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Study and Investigation of Refrigeration System Using Microchannel Condensers and round tube condenser-Review

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ABSTRACT— A brief review of relevant literature is given in the following. Numerous condensation experimental studies have been done to measure heat transfer rate and pressure drop in conventional macro-channels, and several correlations for predicting these parameters have been proposed. In professional circles, there is an ongoing debate about the potential benefits of using microchannel heat exchangers.

The refrigerant charge amount and the refrigerant pressure drop were measured; the results showed a reduction of charge and pressure drop in the microchannel condenser. A numerical model for the microchannel condenser was developed and its results were compared with the experiments. The model simulated the condenser with consideration given to the non-uniform air distribution at the face of the condenser and refrigerant distribution in the headers. The results showed that the effect of the air and refrigerant distribution was not a significant parameter in predicting the capacity of the microchannel condenser experimentally examined in this study. This paper presents the difference measured in the performance for both condensers only as well as the effects on the system. The microchannel heat exchanger was made to have nearly a identical face area, depth and consequently volume, plus the same fin density as the baseline, round-tube heat exchanger with plate fins. Temperature contours, generated from the measured air exit temperatures, showed the refrigerant distribution in the microchannel condenser indirectly. The temperature contours developed from the model results showed a relatively good agreement with the contours for measured air exit temperatures of the microchannel condenser.

KEYWORDS- Microchannel Condensers, Round tube condenser, Refrigeration System, Vapour-compression Refrigeration.

I. INTRODUCTION

Condensation heat transfer studies have been conducted since the early 1900's when Nusselt developed a correlation for a thin film condensing inside a tube (Nusselt, 1919). Since then, multiple experiments have been performed which provide more accurate expressions for the heat transfer coefficient of a condensing liquid. With the advent of refrigeration, interest in condensation has increased since a condenser is one of the main components of the basic vapor-compression refrigeration figure shows a schematic of a full microchannel condenser. The tubes are brazed to the headers with louvered fins in between. The refrigerant is circuited using baffles inside the headers, involving more than one tube in each pass. This reduces the total pressure drop of the condenser due to fewer passes. These heat exchangers provide the same amount of heat transfer with a much lower refrigerant charge (about 2/3 that of a serpentine condenser) than condensers now commonly used in the industry. This attribute is very beneficial to car manufacturers as any reduction in the space Also, a smaller charge requirement translates into a lower cost for installation and less of a threat to the environment should the system ever leak

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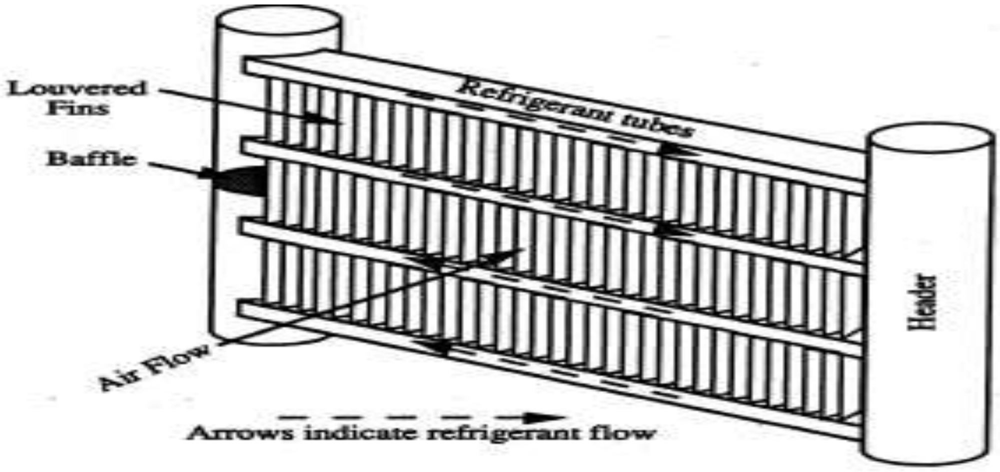

Fig 1. Microchannel condenser

Now, environmental concerns have been introduced into the industry, creating hesitations which have resulted in governmental restrictions. Due to the concern over ozone depletion, greenhouse effect, and other problems associated with the current state of technology, research in refrigeration has grown even more. Now, research focuses on determining the properties and effects of using alternative, non chloro flouro carbon (CFC) refrigerants such as 1, 1, 1, 2-tetrafluoroethane (R-134a) as replacements for the commonly used CFC's. Time is being wisely spent on new refrigeration component technology in order to protect our finite environment. This project will follow suit by using ozone-safe R-134a as its working fluid. The future use of the microchannel condenser technology is predicted to increase substantially over the next decade. The new governmental intervention in the refrigeration and air conditioning industry is also creating an increased interest in this technology. Not present, and this fact alone can cause substantial differences in the physics of the phenomenon. Accordingly, the main aim of the current study was to characterize the condensation heat transfer performance of two selected refrigerants in a single flat-plate, micro-channel condenser.

There is an expectation that heat exchangers with small-channel flat tubes or with microchannel tubes would offer advantages over those with round tubes; but no experimental validation for R290A was found in the open literature. Some advantages were expected to come from substantial charge reductions, some due to a lower airside pressure drop, and others from higher heat-transfer coefficients on the refrigerant side and even on the air side, as well as from greater airside surface area in a given volume. Fan power was also expected to be reduced because of the lower drag coefficients of the flat-tube design. The objective here is to address these issues. Two heat exchangers were used as condensers in the same air-conditioning system, one with round tubes and the other with flat microchannel tubes in a parallel-flow arrangement. The differences were recorded and are explained herein. The baseline condenser along with all other elements of the system was part of the very generously sized, off-the-shelf, air-conditioning system manufactured by one of the market and technology leaders. The system had a scroll compressor, like those typically used in applications such as this (ZP32K3E-PFV-230) and orifice tube used as an expansion device. The baseline system has been examined in detail earlier and presented in a few publications which compared it to a prototype of the Trans critical CO2 system (Beaver et al. 1999, 2000). In the present study, the performance of the baseline system and prototype system was measured under the conditions specified above.

II. LITERATURE SURVEY

2.1 Literature Review:-

1. Liang-Liang Shaoa, Liang Yanga,b, Chun-Lu Zhangb,, Bo Gua[2] presented Numerical modeling of serpentine microchannel condensers Microchannel (or mini-channel) heat exchangers are drawing more attention because of the potential cost reduction and the lower refrigerant charge. Serpentine microchannel heat exchangers are even more compact because of the minimized headers. Using the serpentine microchannel condenser, some thermodynamically good but flammable refrigerants like R-290 (Propane) can be extended to more applications. To well size the serpentine microchannel condensers, a distributed-parameter model has been developed in this paper. Airside misdistribution is taken into account. Model validation shows good agreement with the experimental data. The predictions on the heating capacity and the pressure drop fall into 10% error band. Further analysis shows the impact of the pass number and the airside misdistribution on the condenser performance.
2. Gunda Mader, Georg P.F. Fosel, Lars F.S. Larsen [3] Presented Comparison of the transient behavior of microchannel and fin-and-tube evaporators. The development of control algorithms for refrigeration systems requires models capable of simulating transient behavior with sensible computational time and effort. The most pronounced dynamics in these systems are found in the condenser and the evaporator, especially the transient behavior of the evaporator is of great importance when designing and tuning controllers for refrigeration systems. Various so called moving boundary models were developed for capturing these dynamics and showed to cover the important characteristics. A factor that has significant influence on the time constant and nonlinear behavior of a system is the amount of refrigerant charge in the evaporator which is considerably reduced when microchannel heat exchangers are utilized. Here a moving boundary model is used and adapted to simulate and compare the transient behavior of a microchannel evaporator with a fin-and-tube evaporator for a residential air-conditioning system. The results are validated experimentally at a test rig.
3. J.R. Garcı´a-Cascales, F. Vera-Garcı´a, J. Gonza´lvez-Macia, J.M. Corbera´n-Salvador,M.W. Johnson,G.T. Kohler [4] Presented Compact heat exchangers modeling: Condensation a model for the analysis of compact heat exchangers working as either evaporators or condensers is presented. This paper will focus exclusively on condensation modeling. The model is based on cell discretization of the heat exchanger in such a way that cells are analyzed following the path imposed by the refrigerant flowing through the tubes. It has been implemented in a robust code developed for assisting with the design of compact heat exchangers and refrigeration systems. These heat exchangers consist of serpentine fins that are brazed to multi-port tubes with internal microchannels. This paper also investigates a number of correlations used for the calculation of the refrigerant side heat transfer coefficient. They are evaluated comparing the predicted data with the experimental data. The working fluids used in the experiments are R134a and R410A, and the secondary fluid is air. The experimental facility is briefly described and some conclusions are finally drawn.
4. Pega Hrnjak*,1, Andy D. Litch [5] Reported Microchannel heat exchangers for charge minimization in air-cooled ammonia condensers and chillers This paper presents experimental results from a prototype ammonia chiller with an aircooled condenser and a plate evaporator. The main objectives were charge reduction and compactness of the system. The charge is reduced to 20 g/kW (2.5 oz/Ton). This is lower than any currently available air-cooled

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ammonia chiller on the market. The major contribution comes from use of microchannel aluminum tubes. Two aluminum condensers were evaluated in the chiller: one with a parallel tube arrangement between headers and ''microchannel'' tubes (hydraulic diameter Dh ¼ 0.7 mm), and the other with a single serpentine ''macrochannel'' tube (Dh ¼ 4.06 mm). The performances of the chiller and condensers are compared based on various criteria to other available ammonia chillers. This prototype was made and examined in the Air Conditioning and Refrigeration Center in 1998, at the University of Illinois at Urbana-Champaign.

5. Qian Sub, Guang Xu Yua, Hua Sheng Wanga,, John W. Rosea, [1] reported short communication on Microchannel condensation : Correlations and theory
Attention is drawn, to the fact that, while four different correlations for condensation in Micro channels are in fair agreement for the case of R134a (on which the empirical constants in the correlations are predominately based) they differ markedly when applied to other fluids such as ammonia. A wholly theoretical model is compared with the correlations for both R134a and ammonia.

6. Akhil Agarwal a, Todd M. Bandhauer b, Srinivas Garimella b,*[6] Reported Measurement and modeling of condensation heat transfer in non-circular microchannels Heat transfer coefficients in six non-circular horizontal microchannels (0.424 < Dh < 0.839 mm) of different shapes during condensation of refrigerant R134a over the mass flux range 150 < G < 750 kg m_2 s_1 were measured in this study. The channels included barrel-shaped, N-shaped, rectangular, square, and triangular extruded tubes, and a channel with a W-shaped corrugated insert that yielded triangular microchannels. The thermal amplification technique developed and reported in earlier work by the authors is used to measure the heat transfer coefficients across the vapor-liquid dome in small increments of vapor quality. Results from previous work by the authors on condensation flow mechanisms in micro channel geometries were used to interpret the results based on the applicable flow regimes. The effect of tube shape was also considered in deciding the applicable flow regime. A modified version of the annular-flow-based heat transfer model proposed recently by the authors for circular micro channels, with the required shear stress being calculated from a non-circular micro channel pressure drop model also reported earlier was found to best correlate the present data for square, rectangular and barrel shaped micro channels. For the other micro channel shapes with sharp acute-angle corners, a mist-flow-based model from the literature on larger tubes was found to suffice for the prediction of the heat transfer data. These models predict the data significantly better than the other available correlations in the literature.

7. G.B. Ribeiro, J.R. Barbosa Jr. , A.T. Prata [7] Presented Performance of microchannel condensers with metal foams on the air-side: Application in small-scale refrigeration systems. The thermal-hydraulic performance of microchannel condensers with open-cell metal foams to enhance the air-side heat transfer is investigated in this paper. Three different copper metal foam structures with distinct pore densities (10 and 20 PPI) and porosities (0.893 and 0.947) were tested. A conventional condenser surface, with copper plain fins, was also tested for performance comparison purposes. The experimental apparatus consisted of a closed-loop wind tunnel calorimeter and a refrigerant loop, which allowed the specification of the mass flow rate and thermodynamic state of R-600a at the condenser inlet. The experiments were performed at a condensing temperature of 450C. The air-side flow rate ranged from 1.4 _ 10_3 to 3.3 _ 10to3 m3/s (giving face velocities in the range of 2.1e4.9 m/s). The heat transfer

rate, the overall thermal conductance, the Colburn j-factor, the friction factor and the pumping power were calculated as part of the analysis.

8. ZHANG Huiyong, LI Junming , LI Hongqi [8] Presented Numerical Simulations of a Micro-Channel Wall-Tube Condenser for Domestic Refrigerators In recent years, microchannel heat exchangers have begun to be used in refrigeration and air conditioning systems. This paper introduces a microchannel condenser for domestic refrigerators with a theoretical model to evaluate its performance. The model was used to obtain the optimal design parameters for different numbers of tubes and tube lengths. The results show that the needed tube height of the downward section decreases with the number of tubes and the tube diameter. Compared with the original condenser, the present optimal design parameters can reduce the total metal mass by 48.6% for the two wall two side design and by 26% for the two wall one side design. Thus, the present condenser is much better than the condensers usually used in actual domestic refrigerators.

9. D. A. Luhrs and W. E. Dunn [9] Presented Design and Construction of a Microchannel Condenser Tube Experimental Facility.

   A test facility was built for the purpose of performing heat transfer studies on microchannel heat exchangers. The studies will involve condensation of refrigerant 134a inside the enhanced tubes,' although no condensation results are presented in this document. The design and construction of the experimental facility is detailed with a description of each component and its function in the stand. The operation of the facility was verified using an energy balance analysis and the results are presented. The refrigerant and air side heat transfers agree within ±3% at high air flow rates but fall out of this error bound at lower flow rates. Also, a discussion of the method for determining the refrigerant and air side resistances for the tube is given along with the theory for future correlation development. Finally, future modifications to the stand are suggested in order to correct any problems with it, improving the ability of the stand to produce accurate, reliable heat transfer performance data.

III. PROBLEM DEFINITION

3.1 Remarks from Literature Review:-

1. Heat Transfer Rates in Refrigeration System Can Be Improved by Different Techniques like Internal Micro fins, Wire insert And Microchannel condensers etc.
2. Internal micro fins manufacturing is comparatively difficult that microchannel condensers.
3. Cost reduction initial and Running Cost of the System.

3.2 Objective of the Project:-

1. To Reduce The System Refrigerant Charge.
2. To Develop More Compact System.
3. To Find The Coefficient Of Performance Of Square Port Type Microchannel Condenser Using R134a As A Refrigerant.
4. To Study The Heat Rejection in Square Port Type Microchannel Condenser.

3.3 Scheme of Implementation / Methodology

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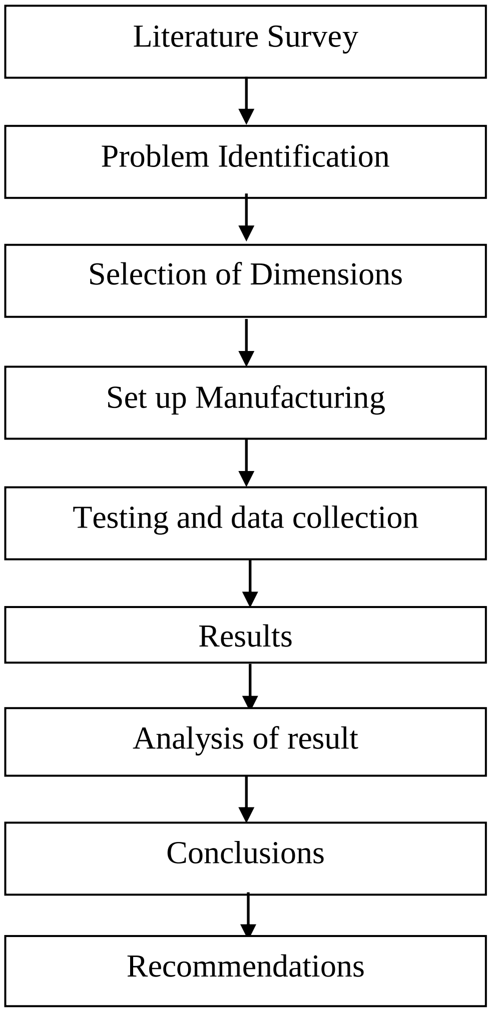

Flowchart for methodology

IV. PROPOSED SOLUTION

A) Theoretical Work:

i) To Study the theoretical concepts of microchannel condenser

ii) To carry out literature review of microchannel condenser

B) Experimental Work:

i) To develop experimental setup of refrigeration system with suitable microchannel condenser

ii) To predict the coefficient of performance of microchannel condenser on the refrigeration system

V. EXPECTED RESULTS

1. Microchannel Heat exchanger Technology is relatively New Technology Made Possible by Recent Advances in Aluminium extrusion and Brazing process. Microchannel condenser has certain advantages:-
2. Microchannel condenser is used with environmentally compatible refrigerant.
3. Reduced dimensions and weights, bringing lower installation costs

4. Smaller internal volume and refrigerant load requires less refrigerant equals lower costs and a smaller environmental impact.
5. No possibility for galvanic corrosions to occur as the heat exchanger is completely manufactured in aluminium alloys.
6. High heat transfer and efficiency.
7. Aluminium construction yields high durability and is easy to recycle
8. Microchannel Condenser Can Be Easy Cleaned.

VI. CONCLUSION

Micro channel condenser is used with environmentally compatible refrigerant.

1. Heat Transfer Rates in Refrigeration System Can Be Improved by Different Techniques like Internal Micro fins, Wire inserts And Microchannel condensers etc.
2. Internal micro fins manufacturing is comparatively difficult that microchannel condensers.
3. Cost reduction initial and Running Cost of the System.
4. Reduced dimensions and weights, bringing lower installation costs
5. Smaller internal volume and refrigerant load: less refrigerant equals lower costs and a smaller environmental impact.
6. No possibility for galvanic corrosions to occur as the heat exchanger is completely manufactured in aluminum alloys.

REFERENCES

[1]Qian Sub, Guang Xu Yua, Hua Sheng Wanga, John W. Rose, Short Communication On Microchannel Condensation : Correlations And Theory, International Journal of Refrigeration, 32 (2009) I I 49- I I 52

[2]Liang-Liang Shao, Liang Yang Chun-Lu Zhang, Bo Gu, Numerical modeling of serpentine microchannel condensers, International Journal of Refrigeration, 32 (2009) I I 62- I I 72.

[3]Gunda Mader, Georg P.F. Fosel, Lars F.S. Larsen, Comparison Of The Transient Behavior Of Microchannel And Fin-And-Tube Evaporators, International Journal of Refrigeration, 34 (20 I I) I 222- I 229.

[4]J.R. Garcıa-Cascales, F. Vera-Garcıa J. Gonzalvez-Macia, J.M. Corberan-Salvador, M.W. Johnson, G.T. Kohler, Compact heat exchangers modeling: Condensation, International Journal of Refrigeration, 33 (20 I 0) I 35- I 47.

[5]Pega Hrnjak, Andy D. Litch, Microchannel heat exchangers for charge minimization in air-cooled ammonia condensers and chillers, International Journal of Refrigeration, 3 I (2008) 658- 668.

[6]Akhil Agarwal, Todd M. Bandhauer, Srinivas Garimella, Measurement and modeling of condensation heat transfer in non-circular microchannels, International Journal of Refrigeration, 33 (20 I 0) I I 69- I I 79.

[7]G.B. Ribeiro, J.R. Barbosa Jr. A.T. Prata, Performance of microchannel condensers with metal foams on the air-side: Application in small-scale refrigeration systems, Applied Thermal Engineering 36 (2012) 152-160

[8]ZHANG Huiyong, LI Junming, LI Hongqi, Numerical Simulations of a Micro-Channel Wall-Tube Condenser for Domestic Refrigerators, TSINGHUA SCIENCE AND TECHNOLOGY ISSNll1007-0214ll09/16llpp426-433 Volume 15, Number 4, August 2010

[9]D. A. Luhrs and W. E. Dunn, Design and Construction of a Microchannel Condenser Tube Experimental Facility. Air Conditioning and Refrigeration Center University of Illinois Mechanical & Industrial Engineering Dept., ACRC TR – 65, July 1994.

[10]S.K. Das, N. Putra, P. Theisen, W. Roetzel, Temperature dependence of thermal conductivity enhancement of nanofluids, Journal of Heat Transfer 125 (2003) 567-574.

[11]W. Duangthongsuk, S. Wongwises, Measurement of temperature-dependent thermal conductivity and viscosity of TiO2-water nanofluids, Experimental Thermal and Fluid Science 33 (2009) 706-714.