HEAT TRANSFER ENHANCEMENT IN SOLAR DUCT WITH ABSORBER PLATE: A REVIEW

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Abstract

Three-dimensional computational fluid dynamics (CFD) analysis of a solar absorber plate has been carried out using V shaped wavy grooves as artificial blockages on the absorber plate. The Reynolds number (Re = 4500–22,000) are chosen as design parameters for analysis. A constant heat flux of 1000 W/m2 is developed on the surface of absorber plate. ANSYS FLUENT 15.0.0 with renormalization group K-epsilon turbulence model was adopted for simulation. An enhancement in Nusselt number and friction factor is presented and discussed with reference to base paper results. The effect of different types of wavy grooves and Reynolds number on enhancement of Nusselt number and friction factor is also presented.

Keywords — *Computational Fluid Dynamics, V shaped, U shaped Transverse shaped wavy grooves, artificial roughness, Nusselt No., Friction factor*

I INTRODUCTION

1.1 Solar power

As all of us know that the herbal assets of fossil power are restricted this is available in the form of oil and stable substance like crude oil, coal and plenty of others. They are used at very big scale because of this they are depleting a good deal faster charge. Hence is the need of the current situation to discover opportunity source of electricity. Solar energy is finding as the one of the most easily available, maximum promising and crucial renewable supply of electricity. It is to be had in considerable shape at anywhere in earth. It is also very smooth to capture and utilized it. The simplest way to applied and save solar electricity is to transform it in to heat power which is basically applied for heating purposed. Heating air through sun electricity form the most important component of sun power exercising gadget. After burning the fossil fuels harmfully greenhouse gases (CO2, SO2, NOx) can stay as byproduct, which causes better degrees of acid rain throughout the rainy season, it additionally will increase the amount of harmful atoms in air which create air pollutants, because of the increase of chlorine atom in ecosystem depletion of ozone layer is also occurring and additionally causing worldwide warming. It is predicted that globally it's miles going to increase very quicker fee in future because of expectancies of a good sized growth in power and heat call for. The heated air electricity call for relates with specific area is pretty substantial. Solar electricity air warmers were used with the intention to decreasing the proportion of consumption of traditional fuels to a totally huge extent. The residential and commercial sectors are larger purchasers of fossil electricity. Therefore, the heating device and air con devises of residential and industrial buildings generate an huge amount of CO2 and many other gases that is responsible for worldwide warming. Fossil energy required to warmness and strength required to preserve air-conditioning of the homes also can be reduced by the use of renewable assets as alternative to fossil electricity (Sanjay and Vilas, 2014)[14]. Heating of air the use of sun radiation is a generation where the radiation coming from the sun, this is solar radiation, is entrapped through an absorbing medium and utilized for air heating. It is a generation that uses inexhaustible power for conditioning of air or keeping the temperature of homes or for exceptional other purposes (Omajaro and Aldabbagh, 2010) [2].

Solar heater is the most most economical and green solar technologies, which is widely used due to their easiness in area heating, getting rid of the moisture from wooden, used for drying the industrial products, vegetables and culmination. They may be extensively utilized in combination with photovoltaic solar absorber panels which is used to fabricate photovoltaic thermal hybrid sun strength collectors (hybrid PV/T structures or PVT) to produce heating impact or to generate electricity. The fundamental advantages of sun energy collectors are: the fluid that's flowing inside the creditors does not get freeze or boil, they cannot create noise at some stage in flowing, the working of sun panel device may be very secure and the running price is likewise very less, system cannot produce any kind of harmful wastes and the jogging existence of sun machine is likewise long sufficient lifestyles cycle (Abdullah and Bassiouny, 2014).[5] but sun energy creditors have some following drawbacks: low density, the thermal absorption ability of solar panel is low and the thermal conductivity of air is likewise low which lead to low thermal efficiency, excessive value gadget set up and non-uniform rate of heat technology

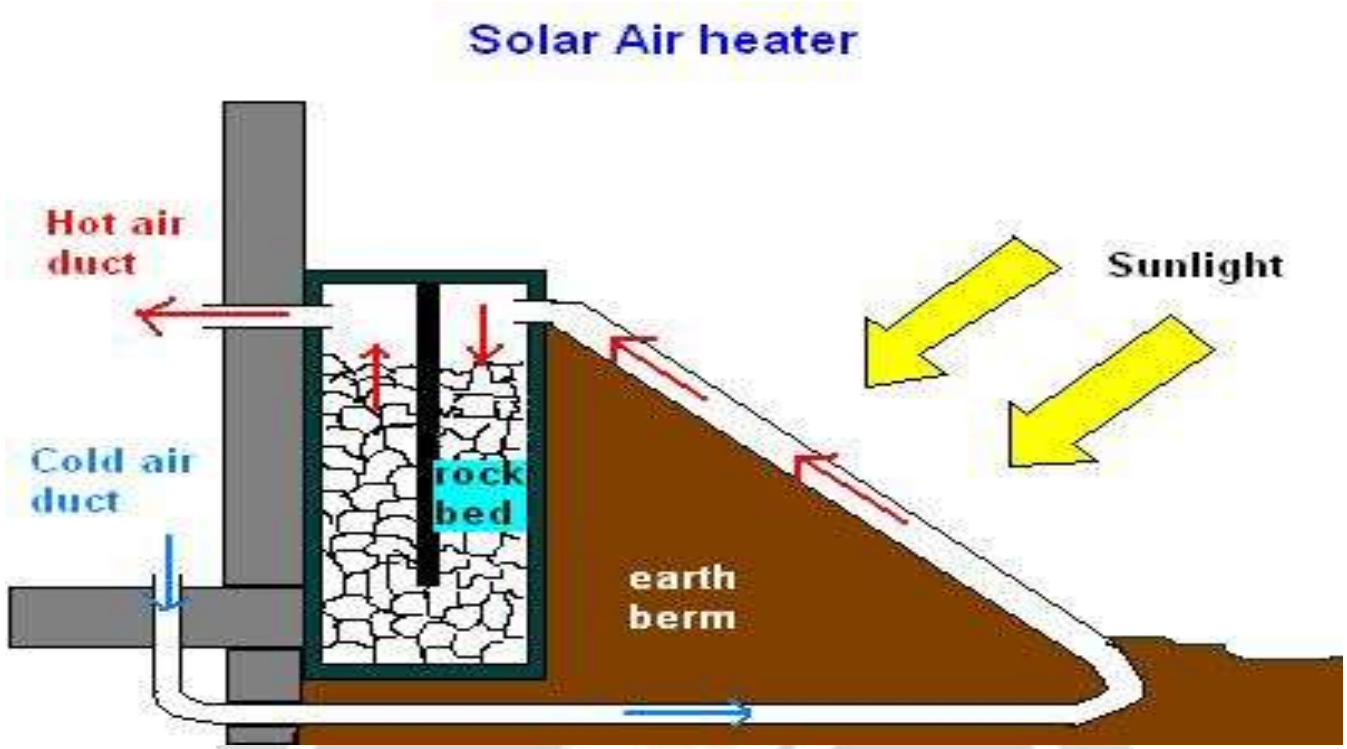

Fig.1.1: solar power air heater

1.2 Classification of solar air heater system based on different type's solar power collector

Collectors are commonly classified by their air ducting methods as one of three types

Through-pass collectors
Front-pass
Back-pass
Combination front and back pass collectors

III SOLAR ENERGY COLLECTORS

Solar collectors are the key component of active solar-heating systems. Solar collectors gather the sun's energy, transform its radiation into heat, then transfer that heat to water, solar fluid, or air. The solar thermal energy can be used in solar water-heating systems, solar pool heaters, and solar space-heating systems.

Solar energy collectors are classified as:

(1) Flat plate collectors.
(2) Concentrating collectors.

If the area of interception of solar radiation is same as the area of absorption, the collector is known as flat plate collector.

3.1 Flat Plate Collectors

Flat-plate collectors are the most common solar collector for solar water-heating systems in homes and solar space heating. A typical flat-plate collector is an insulated metal box with a glass or plastic cover (called the glazing) and a dark-colored absorber plate. These collectors heat liquid or air at temperatures less than 100°C.

The major components of Flat Plate collectors are:

- The absorber plate used for absorbing solar radiations, normally metallic with a black surface. A wide variety of other materials can be used with air heaters. It is usually one plate or an assembly of metal sheets or plates forming a nearly continuous surface coated with radiation absorbing black paint, black porcelain enamel or a metallic oxide.
- A transparent cover which may be one or more sheets of glass or radiation transmitting plastic film or sheet. As the number of covers increases, the loss of heat from top of collector decreases while intensity of radiation incident on absorber plate also decreases.
- Tubes, passages or channels are integral with the collector absorber plate or connected to it, which carry the water, air or other fluid to transfer energy from absorber plate to the fluid.
- Insulation, provided at the back and sides to minimize heat losses.
- The casing or container, which encloses the components and protects them from the weather.

3.2 Concentrating Collectors

A concentrating collector utilizes a reflective parabolic-shaped surface to reflect and concentrate the sun's energy to a focal point where the absorber is located. To work effectively, the reflectors must track the sun. These collectors can achieve very high temperatures because the diffuse solar resource is concentrated on a small area. In fact, the hottest temperatures ever measured on the earth's surface have been at the focal point of a massive concentrating solar collector. Concentrating collectors have been used to make steam that spins an electric generator in a solar power station. This is sort of like starting a fire with a magnifying glass on a sunny day..

IV PERFORMANCE EQUATIONS FOR A SOLAR COLLECTOR

The performance of solar collector is described by an energy balance that indicate the distribution of incident solar energy into useful energy gain (Qu) and heat losses like bottom (Qb) and top (Qt). The details of the performance analysis of a solar collector are discussed by Duffie and Beckman [31] and Goswami [41].The heat transfer in a solar collector takes place by simultaneous radiation, convection and conduction. The heat transfer from the top takes place by convection and radiation while from the side and bottom is by conduction. The net rate of useful energy collected per unit area is the difference of the amount of solar energy absorbed and the energy loss by the collector to the surroundings

V USE OF ARTIFICIAL ROUGHNESS ON ABSORBER PLATE

Use of an artificial roughness on a surface is an effective technique to enhance the rate of heat transfer to fluid flow in the duct of a solar air heater.

Artificial roughness can be produced on a surface by:

(a) Blasting sand/grain over it.

(b) Fixing grooves and ridge.

(c) Fixing wires and ribs of different geometry such as round, rectangular, V-shaped or broken ribs etc.

Use of artificial roughness within the kind of perennial ribs of various geometry on the absorbent material plate has been found to be an economical technique of enhancing the performance of solar air heater.

The low worth of convective heat transfer coefficient is usually attributed to the presence of laminar sub-layer on the heat-transferring surface. A roughness component is employed to enhance the heat transfer constant by making turbulence within the flow. the factitious roughness (ribs) on heat transfer surface breaks up the laminar boundary layer of flow and makes the flow turbulent adjacent to the wall and enhance the heat transfer. However the utilization of ribs leads to a better friction loss resulting in higher excessive power demand for the fluid to flow through the duct. So as to stay the friction losses at an occasional level, the turbulence should be created only within the region very near the duct surface, i.e. in laminar sub layer. This could be done by keeping the peak of the roughness parts to be small as compared with the duct dimensions

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