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Capability Optimization of refrigerant Circuitry for a Finned Tube Heat Exchanger-A Theoretical Review

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ABSTRACT

Increased concerns about climate change and day by day increment in energy cost has created the importance of Refrigeration & Air Conditioning system with high COP. COP of a Vapour Compression Refrigeration system is mainly influenced by the effectiveness of the Heat Exchanger being Employed. Optimization in the design of Heat Exchanger is highly desirable to improve their effectiveness and reduce the cost of production. For Finned Tube Exchanger, one of the most important design parameter is the sequence in which tube are connected to define the path of flow of Refrigerant through the coil i.e. Circuit of flow. In this paper researcher has presented theoretical review of an evaporator and condenser design program EVAP-COND for Finned Tube Heat Exchanger. This incorporates a computational intelligence module, ISHED (Intelligent system for Heat Exchanger Design) for optimization of circuit of refrigerant.

Key words: Optimization, Simulation, Heat Exchanger, Effectiveness

I. INTRODUCTION

The refrigerant circuitry determines the distribution of refrigerant through the heat exchanger which impacts refrigerant mass flux, heat transfer, and pressure drop and saturation temperature in each individual tube. Different refrigerants may benefits from different refrigerant circuitry architectures because of the variation in their thermo physical properties. An optimized refrigerant circuitry is one that finds the best match between refrigerant and air properties and flow parameters at each location to maximize the total heat exchanger capacity. The refrigerant circuitry is typical determined after the heat exchanger `s outside dimensions tube diameter tube and fin spacing and heat transfer surfaces are selected. Currently circuitry design is primarily driven by engineer `s experience aided by supplemental heat exchanger simulations, which are performed manually.

II. METHODS AND MATERIAL

A. LITERATURE REVIEW

The efficacious method of Fibonacci search is adopted to find the interfacing position (Stoecker, 1989). Designing and optimized refrigerant circuitry design is particularly difficult if the air flow is not uniformly distributed over the coil surface. In such a case the design engineer may be tempted to assume a uniform air velocity profile, which will result in capacity degradation (Chwalowski, 1989). Several heat exchanger simulation models, Public domain and proprietary account for the refrigerant circuitry and can be used in the refrigerant circuitry optimization e.g. EVAP-COND (Domanski, 2008). However, the optimization process requires that a design engineer performs these simulations manually, each time specifying different candidate circuitry architectures. The true field is much larger, since it is possible to have multiple inlets and tubes delivers refrigerant to more than one tube. A fin and tube evaporator is one of the main components in refrigeration system. The optimal coil design is complicated by a number of factors (Liang et al., 2001). Presently, an inverter is widely used to regulate the compressor rotation continuously matches to the load (Sarntichartsak et al., 2006).

Foli et al. (2006) used a multi objective GA to optimize the performance of a micro heat exchanger by considering the shape of its channels. In yet another example of the significant costs of using CFD for heat exchanger optimization, a multi objective GA optimization on the tube shape in a tube bank heat exchanger using direct numerical simulation was detailed by Hilbert et al. (2006). Genetic Algorithms (GAs) are general purpose search algorithms that are based on natural selection and natural genetic. Gas was developed in 1975 by [Holland, 1975] whose original interest was to study the phenomenon of adaption in natural system and to develop software that would apply the important adaption mechanism. Since then, gas have been used in various field and proven to provide robust search in complex spaces [Goldberg, 1989]. The major difference between a basic GA program and ISHED is that ISHED uses two independent modules, a knowledge-based Evolutionary Computations Module and Symbolic learning Evolutionary module, for generating new refrigerant circuitry architectures. The knowledge based module does not use the typical GA operators but rather eight refrigerant circuit specific operators (split, break, combine insert move-split, swap, intercross, new-source). The symbolic learning based module generates new individuals (design) in an entirely different way, by hypothesis formulation and intention (Michalski, 2000). When applied, it divides the members of the current population into three classes based on their fitness values (cooling capacity); ”good” “bad” and “indifferent”. The “good” and “bad” classes contain members of the population whose fitness are in the top and bottom 25% of the current generation`s fitness range, respectively. Then the module examines the characteristics of both well and poorly performing designs and creates hypotheses in the form of attribution rules that characterize the better-performing architectures.

B. OPTIMIZATION WITH ISHED

We can perform analytical experimentations with ISHED to test its capability to optimize refrigerant circuits for different refrigerants and non-uniform air distribution at the heat exchanger inlet. In all cases, ISHED generated circuitry design that was as good as better than those prepared manually.

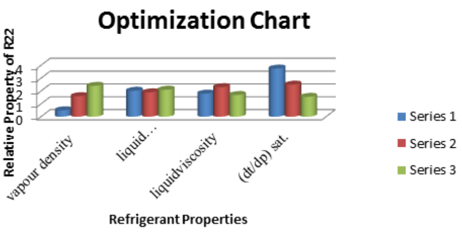

Figure 1: Refrigerant Properties at 7°C for Studied Refrigerant

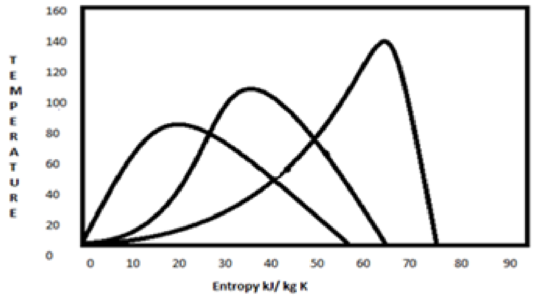

Figure 2: T-E diagram for studied refrigerants

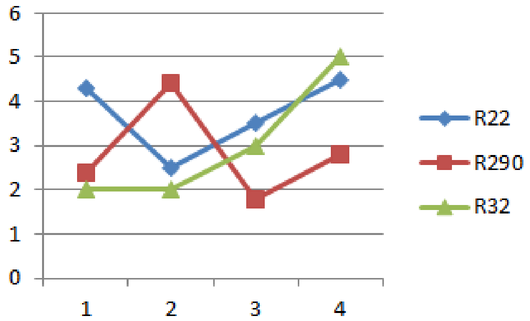

Figure 3: Evaporator capacity Comparison

III. RESULTS AND DISCUSSION

ISHED IMPLEMENTATION

The ISHED optimization module is embedded in the EVAP-COND ver.3.0 package and it is accessible from the main EVAP-COND window through the ‘circuitry optimization’ pull down menu.

Step-I (Pre –Processing)

Input data for an ISHED optimization run consist of the same data needed to execute a simple simulation run by EVAP-COND (input refrigerant circuitry is optional) and some additional data defining how the optimization process is to be carried out. The set of data describing the geometry of the heat exchanger, heat transfer surfaces, and refrigerant are the same as those specified within the EVAP-COND window. Once these items are specified, the user enters the ISHED operating conditions followed by the optimization process control parameters in the 'ISHED control parameter' window. Hence the user can specify certain design rules and constraints for the allowable circuitry architectures in each generation, the number of generations examined in the optimization run and some other advanced parameters. The user also has the option to specify 'seed' files. When using this option, the user –specified circuitry designs (which may be generated by the user pr results of previous optimization runs) will be included in the generation of as starting designs along with the random ISHED –generated designs.

Step-II (Optimization run)

Once all of the input has been entered, the user can initiate the execution of the optimization run. The optimization run may take a considerable amount of time depending on the computer's speed, the size of the heat exchanger, the specified refrigerant, and the entries for the ISHED control parameters. A computer with a multiple core processor will complete an optimization run considerably faster than one with a single core processor of comparable clock speed. Throughout the execution, the program maintains several files containing intermediate results. Most importantly, the program maintains a log file that contains the top ten performing circuitry architectures and updates it each iteration cycle throughout the optimization steps from the beginning of the execution onwards, called is he trace. Log, is continuously updated. A user can recover useful data from these files to prevent loss of program instability; can recover useful data from these files to prevent loss of information during a failed optimization run. It is also impotent to keep in mind that the evolutionary method employed within ISHED has some degree of randomness, as opposed to calculus–based methods, which produce the same results each time.

Step-III (Post –Processing)

In the end of successful optimization run, the program displays a message indicating completion along with the highest heat exchanger capacity obtained as results of the run. The user can access the ten best performing circuitry architecture with in EVAP-COND by navigating to the ISHED results folder. Most often, the user will find it necessary to modify ISHED – generated circuitry architecture to accommodate manufacturing constraints although the user has the option to limit ISHD's exploration with a few design rules and constraints are often much more involved for this reason. During the post processing effort, the user will have to 'clean' the circuitry the performance of the heat exchanger did not change significantly during this post processing effort.

IV. CONCLUSION

Author presented the computational intelligence – based optimization module ISHED. In this paper, ISHED optimizes the performance of a finned-tube heat exchanger by determining the best refrigerant circuitry from the various refrigerants to suit refrigerant, air, and refrigerant flow rates and air distribution. Authors have concluded this through th three steps as preprocessing, optimization and post processing. Inclusion of ISHED expands the utility of EVAP-COND beyond conventional features of a heat exchanger design tool.

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