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Review On Evaluating Geometry Of Evaporator Coil For Refrigerator Enhancing Efficiency Of Heat Transfer

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Abstract— An Evaporator is the Main component of Air-conditioning system. An evaporator is mainly used in different refrigeration and air-conditioning applications in food and beverage industry, in the pharmaceutical industry etc. An evaporator in air conditioning system is used to evaporate liquid and convert in to vapour while absorbing heat in the processes for the refrigeration cycle to be efficient; the design parameters for its key components play a vital role. For this research work, the effort is to identify the effect of geometry for the evaporator coil over the performance of the refrigerator. Typically, the cross section of the tube and the method of fitment e.g.-grooved construction, over the evaporator shall be studied using CFD methodology. ANSYS, Fluent is considered as a CAE tool for evaluating the alternatives. Preliminary mathematical treatment is considered for development to assist the computational efforts. The results using CFD methodology shall be validated using representative miniature prototype for demonstration for the enhancement. The evaporator is one of the four basic and necessary hardware components of the refrigeration system. Pressure drop, heat transfer rate, evaporation rate and most important thing is efficiency of evaporator, all four things are increase and improve by getting optimum parameter of evaporator, this optimum parameter of evaporator are generated with the help of experimental data and CFD analysis.
Keywords- Refrigeration system; Evaporator; Geometry; Hybrid- individual

I. INTRODUCTION

Refrigeration is an enabling technology in a wide range of applications from air conditioning for occupant com-fort to freezing gas required in food preservation. Evaporators are the critical component responsible for ex-tracting heat from conditioned spaces or processes. The focus of this paper is on evaporators that cool air to temperatures below the freezing point of water. When an air-cooling evaporator operates at a temperature below the freezing point with a coincident entering air dew point temperature that is above the evaporator coil surface temperature, frost will form on the evaporator surface. In the evaporator, the refrigerant is evaporated by the heat transferred from the heat source. The heat source may be a gas or a liquid or, e.g. in food freezers, a solid. During evaporation, the temperature of a pure refrigerant is constant, as long as the pressure does not change. This low refrigerant temperature is attained as a result of the reduction in pressure caused by the compressor: When the compressor is started and the pressure reduced, the equilibrium between liquid and vapour in the evaporator is disturbed. To re-establish equilibrium, more vapour is formed through evaporation of liquid. The evaporator is one of our basic and necessary hard-ware components of the refrigeration system. Pressure drop, heat transfer rate, evaporation rate and most important thing is efficiency of evaporator, all four things are increase and improve by getting optimum parameter of evaporator, this optimum parameter of evaporator are generated with the help of experimental data and CFD analysis. The equations of fluid mechanics which have been known or over a century are solvable only or a limited number of flows. The known solutions are extremely useful in understanding fluid flow but rarely used directly in engineering analysis of design.CFD makes it possible to evaluate velocity, pressure, temperature, and species concentration of fluid flow through out a solution domain, allowing the design to be optimized prior to the prototype phase.

II. LITERATURE REVIEW

1) Thermal Performance of a Compact Evaporator Coil in Household Refrigerator- Freezers Man-Hoe Kim (Received July 20, 1997).A high--efficiency evaporator coil, which is placed horizontally between refrigerator and freezer compartments, for household auto-defrost refrigerator-freezers has been developed. Several experiments were performed to investigate the thermal performance of the newly developed compact evaporator coil in a auto-defrost refrigerator-freezer and the results are compared with those of the conventional evaporator.

2) Analysis of flow mal-distribution in fin-and tube evaporators for residential air-conditioning systems Martin Ryhl Kaen in August 2011.This thesis is concerned with the effects of flow mal-distribution in fin-and-tube. Coil evaporators for residential air-conditioning and compensation potentials with regards to system performance. The goal is to create a better understanding of flow mal-distribution and the involved physical phenomenon. Moreover, the study investigates the individual and combined effects of non-uniform inlet liquid/vapor distribution, different feeder tube bending and non-uniform airflow.

3) Analysis of Fin-and-Tube Evaporators in No-Frost Domestic Refrigerators Carles Oliet, Carlos D, Joaquim Rigola, Assensi Oliva Centre Tecnologic Transferencia de Calor. This paper summarizes the research work carried out by the authors on domestic refrigerator no-frost evaporators. It includes an explanation of the experimental unit that is currently being constructed to test isobutene fin-and-tube evaporators, together with a short description of the numerical tools developed. The first preliminary experimental results using single-phase coolants are then given together with their numerical counterparts. The numerical results are presented in detail in order to both complementing the experimental information obtained and to show its potential as an analysis and design tool.

4) Air-side heat transfer enhancement of a refrigerator evaporator using vortex generation A.D. Summers, A.M. Jacobi Department of Mechanical and Industrial Engineering, University of Illinois, 1206 W. Green-Street, Urbana, IL 61801, USA. Received 15 September 2004, received in revised form 17 February 2005, accepted 1 April 2005. In most domestic and commercial refrigeration systems, frost forms on the air-side surface of the air-to-refrigerant heat exchanger. Frost-tolerant designs typically employ a large fin spacing in order to delay the need for a defrost cycle. Unfortunately, this approach does not allow for a very high air-side heat transfer coefficient, and the performance of these heat exchangers is often air-side limited. Longitudinal vortex generation is a proven and effective technique for thinning the thermal boundary layer and enhancing heat transfer, but its efficacy in a frosting environment is essentially unknown.

5) Experimental investigation of the performance of industrial evaporator coils operating under frosting conditions N. F. Aljuwayhel, D. T. Reindl, S.A. Klein, G. F. Nellis. University of Wisconsin-Madison, 1500 Engineering Drive, Madison, WI 53706, USA. Published online 10 July 2007. This paper describes a field experimental investigation of the effects of frost formation on the performance of a low-temperature large-scale evaporator coil used in industrial refrigeration systems. A series of experiments were conducted to determine the coil cooling capacity of the evaporator over time as frost builds on its surfaces. Field-measured quantities include inlet and outlet air temperatures, inlet and outlet air relative humidity, and air volume flow rate. These measurements

provide a baseline set of experimental data that can be used to validate numerical models of industrial evaporators operating under frosting conditions.

6) A companion paper Kim, J.-H., Braun, J.E., Groll E.A., 2009. A hybrid method for refrigerant flow balancing in multi-circuit evaporators: upstream versus downstream control. International Journal of Refrigeration presented a hybrid approach for providing control of refrigerant flow distribution in evaporators that involves the use of small balancing valves in each circuit along with a primary expansion device to control the overall superheat from the evaporator. Furthermore, the companion paper demonstrated that the flow balancing valves should be located upstream rather than downstream of the evaporator in order to realize significant benefits. The current paper utilizes the model presented in the companion paper to more fully evaluate the effects of uneven air and refrigerant flow distributions and the benefits of upstream hybrid control in response to these effects

2.1. Concluding Remark from Literature Review

From study of above research paper following concluding remark is drawn that Thermal performance of evaporator depend upon:

- Air flow rate through the evaporator coil
- Refrigerant circuitry of the evaporator coil
- Direction of air flow in respect to evaporative coil
- Mal-distribution, Non uniform air flow reduces the COP.
- Microchannel evaporator has faster transient behavior than the fin-and-tube evaporator.

2.2. Problem Definition

While attempts are being made by researchers over the material for refrigerant and for improving the physical components for each stage of refrigeration cycle, this work intends to pursue the evaluation of the generic con-figuration of the evaporator in terms of the type of cross section, pitch between tubes and presence of fins. The effect on the rate of heat transfer shall be evaluated for each configuration. The parameters to be constant through the exercise are identified as material of the coil ambient temperature, mass flow rate of refrigerant.

III. HYBRID METHOD FOR REFRIGERANT FLOW BALANCING

A companion paper Kim et al., this issue introduced a hybrid method for controlling refrigerant flow in individual evaporator circuits, developed a model for evaluating the benefits of this concept, and demonstrated that upstream flow balancing is superior to downstream control. "Figure 1" shows a schematic of the hybrid upstream concept. A primary expansion valve provides most of the necessary pressure drop and maintains an overall evaporator exit superheat, whereas individual valves provide flow balancing of the individual circuits. It is believed that this approach could be achieved at relatively low cost because the valves would not need to impose a large pressure drop or operate over a wide range of openings and could have relatively non-linear and slow responses. Several researchers Mueller and Chiou, Domansk, Payne and Domanski, have studied refrigerant mal-distribution in evaporators and its associated impacts on the cooling capacity. However, most of these studies focused on refrigerant flow mal-distribution caused by a single factor such as uneven air flow distribution, unbalanced refrigerant circuitry, and uneven two-phase flow distribution in distributors. They did not consider combinations of effects. Furthermore, the work did not involve the development and use of a model to perform a systematic study of mal-distribution effects and the benefits of individual circuit. Each circuit of the evaporator has a feeder tube at the inlet of the circuit. In practice, upstream refrigerant flow control would be accomplished using controllable valves for the purposes of this study.

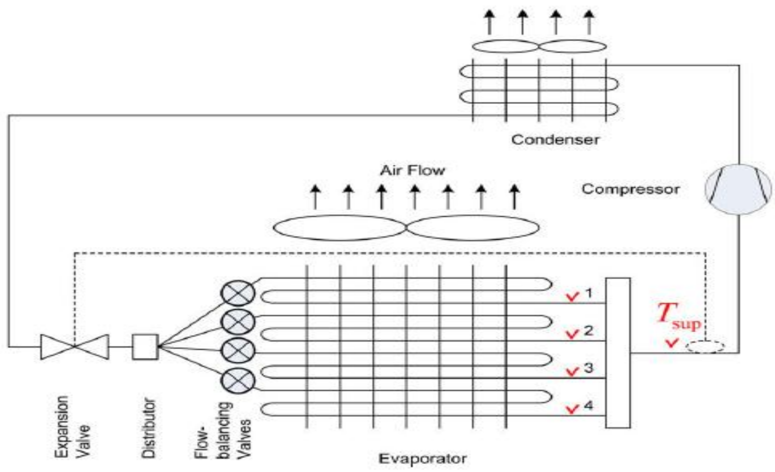

Fig. 1: Compression System with Hybrid Individual [6]

However, by controlling either the inside diameters of the feeder tubes or the throat areas of the variable orifice plates, a uniform exit superheat can be achieved. As a result, some of the reduced cooling capacity due to the non-uniform air can be recovered. The effect of air flow mal-distribution on cooling capacity and efficiency was considered in Kim et al. (this issue) for a heat pump operating with R410A in cooling mode. Using this definition, it was found for the R410A heat pump that an air distribution mal-distribution factor of 0.4 resulted in a reduction in cooling capacity of approximately 6% and a degradation in system COP of approximately 4% compared to the baseline performance. Furthermore, practically all of the cooling capacity and system COP degradation was recovered using the upstream hybrid control method [6].

IV. EXPERIMENTATION

Use of the existing refrigeration system can be considered for finding the behavior foe heat transfer. The coils in the form of arrays connected with circular fins (rods) are found as the 'typical' feature of the evaporator. Constants for mechanical strength and esthetics and maintenance need to be considered for final proposal and should be the outline for development of the prototype.

V. VALIDATION

The inputs are typically secured from the mathematical treatment of the data are further used for comprising or evolving the analytical model. The results offered by CFD analysis as a methodology shall be compared with the physical experiment.

CONCLUSION

In this way we are concluded that by using different cross-section of evaporator tube we can find the optimum cross section and geometry of tube that will give the high heat transfer rate and it will improve COP of refrigerator.

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