ABSTRACT

The plate-fin heat exchanger constitutes one of the most important components of various cryogenic systems, chemical process plants and aerospace applications. Plate-fin heat exchangers ranging from tiny to very large ones operate at a wide range of NTU and Reynolds number. It imposes a number of stringent constraints on the designer to meet the operating conditions. Crossflow plate-fin heat exchangers are one important member of the compact plate-fin heat exchanger family, which need a greater attention from the research community. The present work concentrates on optimum design and thermal performance of crossfow plate-fin heat exchangers. Optimum design of plate-fin heat exchanger has been obtained, using Genetic Algorithm based on minimum entropy generation units and total annual cost separately. Steady state performance being well-known, transient thermal behaviour of two and three fluid crossflow heat exchanger has been obtained using finite difference technique. Finally, a brief description of experimental determination of heat transfer and flow friction characteristics has been discussed and some preliminary results for friction characteristics have been presented.

Optimum design of multilayer crossflow plate-fin heat exchanger has been considered with different geometrical and operating constraints. Apart from heat exchanger geometries, fin specifications have also been optimised. Genetic algorithm has been used as a tool to minimise total annual cost and total number of entropy generation units producing optimum solutions for the combination of discrete and continuous variables.

Transient temperature response of the crossflow heat exchanger has been obtained for the combined effect of finite capacity of the two fluids and the separating sheet, core longitudinal conduction and axial dispersion. Apart from standard inputs like step, ramp and exponential perturbations, sinusoidal perturbation in hot fluid inlet temperature has also been considered. Individual and combined effect of one-dimensional non-uniformity in temperature and flow on the dynamic behaviour has been presented for some specific cases. Finally, the effect of flow transients has also been considered along with temperature transients.

Transient temperature response has been obtained for three-fluid crossflow heat exchanger with step, ramp, exponential and sinusoidal excitation in hot fluid inlet temperature. Four possible arrangements for three-fluid crosssflow heat exchanger have been compared under steady state as well as for transient conditions.

Finally, design and fabrication details of an experimental facility for determining heat transfer and flow friction characteristics have been presented based on standard steady state testing technique of Kays and London. Experimental results for flow friction behaviour of some new plate-fin surfaces (wavy fins) have also been presented.

Keywords: crossflow heat exchanger, three-fluid crossflow heat exchanger, plate-fins, transient behaviour, axial dispersion, longitudinal conduction, maldistribution, optimisation, entropy generation, economics, genetic algorithm, flow friction coefficient 'f', Colburn 'j' factor.