EDUZONE: International Peer Reviewed/Refereed Multidisciplinary Journal (EIPRMJ), ISSN: 2319-5045
Volume 12, Issue 2, July-December, 2023, Available online at: www.eduzonejournal.com

Thermal Performance Analysis of Wire Mesh Solar Air Heater

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ABSTRACT

Solar energy is a clean, renewable energy that is used for drying, desalination and hot water heating. Solar energy, one of the renewable energy sources, is an alternative energy source with many advantages compared to fossil fuels. Air heating has a wide range of industrial applications and electric heating coils are commonly used to achieve this purpose, which consumes a lot of energy. Air humidification is also commonly used in the dairy and pharmaceutical industries. The aim of the current work is to design and develop an experimental setup to enable hot air dryers using solar energy as a heat source and to achieve this objectivewire mesh solar air heater is fabricated and K Type thermocouples are used to measure temperature at various locations and blower is used to supply air to the heater.

Keywords: Wire Mesh Solar Air Heater, Solar Energy, Renewable Energy, K-type thermocouples

INTRODUCTION

Energy is the main driver of economic growth and essential to the survival of modern economies. Future economic growth will depend heavily on the long-term availability of energy from affordable, accessible and environmentally friendly technologies. Major uses of solar energy include solar hot water and heating, solar drying of crops, salt production by evaporating seawater, solar community scale distillation, solar cookers, solar motors for pumping water, heating and cooling of building, solar power generation, heat high temperature applications etc. They can be broadly classified into thermal applications and electrical applications. Compared to other solar collectors, solar air heaters (SAH) have some distinct advantages. The main difference between liquid plane collectors and air heaters is the type of heat transfer from the absorber plate and working medium. Air heaters eliminate the need to transfer heat from one working medium to another. Air is used directly as working medium. The system is not very complicated and compact.

TabishAlam [1], using winglets in air heaters is an effective way to generate turbulence and hence boost the heater's heat transfer rate. According to research conducted by Anil Singh Yadav [2], adding artificial roughness to the ducts of a solar-powered air heater improves its effectiveness by increasing the rate at which heat is transferred to the fluid flowing through the duct. The thermal performance of a double-pass solar-powered air heater with fins and baffles was tested by Chii-Dong Ho [3] in a recycling operation. Using a novel solar collector design, FouedChabane [4] was able to achieve the transfer of heat in a solar based air heater. Experiments have been conducted to compare the collector efficiency of a solar air heater with and without fins connected under the absorbing plate. The purpose of this research, conducted by AlirezaZendehboudi [5] in a warm and humid region of Iran, is to evaluate the efficiency of a Solar Desiccant Cooling System manufactured by TRNSYS. M. A. Aravindh et al. [6] looked at creating a solar air heater using wire mesh as the absorber due to its nominal porosity and its potential use in drying applications. Air is permitted to circulate via a double-layered wire mesh that was employed as absorber material in this innovation. The impact of various obstructions on the thermal performance of a solar air heater was experimentally investigated by EbruKavakAkpinarit et al. [7]. In this work, we evaluated four different solar air collectors and compared their first and second-law efficiencies. The layout of a solar powered air heater featuring offset strip fins has been optimized using numerical modeling by Ming Yang, Xudong, et al. [8]. A.A. El-Sebaii et al. [9] investigated how changing the coating on the absorber plate of a solar air heater affected its efficiency. Using exergy analysis, M. Sabzpooshani et al. [10] looked into the efficiency of solar air heaters. Exergy efficiency was studied by changing variables such as fin and baffle dimensions, glass cover count, bottom insulation thickness, and inlet air temperature across a range of mass flow rates.
Solar air heaters using granular carbon as the absorbing media were developed and tested by Abhishek Saxena et al. [11]. .Rizzi et al. [12] designed and fabricated a simple (brick) solar collector storage system integrated with the FP-SAH. Fath [13] presents the thermal efficiency of a simple designed SAH. Chauhan et al. [14] tested a solar dryer combined with a SAH stone bed that can work even outside of sunny hours. Enibe [15] designed and evaluated the performance of a passive solar air heating system with potential application in crop drying. Abbaspour-sani [16] explains that fixed bed units are the most suitable storage units for SAH. Ozt¨urk et al. [17] studied the thermal performance of SAHs with flow channels filled with Raschig rings. Naphon [18] investigated the properties and heat transfer performance of dual-transfer FP-SAH with and without a porous medium. El-Sebaii et al. [19] investigated the thermal performance of double-layer, double-layer HSA with an encapsulated bed. Prasad et al. [20] studied a HAS packing bed using wire mesh as the packing material. Karwa et al. [21] used sturdy, fully perforated baffles that attach

to the wide, uniform heatpipe wall. BKMaheshwari et al. [22] experimentally studied the performance of SAH with semi-perforated septum. Bhagoria et al. [23] conducted experiments to determine the effects of wedge-shaped ribs on many factors. Experiments were performed by Sahu and Bhagoria [24] on transverse rift coasts, and their effects on heat transfer properties were evaluated. The effect of discrete and horizontal slopes on the thermal performance of SAH was investigated by Varun et al. [25].

Arun Kumar Yadav et al [26] carried out CFD Based Performance Analysis of Artificially Roughened Solar Air Heater. Alok Bharti et al [27]reviewed the various methods used for enhancement of the heat transfer rate with little penalty of friction in SAH. Varun Pratap Singh et al [28] focused on comparative evaluation of thermal performance of several roughness geometries and kinds of SAH. Ashish Ranjan et al [29] studied the effect of half rhombus on thermal performance of solar air heater.

Ekechukwu et al [30] conducted a detailed review on different designs, construction and principles of operation of a wide variety of SAHs for drying. Chabane et al. [31] fabricated a single pass solar air heater and evaluated its thermal performance. Bayrak et al. [32] investigated the performance of five collectors using baffles made of Closed-cell aluminum foams. El-Sebaii et al. [33] constructed an experimental test rig for double pass SAH. Gao et al. [34] constructed a baffled double-pass SAH and carried out thermal performance of same. Bouadila et al. [35] constructed an experimental test-rig to study the performance of a SAH with latent storage collector. Krishnananth et al [36] fabricated a counter flow double pass SAH. Yamali et al [37] fabricated the double-pass solar air heater in which copper sheet with black color coating is used.[38-47] Anand Patel et al. [48] HD Chaudry et al [66] [67] Patel Anand. includes research studies about thermal performance evaluation of different geometries of solar sir/water heater and solar cooker to enhance heat transfer capabilities for faster heating.

The solar based energy has wide application apart from solar heater which are [49, 50] Patel Anand et al. for heat exchanger devices [51, 52] Nikul Patel et al for biofuels. The research studies [53-65] thermal efficiency improvement in solar air heater construct with steel wire mesh and fins as an alternative to an absorber plate.

EXPERIMENTAL SET UP

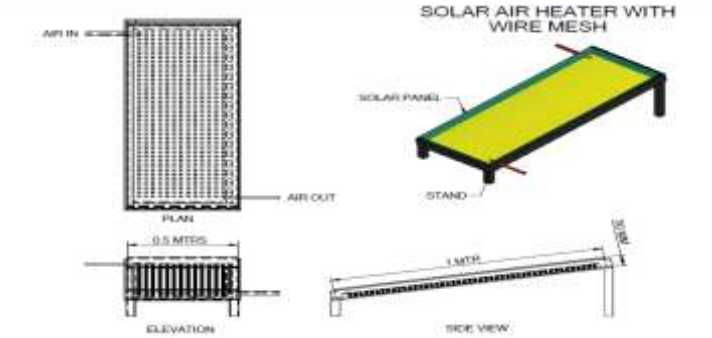

Fig 1: CAD Model of Experimental Set up

Fig 2: Wire Mesh Solar Air Heater

Fig 3: Assembly of Experimental Set up

In this work the wooden box which having dimensions of 1.1 m X 0.6 m X 0.05 m is fabricate and the bottom of the box consists of absorber plate of 0.5 mm thick and top portion is covered with 2 mm thick transparent cover. In the box wire mesh of 20 meshes is placed over absorber plate and box having air entry and air exit facility is provided. The blower is used for air supply and K type thermocouples are used for temperature measurement.

RESULT AND DISCUSSION

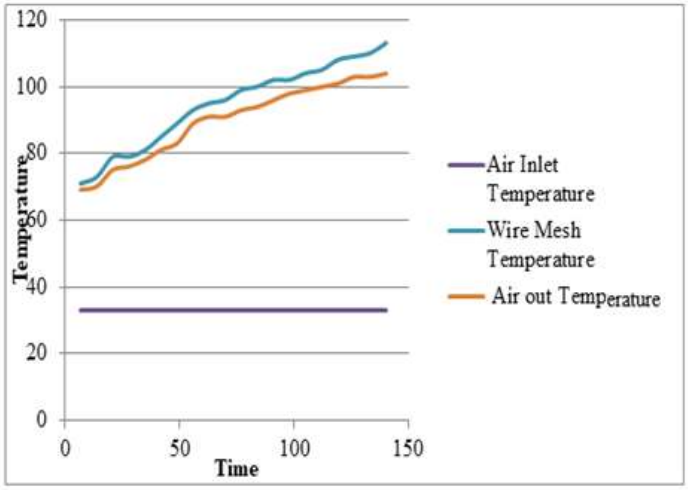

Fig. 4: Various Temperature Variation of Solar Air Heater with respect to time

Table 1: Result Table

Ma Kg/s	Qa kW	Qi kW	Efficiency %
0.004	0.15	0.68	22.41
0.004	0.16	0.68	23.03
0.004	0.18	0.68	26.14
0.004	0.18	0.68	26.76
0.004	0.19	0.68	28.01
0.004	0.20	0.68	29.87
0.004	0.21	0.68	31.12
0.004	0.24	0.68	34.85
0.004	0.24	0.68	36.10
0.004	0.24	0.68	36.10
0.004	0.25	0.68	37.34
0.004	0.26	0.68	37.96
0.004	0.26	0.68	39.21
0.004	0.27	0.68	40.45
0.004	0.28	0.68	41.08
0.004	0.28	0.68	41.70
0.004	0.29	0.68	42.32
0.004	0.29	0.68	43.57
0.004	0.29	0.68	43.57
0.004	0.30	0.68	44.19

Fig 4 temperature variation in case of solar air heater and Table 1 Shows results obtain by experimentation on solar air heater. Here the role of wire mesh is to create turbulence in the air flow which leadsincreases the temperature of air and in case of air turbulence is necessary to improve the rate of heat transfer; additionally, the wire mesh behaves like thermal source which stores the solar heat energy when there is proper orientation of sun on set up.

CONCLUSION

The major conclusion of present work is that wire mesh better and cheapest option to improve thermal performance of solar air heater.

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