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Thermal performance investigation of double pass-finned plate solar air heater

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ABSTRACT

In this paper, the double pass-finned plate solar air heater was investigated theoretically and experimentally. An analytical model for the air heater was presented. Numerical calculations had been performed under Tanta (latitude, 30° 47′N and longitude, 31°E) prevailing weather conditions. The theoretical predictions indicated that the agreement with the measured performance is fairly good. Comparisons between the measured outlet temperatures of flowing air, temperature of the absorber plate and output power of the double pass-finned and v-corrugated plate solar air heaters were also presented. The effect of mass flow rates of air on pressure drop, thermal and thermohydraulic efficiencies of the double pass-finned and v-corrugated plate solar air heaters were also investigated. The results showed that the double pass v-corrugated plate solar air heater is 9.3–11.9% more efficient compared to the double pass-finned plate solar air heater. It was also indicated that the peak values of the thermohydraulic efficiencies of the double pass-finned and v-corrugated plate solar air heaters were obtained when the mass flow rates of the flowing air equal 0.0125 and 0.0225 kg/s, respectively.

1. Introduction

The main applications of solar air heaters are space heating, drying of agricultural and paint spraying operations. Solar air heaters are simple in design and maintenance. Corrosion and leakage problems are less severe compared with liquid heater solar systems. The main drawback of solar air heaters is the low heat transfer coefficient between the absorber plate and the air stream due to poor thermal conductivity and low heat capacity of air, which result in a lower thermal efficiency. However, different modifications are suggested and applied to improve the heat transfer coefficient between the absorber plate and flowing air. One of the effective ways to increase the convective heat transfer rate is to increase the heat transfer area or to increase turbulence inside the flowing channel by using fins or corrugated surface [1–5] where many studies have been carried out in this topic. The influence of recycle on the performance of baffled double-pass flat-plate solar air heaters with internal fins attached is studied by Ho et al. [6]. Alta et al. [7] investigated experimentally three different types of solar air heaters, two having fins and the other without fins, one of the heaters with a fin had single glass cover and the others had double glass covers. Based on the energy and exergy output rates, they concluded that, the heater with double glass covers and fins is more effective and the difference between the input and output air temperature is higher than the others. The performance of single and double-pass solar air heater with fins and steel wire mesh as absorber is investigated experimentally by Omojaro and Aldabbagh [8]. They found that, the efficiency increase with increasing air mass flow rate and for the same mass flow rate, the efficiency of the double pass is found to be higher than the single pass by 7–9%. Karim et al. [9] investigated the thermal performance of flat plate, v-corrugated and finned air collectors. They concluded that, the v-groove collector is the most efficient collector and the flat-plate collector is the least efficient one. They found also that the v-groove collector has 7–12% higher efficiency than flat-plate collectors. Optimum conditions of these three collectors are studied to perform up to approximately 70% thermally efficient at 0.031 $kg/m^2 s$ could be attained with the v-groove. Nwosu [10] investigated the pin fins attached to the absorber of a solar air heater. Application of folded sheet metal in flat bed solar air collectors is presented by El-Sawi et al. [11]. The performance analysis of a new flat-plate solar air heater with several obstacles at different angles and without obstacles is experimentally studied by Akpinar and Kocyigit [12]. They found that the efficiency of the solar air collectors depends significantly on the solar radiation, surface geometry of the collectors and the extension of the air flow line. They concluded also that, the largest irreversibility was occurring at the solar air heater without obstacles collector in which collector efficiency is smallest. The formation of the thin boundary layer at the absorber plate surface commonly known as the viscous sub-layer is another reason of the low heat transfer

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