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Effect of selective coating on thermal performance of flat plate solar air heaters

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ABSTRACT

A transient mathematical model was presented for a single pass flat plate solar air heater. This model was based on an analytical solution of the energy balance equations for various elements of the heater. The flowing air temperature was assumed to vary only in the flow direction. The thermal performance of the heater was investigated by computer simulation using the climatic conditions of Jeddah (lat. 21° 42′ N, long. 39° 11′ E), Saudi Arabia. Effects of solar radiation intensity, mass flow rate of the flowing air ($\dot{m}_f$) and the length (L) and width (b) of the absorber plat on the flowing air outlet temperature (T_{fo}) and the heater instantaneous (η_{inst}) and daily (η_d) efficiencies were studied. To improve the heater performance, effect of using absorber plates coated with various selective coating materials on the heater performance was also investigated. The best performance was achieved using nickel–tin as a selective coating material with a daily average of the instantaneous efficiency of 0.46. To validate the proposed mathematical model, the simulated results were compared with the measurements that had been performed for the heater with a black painted absorber plate under Tanta, lat. 30° 47′ N (Egypt), weather conditions. It was found that the proposed model is able to predict the T_{fo} accurately with a daily average relative percentage error of 7.7%. It was also inferred that the annual average of η_d with a nickel–tin selectively coated absorber is higher than that with a black painted absorber by 29.23%.