ABSTRACT

The effective utilization of solar energy requires that the performance of solar collectors be accurately predicted. There is, to date, no analysis which can predict accurately the performance of most designs of flat-plate solar collectors. The aim of this study, therefore, is the development of a generalised analysis for the prediction of the performance of flat-plate solar collectors.

The generalised performance equation for flat-plate solar collectors is derived by a novel method developed in this work. A generalised multi-pass solar air heater is postulated and the mathematical model of this collector is derived. It is then shown that this model is capable of representing any multi-pass solar air heater design. This model yields closed form solutions for the temperature distributions of the plates and air streams. Procedures are given whereby the matrices of any multi-pass solar air heater can be easily obtained by inspection, thus rendering the modelling of any multi-pass solar air heater a simple and routine matter. The model is capable of predicting the performance of multi-pass solar air heaters when both the hydrodynamic and thermal boundary layers merge within the flow channels and also when neither the hydrodynamic nor thermal boundary layers merge within the flow channels.

The HWB model is shown to be a simplified form of the generalised model developed in this work and a generalised method, based on this model, is presented for the determination of the overall loss coefficient, the

collector efficiency factor and the effective transmittance-absorptance product for single pass solar air heaters. This method reduces considerably the algebra involved in the determination of these parameters and is also more accurate than the conventional method. An application of this generalised method to a single pass solar air heater indicated the explicit dependence of the effective transmittance-absorptance product on the collector back loss coefficient.

It is then shown that the generalised performance equation for multi-pass solar air heaters is the generalised performance equation for flat-plate solar collectors.

As an example, the generalised performance equation for flat-plate solar collectors is then used to predict the performance of a two-glass cover solar air heater when operated in both the single pass and two-pass modes of operation. It is concluded that the two-pass mode of operation leads to improved collector performance.