SIMULATION AND OPTIMIZATION OF HEAT TRANSFER EQUIPMENT USED IN REFRIGERATION SYSTEMS

BY

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CERTIFICATE

This is to certify that this dissertation ~~thesis~~ entitled 'Simulation and Optimization of Heat Transfer Equipment used in Refrigeration Systems' being submitted by Mr. C. Robert Samuel 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 requirement for the submission of this thesis, which in my opinion has reached the requisite standard.

The results contained in this work has 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 heat exchangers used in refrigeration practice. The investigation is carried out with R-22 as refrigerant on (1) shell and tube condenser, (2) flooded chiller, and (3) DX-chiller.

The simulation algorithm for shell and tube condenser solves the mathematical model for the condenser processes using logarithmic mean temperature iterative scheme. This algorithm is used to study the effect of geometry and operating conditions on the performance of the condenser. Based on this study, an empirical model for the shell and tube condenser is developed, and this model is used in the optimization routine for the condenser by univariate search. The optimal tube diameter for shell and tube condenser is found to be 1/2 inch nominal size K class copper tube converted to integral fin tubes of fin height 0.8 mm and fin ratio 0.4 at 748 fins per meter. The optimal water pass length is 4 m to 6 m, and the variation of optimizing function in this range is small.

The logarithmic mean temperature iterative scheme is made use of in the simulation of flooded chiller also. The simulation algorithm is used to study the effect of geometry and operating conditions on the performance of the flooded

chiller. Based on this study, an empirical model for flooded chiller is developed. The optimization routine for flooded chiller makes use of this model for optimization using gradient search. The optimal tube diameter and optimal water pass length are found to be related and both are considerably affected by the operating conditions.

The variation of heat transfer coefficient in the DX-chiller is considerably large and is non linear, and hence the simulation of DX-chiller is more complex and the solution by Runge Kutta discretization tends to oscillate. Hence the simulation routine makes use of damping constants in obtaining a fast accurate solution while using Runge Kutta discretization. The optimization routine generates a set of alternate designs having slightly lower optimizing function, discards those alternatives with excessive refrigerant pressure drop or less than rated capacity. Of the remaining alternatives, the alternative with the lowest refrigerant pressure drop is selected as the next improved design. The results of optimization indicate that the 19 mm outer diameter copper tube used is optimal. Further, the ratio of the tubes in a certain pass to the total number of tubes in the test commercial 8 pass DX-chiller is also optimal. However, the optimal length of each pass is found to be about 1.2 m.

The three simulation algorithms are validated on test commercial heat exchangers. Optimization of these heat exchangers resulted in 23 per cent saving on the shell and tube condenser, 8.3 per cent on the flooded chiller and 22 per cent on the DX-chiller, indicating that there is ample scope for optimization of the commercial heat exchangers used in refrigeration practice.

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