Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 109 (2017) 463 – 470

Energy Procedia

International Conference on Recent Advancement in Air Conditioning and Refrigeration, RAAR 2016, 10-12 November 2016, Bhubaneswar, India

Performance analysis of trapezoidal corrugated solar air heater with sensible heat storage material

D.V.N.Lakshmi[a]*, Apurba Layek[b], P. Muthu Kumar[c]

[a]Assistant Professor,C.V.Raman College of Engineering, Departmentof Mechanical Engineering,Bhubaneswar 752054,India.
[b]Associate Professor, Departmentof Mechanical Engineering ,NIT Durgapur,Durgapur, India.
[c]Department of Mechanical Engineering, Indian Institute of Technology Guwahati, Guwahati-781039, India.

Abstract

The energy and exergy analysis of solar air heater having absorber plate corrugated in the shape of trapezoid along with sensible heat storage material is carried out. Gravel is used as a sensible heat storage material and placed below the absorber plate. Thermal performance analysis of solar air heater with and without sensible heat storage materials is carried out and compared with flat plate solar air heater. The parameters such as solar radiation intensity, temperatures at various positions in solar air heater, and daily thermal and exergy efficiency are calculated. The average daily thermal efficiency of flat plate solar air heater and that having trapezoidal corrugation are 8.5% and 12.2% respectively, while trapezoidal corrugated absorber with sensible heat storage material shows thermal efficiency of 36.6%.The maximum exergy efficiency obtained having trapezoidal corrugated absorber with sensible heat storage material is 12.56 %.

Peer-review under responsibility of the organizing committee of RAAR 2016.

Keywords: **Solar air heater, Sensible heat storage, Trapezoidal corrugated absorber plate.**

1.**Introduction:** Given the geographical location, India has enormous scope to generate solar energy. This accounts to the fact that India is a tropical country and hence receives solar radiation throughout the year, which may be as much as 3,000 hours of sunshine equivalent to more than 5,000 trillion kWh. Approximately, 4-7 kWh of solar radiation per square meters is received by all parts of India, that being equivalent to 2,300-3,200 sunshine hours per year. The states like Andhra Pradesh, Bihar, Gujarat, Haryana, Madhya Pradesh, Maharashtra, Odisha, Punjab,

* Corresponding author. Tel.: +91-8763760530; fax: +91 674 2113593.
E-mail address:lakshmiratan2311@gmail.com

Peer-review under responsibility of the organizing committee of RAAR 2016.
doi:10.1016/j.egypro.2017.03.069

Rajasthan and West Bengal are with benefit in tapping solar energy. The state Odisha receives sunshine for over 300 days a year, owing to its location. Approximately, 5.4 to 5.6 kWh per sqm of daily average solar radiation is incident on Odisha according to the solar radiation map of India. Either solar photo voltaic or solar thermal collectors can be used to store solar energy available. These collectors are classified based on the circulation of fluid [1] as solar water and solar air collectors and also another classification based on the mode of circulation of fluid natural and forced convection. The main application of solar air collectors are for heating the buildings and drying of grains. Enibe [2] developed and modeled a natural convection solar air heater with energy storage material. The authors found that the outlet temperature of air is decreases with increasing gap spacing. Gao et al [3] carried out analytical and experimental studies on two types of cross corrugated solar air heater and compared with the flat plate collector, they found that efficiencies of type 1 and type 2 absorber are about 58.9%, 60.3% where the flat plat has about 48.6% of efficiency .The efficiency of corrugated collectors are high and turbulence enhances the heat transfer as a result efficiency is more. Esen [4] carried out the experimental study for a double flow solar air heater placed different obstacles on the absorber plate and compared with a solar air heater without obstacles on the absorber plate. The authors measured inlet and outlet temperatures and absorber plate temperatures and found that exergy efficiency of flat plate collector is less compared to collector with obstacles which is mainly due to irreversibility's are more in flat plate collector. The obstacle creates a good turbulence and reduces the dead zones so efficiency of collector with obstacles is more compared to the collector without obstacles. Many authors [5-8] carried out their analysis with different shapes of obstacles placed on the absorber plate and they have studied the energy and exergy efficiencies. Many solar air heaters are reported in the literature and the disadvantage of these collectors that, they can't store solar energy after sunshine hours. For continuous space heating the energy required for longer hours this can be done by incorporating thermal energy storage materials. In the present work, the authors carried out experiments with and without sensible heat storage material (Gravels) with the solar air heater.

Nomenclature

A_c	=	Collector area (m^2)
Ex_i	=	Exergy associated with mass flow rate of air entering in to the solar collector
Ex_o	=	Exergy associated with mass flow rate of air leaving the solar collector
m	=	Mass flow rate of air at exit of collector (kg/S)
I	=	Intensity of solar radiation (W/m^2)
Q_u	=	Useful Heat gain (Kw)
T	=	Temperatures
h	=	Specific Enthalpy of air (kJ/kg)
s	=	Specific Entropy of air (kJ/kg-K)

Greek Letters

η	=	Efficiency

Subscripts

i	=inlet
o	=Outlet
th	=Thermal
Ex	=Exergy

2.Experimental Setup: The schematic and experimental setup is shown in Fig.1.The air heater is mainly divided in to four major parts absorber plate, glass cover, insulation material and SHM. Single flow with 2 m length × 1m width × 40 cm depth solar air heater fabricated with locally available material. The experiments were conducted in the C.V. Raman college of Engineering, Bhubaneswar, Odisha, India. The Bhubaneswar city is located with latitude