NUMERICAL ANALYSIS OF COMPACT PLATE-FIN HEAT EXCHANGERS FOR AEROSPACE APPLICATIONS

C. Ranganayakulu
Email: chennu_r@rediffmail.com

ABSTRACT

The Compact Heat Exchanger (CHE) is characterized by a small volume and a high rate of energy exchange between two fluid streams by employing intricate flow passages. Thermo-hydraulic performances of Compact Heat Exchangers is strongly depending upon the prediction of performance of various types of heat transfer surfaces such as Offset Strip fins, Wavy fins, Rectangular fins, Triangular fins, Triangular and Rectangular perforated fins in terms of Colburn ‘j’ and Fanning friction ‘f’ factors. Earlier, this data can be generated only through a dedicated experimental test rigs. Now, the numerical methods plays major role for analysis of compact plate-fin heat exchangers, which are cost effective and fast. This paper presents the on-going research and work carried out earlier for single-phase steady state heat transfer and pressure drop analysis on CHE passages and fins.

An analysis of a crossflow plate-fin compact heat exchanger, accounting for the individual effects of two-dimensional longitudinal heat conduction through the exchanger wall, inlet fluid flow mal-distribution and inlet temperature non-uniformity are carried out using a finite element method (FEM). The performance deteriorations of high-efficiency cross flow plate-fin compact heat exchangers have been reviewed with the combined effects of wall longitudinal heat conduction and inlet fluid flow/temperature non-uniformity using a dedicated FEM analysis. It was found that the performance deteriorations are quite significant in some typical applications due to the effects of wall longitudinal heat conduction and inlet fluid flow nonuniformity on crossflow plate-fin heat exchangers. A mathematical equation is developed to generate different types of fluid flow/temperature maldistribution models considering the possible deviations in fluid flow. The finite element analysis is also extended for a crossflow tube-fin compact heat exchanger.

A Computational Fluid Dynamics (CFD) program FLUENT has been used to predict the design data in terms of ‘j’ & ‘f’ factors for plate-fin heat exchanger fins. The suitable design data is generated using CFD analysis covering the laminar, transition and turbulent flow regimes for various types of fins. Also, several compact plate-fin heat exchangers have been optimized and analyzed using a CFD tool for quantification of flow maldistribution effects and flow visualization studies. The complete design cycle of CHE is presented, which includes Vaccum Brazing Technology, Fabrication, Flight Qualification Tests for Aerospace applications.