Abstract

Transfer of heat can take place either due to a difference in temperature or due to change of phase. Accordingly, it is termed as sensible or latent heat transfer. There are some typical equipment which exploit both sensible and latent heat transfer. Such equipment are unique as they often transfer a substantial amount of heat across a small temperature difference; thereby they are preferable both from aspects of energy conversion and environmental protection. Many of these equipment either require low amount of electrical energy or are passive devices. Therefore, their relevance in the domestic, commercial and industrial sector need not be over emphasized. In the present work, the analysis of three such devices namely evaporative heat exchangers, pot-in-pot refrigerator, and cooling and dehumidifying fins are attempted and their performance has been evaluated over a wide range of operating parameters.

Cooling towers and air washers can be termed as evaporative heat exchangers. The most recent technique of cooling tower analysis, termed after the name of its proposer, the Poppe method, relaxes most of the approximation adopted by the earlier analyses. Cooling tower analysis by the Poppe method is outlined in the present work as the basis of evaporative heat exchanger analysis. Based on that, the analysis of air washer has been developed. The performance of some specific air washers has been made over a wide variation of operating parameters. Next, the same methodology has been used to develop the formalism of effectiveness-NTU analysis of air washers. This effort has brought this unique direct contact heat exchangers for heat and mass transfer in the general ambit of a design of the traditional heat exchangers.

A pot-in-pot refrigerator or a clay pot refrigerator is a typical evaporative refrigerator used in case electricity is not available or affordable. In this work, this low-cost, passive, environment- friendly device is investigated both experimentally and theoretically. The tests have been conducted for three such devices in an environmental chamber at different relative humidity and dry bulb temperature and the test results have been utilized to obtain the pot efficiency, the COP and the variation of other parameters with the ambient conditions. Besides, both a one-dimensional steady state analysis and a transient, axisymmetric two-dimensional analysis of the device have been conducted. The presence of the porous medium as clay and sand have been given a special considerationfor modelling the clay pot. The effect of ambient conditions on mass transfer coefficient, evaporation loss, hydraulic conductivity of clay and sand have been studied and analyzed. Experimental results and theoretical predictions provide a close match (within 2%).

Lastly, an extensive experimental investigation followed by a theoretical analysis has been done on solid and porous fins for cooling and dehumidification of ambient air. The dehumidification of air or the condensation of water vapour occurs only when the temperature of the fin is lower than the dew point temperature of the air passing across the fins. The visual observation of dehumidifying phenomenon over a fin inside an environmental chamber identifies four stages which include larger droplets, very fine droplets, the film like region and dry region. The porous fins are found to have a tendency to retain the condensate. This will prevent further direct contact between the fin material and air. The suitability of porous fin for dehumidification application should be judged carefully. The maximum dehumidification occurs at the base of the fin. The porous fin is also subjected to forced convection. Good comparison between theory and experiment is observed.