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Selection of Capillary Tube for Refrigeration System

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Abstract: *Proper selection of capillary tube it is essential to study the effect of capillary tube geometry on the performance of refrigeration systems. The literature review is focused on the influence of geometrical parameters like tube length, diameter, coil pitch, number of twist and twisted angle on pressure drop and coefficient of performance (COP) of the system. These parameters can be optimized using mathematical modeling, experimental methods and maintaining proper pressure between condenser and evaporator.*
Keywords: Capillary Tube, Refrigeration system, Selection, Tube diameter.

I. INTRODUCTION

A capillary tube is a common expansion device used in small sized refrigeration and air conditioning systems. A capillary tube is a constant area expansion device used in a vapor compression refrigeration system located between the condenser and evaporator and whose function is to reduce the high pressure in the condenser to low pressure in the evaporator. Capillary tubes are extensively used where load is fairly constant due to its advantage such as cheap, reliable, simple to install, zero maintenance and requirement of a low starting torque to run the compressor.

II. LITERATURE REVIEW

Several literature sources are focused on the size of capillary tubes used in refrigeration and Air conditioning systems. The appropriate size of capillary tube can be calculated from the refrigerant effect, coefficient of performance (COP) and others. The effects of various geometries of capillary tubes have been investigated by many researchers. Since the capillary tube is to be folded in order to reduce the required space. Hence the following literature is focused on the effect of capillary tube geometry on the performance of refrigeration system.

Amr O. Elsayed (2006) studied Performance characteristics of twisted capillary tube have been presented and compared with the original capillary tube of window type air conditioner using R-22 as a refrigerant. Three twisted capillary tubes with the same inner diameter and length, as the original capillary tube, have been tested experimentally. The effect of twist angle and the number of twisted points on the refrigeration cycle performance have been investigated and discussed. From the above conclusions it can be deduced that the control of the capillary tube length can be done by selecting the suitable number of twisted points with correct choice for the twist angle to obtain the required pressure drop across the capillary tube. Future experimental investigations are needed to correlate the capillary tube length and diameter with different twist angles at various numbers of twisted points for alternative refrigerants in different refrigeration cycles.

Hirendra Kumar Paliwal and Keshav Kant (2006) developed a flow model to design and study the performance of helical capillary tubes and to mathematically simulate a situation closer to that prevailing in practice. Homogeneous flow of two phase fluid is assumed through the adiabatic capillary tube. The model includes the second law restrictions. The effect variation of different parameters like condenser and evaporator pressures, refrigerant flow rate, degree of sub cooling, tube diameter, internal roughness of the tube, pitch and the diameter of the helix on the length of the capillary tube are included in the model. Theoretically predicted lengths of helical capillary tube for R-134a are compared with the length of the capillary tube needed under similar experimental conditions and majority of predictions are found to be within 10% of the experimental value.

S. M. Sami et al. (2001) experimentally investigated capillary tube behavior using various new alternatives under different geometrical parameters. Capillary geometrical parameters will include length, diameter, as well as entrance conditions. The results clearly showed that the pressure drop across the capillary tube is significantly influenced by the diameter of the capillary tube, inlet conditions to the capillary and refrigerant type. The data demonstrated that the capillary pressure drop decreases with the increase of the capillary diameter and that alternatives in general experience higher pressure drop than that of R-22.

Chunlu Zhang and Guoliang Ding (2004) developed two kinds of approximate analytic solutions of adiabatic capillary tube. One is the explicit function of capillary tube length. Another is the explicit function of refrigerant mass flow rate. In these solutions, the choked flow condition is taken into account without iterative calculations. The approximate predictions are found to agree reasonably well with experimental data in open literatures.

Akkarat Poolkrajang et al. (2009) evaluate the optimization of a capillary tube in a split type air conditioning system and to determine the coefficient of performance (COP) of the system. The optimization was determined by mathematical calculation to evaluate COP of a split-type air conditioning system within 5 different sizes of capillary tube. Following this, the experimental equipment was designed and constructed to verify the COP data obtained from the calculation. The results found that from the theoretical analysis and experiment, the COP was changing in a direction contrary to the diameter of the capillary tube. When the capillary tube diameter is smaller, COP values tend to be higher.

Akash Deep Singh (2009) developed a mathematical model of diabatic capillary tube. The mathematical model has been developed by using equations of conservation of mass, momentum and energy for predicting the length of diabatic capillary tube. Moody (1944) correlation is used to calculate the friction factor. McAdams et al. (1942) viscosity correlation has been used to evaluate the two phase viscosity of the refrigerant. Input parameters have been taken from the data of Mendoca et al. (1998). Further, a geometric model is developed in Pro-E and the mesh is created in Ansys ICEM CFD and analysis is carried out in Ansys CFX which has three modules CFX-Pre, Solver and CFX-Post.

M.A. Akintunde (2008) investigated the effects of various geometries of capillary tubes based on the coil diameters and lengths alone, with no particular attention placed on the effect of coil pitch. This paper examined the effects of pitches of both helical and serpentine coiled capillary tubes on the performance of a vapor compression refrigeration system. Several capillary tubes of equal lengths (2.03 m) and varying pitches, coiled diameters and serpentine heights were used. Both inlet and outlet pressure and temperature of the test section (capillary tube) were measured and used to estimate the COP of the system. In the case of helical coiled geometries, the pitch has no significant effect on the system performance. In the case of serpentine geometries, both pitch and height affects the system performance. Performance improves with both increase in the pitch and the height. Correlations were proposed to describe relationships between straight and coiled capillary tube and between helical coiled and serpentine coiled capillary tubes. The COP obtained was 0.9841 for mass flow rates of helical and serpentine with straight tubes, 0.9864 and 0.9996 for mass flow rates of serpentine and helical coiled tube respectively. This study investigated the performance of capillary tube geometries having R-134a as the working fluid

Corberan et al. (2008) found a numerical method used to calculate mass flow rate in a capillary tube. The proposed method solves the conservation laws (continuity, momentum and energy) in 1D mesh. An iterative process is performed for a guessed value of the mass flow rate and it is followed until critical flow conditions are obtained. The resulting length is compared with the capillary tube length and a new guess of the mass flow rate is imposed. The iteration is repeated until convergence. In two phase flow, a separated flow model is assumed. Both, two-phase friction factor and viscosity models were determined by Lin correlation and void fraction from Zivi correlation. This model is included in 'IMST-ART', software for simulation and design of refrigeration equipment. The addition of capillary tube model allows calculating the superheat at the evaporator giving the capillary tube geometry. A simulation with different operative conditions and capillary tube geometry is presented and the results are compared with those given by ASHRAE correlation with the integration of the conservation equations (mass, momentum and energy) over individual control volumes. The model includes non critical and critical flow conditions. The model assumes thermodynamic equilibrium and one-dimensional two-phase flow. The meta stable condition is not taken into account.

Jiraporn Sinpiboon et al. (2002) developed a mathematical model to study flow characteristics in non adiabatic capillary tubes. The theoretical model is based on conservation of mass, energy and momentum of fluids in the capillary tube and suction line. The mathematical model is categorized into three different cases, depending on the position of the heat exchange process. The first case is considered when the heat exchange process start in the single-phase flow region, the second case is determined when the heat exchange process start at the end of the single-phase flow region, and the last case is considered when the heat exchange process takes place in the two-phase flow region. A set of differential equations is solved by the explicit method of finite difference scheme. The model is validated by comparison with the experimental data working with alternative refrigerants for design and optimization.

Jain et al (2004) studied the effect of capillary tube-suction line heat exchanger (ctslhx) geometry on system performance was explored at various design and off-design conditions by embedding it in a system model. A detailed finite-volume model of the capillary tube and suction line, capable of handling all the phase-change complexities was used. All the ctslhx configurations considered meet the design constraints and didn't affect the design COP very much. Capillary tubes with large inlet sections and relatively small outlets were found to give best performance at all the simulated off-design perturbations.

Dongsoo Jung et al. (2006) studied pressure drop through a capillary tube and modeled this pressure drop in an attempt to predict the size of capillary tubes used in residential air conditioners and also to provide simple correlating equations for practicing engineers. Stoecker's basic model was modified with the consideration of various effects due to subcooling, area contraction and different equations for viscosity and friction factor, and finally mixture effect. McAdams' equation for the two-phase viscosity and Stoecker's equation for the friction factor yielded the best results among various equations. With these equations, the modified model yielded the performance data that are comparable to those in the *ASHRAE handbook*. After the model was validated with experimental data for CFC12, HFC134a, HCFC22, and R407C, performance data were generated for HCFC22 and its alternatives, HFC134a, R407C, and R410A under the following conditions: condensing temperature; 40, 45, 50, 55°C, subcooling; 0, 2.5, 5°C, capillary tube diameter; 1.2–2.4 mm, mass flow rate; 5–50 g/s. These data showed that the capillary tube length varies uniformly with the changes in condensing temperature and subcooling. Finally, a regression analysis was performed to determine the dependence of mass flow rate on the length and diameter of a capillary tube, condensing temperature, and subcooling. Thus in this study simple practical equations yielded a mean deviation of 2.4% for 1488 data obtained for two pure and two mixed refrigerants.

Mittal et al. (2009) investigated the effect of coiling on the flow characteristics of R-407C in an adiabatic spiral capillary tube. The characteristic coiling parameter for a spiral capillary tube is the coil pitch; hence, the effect of the coil pitch on the mass flow rate of R-407C was studied on several capillary tube test sections. The authors observed that the coiling of the capillary tube significantly reduced the mass flow rate of R-407C in the adiabatic spiral capillary tube. In order to quantify the effect of coiling, the experiments were also conducted for straight a capillary tube, and observed that the coiling of the capillary tube reduced the mass flow rate in the spiral tube in the range of 9―18% as compared with that in the straight capillary tube. A generalized non dimensional correlation for the prediction of the mass flow rates of various refrigerants was developed for the straight capillary tube on the basis of the experimental data of R-407C of the present study, and the data of R-134a, R-22, and R-410A measured by other researchers. Additionally, a refrigerant-specific correlation for the spiral capillary was also proposed on the basis of the experimental data of R-407C.

NEGRÃO C.O.R. et al. (1999) worked on a numerical model to simulate the refrigerant flow through capillary tube-suction line heat exchangers. The refrigerant flow is modelled by the conservation laws of mass, momentum and energy. The resulting set of equations is solved numerically, but the model is not unconditionally convergent. It is shown that the divergence source is a discontinuity in the set of equations. The discontinuity occurs when the slope of the refrigerant flow and saturation pressure profiles, along the capillary length, are very similar. The results reveal that the discontinuity is fairly sensitive to the subcooling and to the heat transfer rate to the suction line. Finally, some suggestions are provided in order to overcome the divergence problem.

Krishna reddy Venna et al. (2012) studied and investigated the flow characteristics of R410a in coiled non-adiabatic capillary tubes and the performance of spiral capillary tubes which simulate a situation closer to that existing in practice. The effect of the pitch of spiral on the mass flow rate of refrigerant and the on the length of capillary was examined in this work. A one-pass-through experiment apparatus is set up for the experiment. Mass flow rate of R410A through the capillary is measured with different tube geometries and under various operating conditions through coiled capillary and straight capillary tubes for adiabatic and diabatic. The mass flow rates of the coiled capillary tubes decreased by 5 to 16% more than those of the straight capillary tubes at the same operating conditions. The test results show that mass flow rate in a capillary tube increases with increase of coiled pitch (P), but changes little beyond P = 120 mm.

III. CONCLUSIONS

Optimization of geometrical parameter such as diameter, length, coil pitch, twisted angle of capillary tube is possible by using experimental methods, mathematical model and by maintaining proper pressure between condenser and evaporator. The influence of such geometrical parameters on the coefficient of performance (COP) of the system, pressure drop, refrigerant flow rate, degree of sub cooling is reviewed in this paper.

REFERENCES

[1]. Amr O. Elsayed, “Experimental study on the performance of twisted capillary tube,” International Refrigeration and Air Conditioning Conference Purdue University , 2006

[2]. Hirendra Kumar Paliwal1, Keshav Kant2 , “ A model for helical capillary tubes for refrigeration systems,” International Refrigeration and Air Conditioning Conference Purdue University , 2006

[3]. S. M. Sami, P.E., H. Maltais and D. E. Desjardins, “Influence of Geometrical Parameters on Capillary Behavior with New Alternative Refrigerants,” M.Tech Thesis, Department of Mechanical Engineering, School of Engineering University of Moncton, Moncton, 2001.

[4]. Chunlu Zhang, Guoliang Ding, “Approximate analytic solutions of adiabatic capillary tube,” International Journal of Refrigeration 27 (2004) 17–24.

[5]. Akkarat Poolkrajang and Nopporn Preamjai, “Optimization of capillary tube in air conditioning system,” Asian Journal on Energy and Environment, 2009, 10(03), 165-175.

[6]. Akash Deep Singh, "Flow characteristics of refrigerant inside diabatic capillary tube," Thapar University, Patiala, (2009), pp. 1-96.

[7]. M.A. Akintunde, Ph.D. "Effect of Coiled Capillary Tube Pitch on Vapor Compression Refrigeration System Performance," The Pacific Journal of Science and Technology Volume 9. Number 2. November (2008), pp. 284-294.

[8]. Jose Miguel CORBERÁN , David FUENTES , José GONZÁLVEZ, "Numerical calculations of mass flow rate in capillary tubes using 'ART' an advance simulation software," Universidad Politécnica de Valencia, ETSII, Valencia, Valencia, Spain (2008), pp. 1-10.

[9]. Jiraporn Sinpiboon, Somchai Wongwises, "Numerical Investigation Of refriregent flow through non-adiabetic capillary tubes," Applied Theramal Engineering 22(2002) pp. 2015-2032.

[10]. Jain, Gaurav, Bullard, Clark, "Design and optimization of capillary tubesuction line heat exchangers," International Refrigeration and Air Conditioning Conference, Purdue University,2004.

[11]. Dongsoo Jung, Chunkun Park, Byungjin Park, "Capillary tube selection for HCFC22 alternatives," International Journal of Refrigeration 22, (2006) pp. 604-614.

[12]. M. K. Mittal, R. Kumar, A. Gupta, "An Experimental Study of the Flow of R-407C in an Adiabatic Spiral Capillary Tube," Journal of Thermal Science and Engineering Applications, Vol. 1, DECEMBER (2009), pp. 041003-041011.

[13]. C. O. R. Negrão, C. Melo, "Shortcomings of the numerical modeling of capillary tubesuction line heat exchangers," 20th international congress of refrigeration, iir/iif, sydney, 1999.