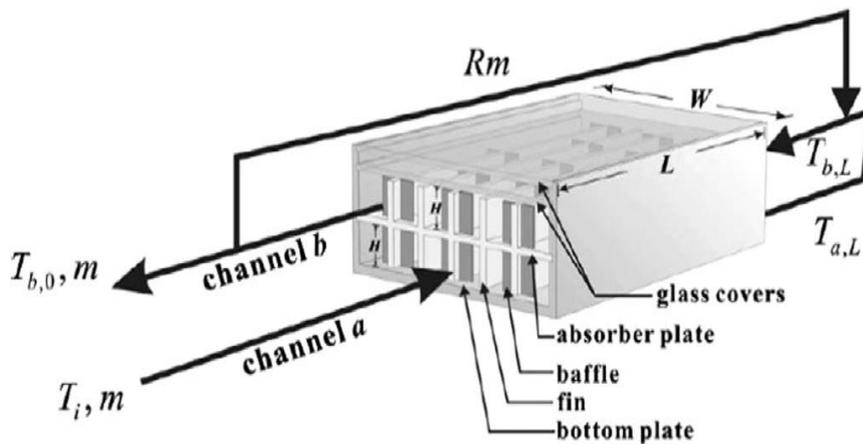


**Fig.13.** Schematic representation of a roughened absorber plate

Creating the turbulence in the flow has also reduces the power requirement. Many scientist have given their contribution in this like Yadav and Bhagoria there study concerned with the impression of comparative roughness pitch, comparative roughness height and Reynolds number on the thermos-hydraulic performance of the roughened heater for this they proposed a two dimensional CFD model of a solar air heater as shown in the fig:

The results are studied which displayed that the average Nusselt number has the propensity to upsurges with increases in Reynolds number.

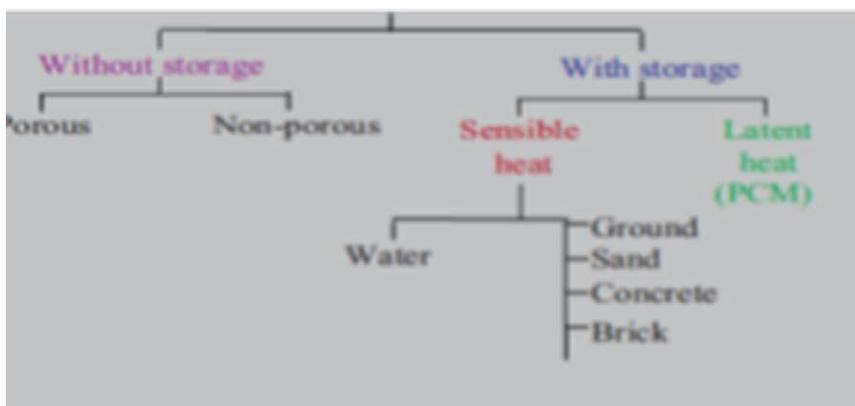
To evaluate the performance in the terms of the ratio of energy augmentation, effective energy augmentation and exergy augmentation at various roughness parameters and various Reynolds number of expanded metal network roughness geometry Gupta and Kaushik accomplished a study on exaggeratedly roughened soar air heater. The augmentation had get improved by the use of expanded metal network type roughened solar air heater as shown in fig.14.



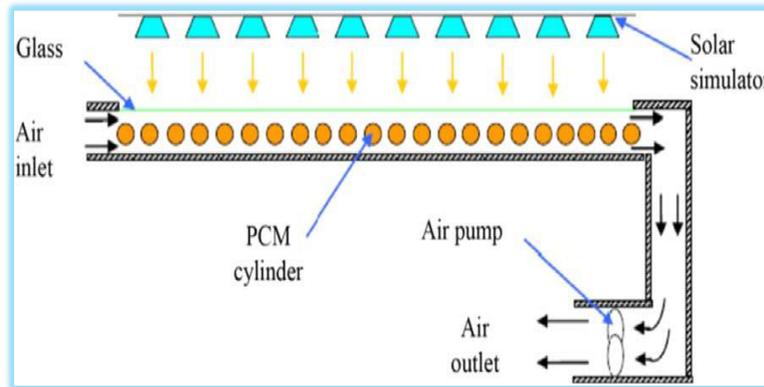
**Fig.14.** Baffled SAH with internal fins attached and external recycle

**Third is effect of the use of the storage materials, absorbers coating and packed bed:**

To increase the performance of the solar air heater energy storage absorbers coating with the dark substance and packed bed are getting used in addition to the role of solar air heater in conserving the energy. Energy storage solar air heater are used .in those areas where the temperature dissimilarity is much higher in day and night time. Two type of storage materials are there first is latent and second is sensible as shown below:



The most famous storage material is phase changing material which get melted while it is storing the energy. Alkilani et al. had gathered a setup shown below which was integrated with the phase changing material to envisage the output temperature. As shown in fig, glass cover and the PCM were divided into cylinder which act as absorbing material. There was interior one in the PCM entailed of the paraffin waxes of about the mass fraction of 0.5% aluminium ash.



**Fig.15.** A SAH with PCM cylinders

El-Sebaai and Al-Snani has investigate the performance of solar air heater by exciting it with dissimilar dark painted and selectively covered absorbers, for this they presented a model that was a transient mathematical model. Studying this model best efficiency was achieved using the Nickel-tin as a coating material. The total energy loses was dropped to 30%. Plus point is this that the rate of useful energy was increases by 30.95%

## 9. CONCLUSION

*Based on the present and above review it can be clinched that:*

Solar air heater, it was very valuable/ beneficial device which had been transformed time by time and is used in a sustainable way that it uses the solar energy which can be store further, can used to generate hot air, can be used to generate the thermal energy etc. many other application are there of solar air heater as conversed above. For the forthcoming generation it can used as the energy accomplishing device. It is advance further by the researcher to improve its efficiency thus by doing this the only solar air heater does many kinds of works alone. Solar air heater is used on low operational cost. Equating to those device which are being use in today's world the loss by use of solar air heater are zilch. Various designs of solar air heater are which the more focusing tendency of solar irradiance than those of simpler one. This focusing tendency thus further increase the efficiency of the solar air heater. Hybrid of the solar air heater are coming in there role. Various scientist have put their efforts to develop the hybrid model. From these models it can be concluded that these hybrid solar air heater have come more efficient storage power, more efficiently producing the electricity, at low input giving the better results and high rate of the flowing air. A hybrid of photovoltaic/thermal solar air heater is a good example of hybrid solar air heater. From the method which are applied to enhance the performance of the solar air heater like the use of different types of fins, use of the storage materials(like tin and nickel), by creating the artificial roughness on the surface, use of absorber coating(coating with dark substance/colour) has incremented the working efficiency by creating the turbulence in

the air flow, by increasing the absorbing coefficient of the solar energy, by increasing the quantity of the flowing air. In this review an attempt has also been made to compare its efficiency, to prove its increased efficiency, and the profit we got from solar air heater.

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