SIMULATION AND OPTIMIZATION OF COOLING COILS

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TO MY FATHER

M.P. RAMA VARIAR

CERTIFICATE

This is to certify that this thesis entitled 'Simulation and Optimization of Cooling Coils' being submitted by Mr. P.V. Ramachandran to the Indian Institute of Technology, Delhi, for the award of the Degree of Doctor of Philosophy in Mechanical Engineering is a record of bonafide research work carried out by him. He has worked under my supervision and guidance, and has fulfilled the requirements for the submission of this thesis, which in my opinion has reached the requisite standard.

The results contained in this work have not been submitted, in part or in full, to any other University or Institute for the award of any degree or diploma.

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ABSTRACT

The main objective of this investigation is to develop suitable simulation and optimization routines for the design of cooling and dehumidifying coils. The investigation is carried out for the design of Chilled Water (C-W) coils and Direct Expansion (D-X) coils.

Mathematical models, incorporating the various thermal processes occurring in cooling and dehumidifying coils are developed and are solved numerically to estimate the performance of the coils in the simulation algorithms. A cooling coil may operate as dry coil if there is no moisture separation from the air as it is cooled, or it may operate as a wet coil if dehumidification of air is present. The simulation models developed are used to analyse both dry and wet coils.

The present investigation is limited to cooling coils with more than one, but identical circuits of the cold fluid. A tube by tube analysis from the inlet to the exit of the cold fluid is performed. The total length of the circuit is discretized into a number of sections and the basic energy transfer equations are applied to each section. These equations are assembled to form a system of simultaneous equations, and the solution of this system of equations gives the performance of the coil. The equations formed are highly nonlinear and a quazi-linearisation technique is used to solve the system of equations.

A detailed parametric study to understand the influence of various parameters on the performance of the cooling coils is made. Then a basic design procedure is developed to design a cooling coil. For this the coil geometric parameters are assumed and the coil dimensions are determined to meet a given cooling load with given inlet conditions of the cold fluid there by cooling the air from a fixed initial state to the required final state. This basic design obtained is then optimized by varying the different coil geometric parameters initially assumed, so that an optimal design of the cooling coil is obtained. In the present optimization procedure, the cost of material is considered as the optimization function, to be minimised.

The simulation routine developed for C-W coil and D-X coil are validated on test commercial coils. Optimization of these coils resulted in 38 percent saving in material cost on C-W coil, and 30 percent saving on D-X coil, indicating that there is ample scope for optimization of commercial cooling coils used in refrigeration practice.

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