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Heat Transfer Analysis on Finned Plate Air Heating Solar Collector for its Application in Paddy Drying

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Abstract

The performance of an extruded finned plate air heating solar collector is studied theoretically for paddy drying applications. Climatic conditions and solar radiation data are accounted based on Guwahati region (26.11˚N, 91.72˚E). Outlet air temperature and pressure drop are considered as controlling parameters to find optimum number of fins, fin height and fin thickness. Outlet air temperature increases and then decreases with number of fins whereas pressure drop increases with number of fins. The analysis showed that finned plate air heating solar collector with 80 fins, 0.6 Height (H) to-Duct length (D) ratio and 2 mm fin thickness yield best results for paddy drying applications at Guwahati weather conditions.

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Keywords: Air heating solar collector; Paddy drying; Number of fins; Fin height; Fin thickness

1. Introduction

Flat plate solar collectors are very popular among various non-concentrated solar thermal collectors because of their simple design and wide range of applications. Flat plate air heating solar collectors are widely used for space heating

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in households and for drying purposes in industry, agricultural fields, and laundry. Several improvements in design have been proposed by various researchers to increase the heat transfer in flat plate solar collectors. One of the several design methodologies includes increase in heat transfer area of the collectors using longitudinal finned absorber, reflecting finned absorber, rectangular finned absorber etc.

Garg *et al*. [1] theoretically analyzed the heat transfer augmentation in flat plate solar collectors for various controlling parameters such as number of fins, air flow rate, length of the fin, duct depth etc. Yeh *et al.* [2] studied the collector efficiency of double pass solar air heater with internal fins attached. It was reported that the collector efficiency is best achieved when the optimal fraction of airflow rate, r is 0.5, and when r and (1-r) go away from 0.5, the thermal performance decreases. Naphon [3] analyzed the entropy generation and performance of double pass solar air heater having longitudinal fins on both sides of the absorber plate. It was found that the thermal performance increases with the fin height, number of fins and reduction in entropy generation. Pakdamn *et al.* [4] analyzed the rectangular finned air heating collector for natural convection and reported that the effect of solar radiation is found to be 79 times greater than the effect of ambient air condition. Ho *et al.* [5] analyzed the performance of double pass solar air heater with baffles and fins. The thermal efficiency of the design was compared with two other double pass solar air heaters with and without fin, respectively and the analysis revealed that the presence of baffles has significant contribution in increasing the efficiency. Fudholi *et al.* [6] analyzed the presence of rectangular fin attached to absorber plate for double pass air heating solar collector and reported that the proposed system produced energy efficiency of 10-78% with the outlet temperature of 35-115^oC. Yang *et al.* [7] experimentally and theoretically evaluated the effect of presence of offset strip fin on solar air heating collector. The instantaneous thermal efficiency was found to be 40% at 100 m^3/h mass flow rate, 600 W/m^2 solar irradiation, 20 W fan power, 14^oC indoor air temperature, 5^oC outdoor air temperature and 0-30^o incident angle.

Modifications in the design of solar air heating collectors with the help of rectangular longitudinal fin have received considerable attention. However, study of effect of longitudinal rectangular fins in single pass solar air heater is still limited. The aim of this article is to determine the optimum number and height of the longitudinal rectangular fin in single pass solar air heater for its application in paddy drying. The simulation is carried out for two different fin thicknesses to find out maximum heat transfer and minimum pressure drop.

Nomenclature

A	Area of heat transfer (m^2)	L	Length of the collector (m)
B	Breadth of the collector (m)	m	Mass (Kg)
C	Specific heat of solid (J/Kg K)	m_{flow}	Mass flow rate (Kg/s)
C_p	Specific heat of fluid (J/Kg K)	R	Conduction heat transfer resistance (W/m^2K)
D	Duct depth of the collector (m)	R_b	Geometric factor
D_h	Hydraulic diameter (m)	R_d	View factor to the sky
H	Fin height (m)	R_r	View factor to the ground
I_b	Total beam irradiance (W/m^2)	T	Temperature (K)
I_d	Total diffused irradiance (W/m^2)	t	Fin thickness (m)
Greek Symbols		Subscripts	
a	Air gap	α	Absorptivity
ab	Absorber	β	Tilt Angle of collector (˚)
c	Glass cover	γ	Reflectivity
f	Fluid	τ	Transmissivity
fi(n)	Fin node	ε	Emissivity
ib	Bottom surface of insulation		
it	Top surface of insulation		