IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

Experimental Performance of Window Air Conditioner Using Alternative Refrigerants with Different Configurations of Capillary Tube A Review

Richa Soni [*1], P.K. Jhinge & R.C. Gupta[2]

[*1,2] Department of Mechanical Engineering, Jabalpur Engineering College, Jabalpur-482011, MP, India

madhu88jhariya@gmail.com

Abstract

This review paper presents the work of various researches on the performance of capillary tube ,used in air conditioners with various refrigerants. Research carried out by different authors uses different type of capillary tubes (straight, twisted, coiled) in different length and diameter. they determined various parameters like coefficient of performance (COP),cooling capacity, energy efficiency ratio (EER) of the system. Various approaches have been used by different authors to predict the performance of capillary in window air conditioner using alternative refrigerant as capillary expansion device.

Keywords: Air conditioner, capillary and refrigerants R-22, R-410A.

Introduction

Air conditioning and refrigeration systems plays an important role in industry, infrastructure and households. The industrial sector includes the food industry, textiles, chemicals, printing, transport and others. Infrastructure includes banks, restaurants, schools, hotels and recreational facilities. Therefore, installation, repair and maintenance of equipment to function properly are important for the operations associated with those activities. The capillary tube is made from copper pipe, with a diameter around 0.5 mm to 5 mm and length around 0.5 m to 5 m. Its use depends on power and load capacity of the system. The capillary tube is often used with small cooling load or small changing load systems, such as refrigerators, water coolers and small air conditioners [1] .

Capillary tube is one of the most commonly used throttling devices in the refrigeration and air conditioning systems. The capillary tube is a copper tube of very small internal diameter. It is of very long length and it is coiled to several turns so that it would occupy less space. Capillary tube used as the throttling device in the domestic refrigerators, deep freezers, water coolers and air conditioners. When the refrigerant leaves the condenser and enters the capillary tube its pressure drops down suddenly due to very small diameter of the capillary. In capillary the fall in pressure of the refrigerant takes place not due to the orifice but due to the small opening of the capillary.The decrease in pressure of the refrigerant through the capillary depends on the diameter of the capillary and the length of the capillary.

Here are some of the advantages of using capillary tube as the throttling device in the refrigeration and the air conditioning systems:

1) The capillary tube is a very simple device that can be manufactured easily and it is not very costly.
2) The capillary tube limits the maximum amount of the refrigerant that can be charged in the refrigeration system due to which the receiver is not required in these systems.
3) When the refrigeration plant stops the pressure across the capillary tube becomes same and also along the whole refrigeration cycle the pressure is constant. This means that when the plant is stopped the pressure at the suction and discharge side of the compressor are same. Thus when the compressor is restarted there is not much load on it since it does not have to overcome very high pressures. Due to this the compressor motor of smaller torque can be selected for driving the compressor, thus reducing the cost of the compressor. This along with the above two advantages helps reducing the overall cost of the refrigeration and the air conditioning system **[2]**.

Literature Review

The objective of this study is to present test results and to develop a dimensionless correlation on the basis of the experimental data of adiabatic capillary tubes for R22 and its alternatives, R407C (R32/125/134a, 23/25/52 wt.%) and R410A (R32/125, 50/50 wt.%). Several capillary tubes with different length and inner diameter were selected as test sections. Mass flow rate through the capillary tube was measured for several condensing temperatures and various degrees of subcooling at the inlet of each capillary tube **[3].**

This paper focuses on an investigation of the proper capillary tube length for an inverter air conditioner. Air to air variable capacity systems with R-22 and R-407C were tested and modeled. First, the optimum refrigerant charge was determined for four capillary tubes at full load condition by varying the mass charge from 1.1 kg to 1.9 kg. The capillary tube lengths were 1.016 m, 0.914 m, 0.813 m and 0.711 m. The two zone model, the distributed model and the combined model were compared to estimate the optimal charge inventory. The combined model analysed a simple path evaporator, a complex path condenser with a two zone model and a distributed model,respectively. It obtained good agreement with experimental results for the system performances and the optimum mass charge **[4]**.

In this paper, pressure drop through a capillary tube is modeled 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, 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. 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 **[5].**

This paper presents an experimental investigation of coiling effect on the flow of R-407C in an adiabatic helical capillary tube. It has been observed that the coiling of capillary tube significantly influences the mass flow rate of R-407C through the adiabatic helical capillary tube. For the sake of comparison, the experiments have also been conducted for straight capillary tube and it has been observed that the mass flow rates in coiled capillary tube are 5–10 percent less than those in a straight one. The data obtained from the experiments have been analyzed and non-dimensional correlations for the prediction of mass flow rate of R-407C in straight and helical capillary tube have been developed. The proposed correlations predict our experimental data in an error band of ±10 percent. The predictions by developed correlations are also in good agreement with the data of other investigators **[6].**

This paper experimentally investigated the system performance of a split-type air conditioner matching with different coiled adiabatic capillary tubes for HCFC22 and HC290. Experiments were carried out in a room-type calorimeter. The results have shown that (1) similar cooling effects can be achieved by matching various capillary tubes of different inner diameters; (2) parallel capillary tubes presented better system performance and flow stability with weaker inlet pressure fluctuations than the single capillary tube; (3) with the coil diameter of the capillary tube increasing from 40 mm to 120 mm, the mass flow rate tended to increase slightly. But the cooling capacity, input power and energy efficiency ratio (EER) did not show evident tendency of change; (4) the refrigerant charge and mass flow rate for HC290 were only 44% and 47% of that for HCFC22, respectively, due to the much lower density. And HC290 had 4.7–6.7% lower cooling capacity and 12.1–12.3% lower input power with respect to HCFC22. However, the EER of HC290 can be 8.5% higher than that of HCFC22, which exhibits the advantage of using HC290. In addition, the experimental uncertainties were analyzed and some application concerns of HC290 were discussed **[7] .**

The present work presents a simple model for matching coiled capillary tubes and the refrigerant charge in a split air conditioner when the other components are fixed. The system model is composed of sub models for the key components, i.e., a lumped model for the compressor, zone models for the condenser and the evaporator, and a four flow region distributed model for the coiled adiabatic capillary tube in series with the liquid tube. The C-M-N method is employed to calculate the friction factors in the coiled capillary tube. HCFC22 and HC290 are used for the simulations. The comparison of the model prediction with experimental data shows the errors are less than ±5% except for the mass flow rate with a maximum deviation of 8.63%. The results confirm that both the cooling capacity and input power are slightly reduced when HCFC22 is replaced by HC290 with the coiled capillary tube and refrigerant charge matched to the HC290 refrigerant. The results also show that when coil diameter is reduced from 0.3 m to 0.04 m, the capillary tube length is reduced by about 10% for both HCFC22 and HC290 **[8]**.

Air-conditioners use spirally coiled capillary tubes as an expansion device to enhance compactness of the unit. However,most empirical correlations for predicting refrigerant flow rate through capillary tubes were developed for straight capillary tubes without consideration of coiled effects. The objectives of this study are to investigate the flow characteristics of the coiled capillary tubes and to develop a generalized correlation for the mass flow rate through the coiled capillary tubes.. A generalized correlation for predicting refrigerant mass flow rate through coiled capillary tubes was developed by introducing the parameter of capillary equivalent length. The present correlation showed good predictions with the present database for R22, R407C and R410A in the straight and coiled capillary tubes, yielding average and standard deviations of 0.24% and 4.4%, respectively **[8].**

Conclusion

The above literature review presents that the diameter and the length of capillary tube have a direct relationship. If the diameter is smaller, the length is shorter. If the diameter is larger, the length is longer. All of these factors enable the exit pressure from the capillary tube to be reduced corresponding with the cooling requirements. The proper refrigerant charge in an air conditioner is an important subject in the system design. Hence, the optimum refrigerant charge was investigated for each capillary tube at standard conditions. In capillary tube, the mass flow rate variation with subcooling is independent of capillary length, inlet pressure and coil diameter.

Dimensionless correlation was developed to predict mass flow rates through adiabatic capillary tubes as a function of several dimensionless parameters based on the Buckingham π theorem.

References

[1] Akkarat Poolkrajang1* and Nopporn Preamjai2, Optimization of capillary tube in air conditioning system, As. J. Energy Env. **2009**, 10(03), 165-175 .

[2] http://www.brighthubengineering.com/hvac/58420-capillary-tube-for-refrigeration-and-air-conditioning-systems/

[3] S. G. Kim, M. S. Kim1*, S. T. RO Experimental investigation of the performance of R22, R407C and R410A in several capillary tubes for air-conditioners, International Journal of Refrigeration 25 (2002) 521–531

[4] Pongsakorn Sarntichartsak a,*, Veerapol Monyakul b, Sirichai Thepa c, Modeling and experimental study on performance of inverter air conditioner with variation of capillary tube using R-22 and R-407C, Energy Conversion and Management 48 (2007) 344–354

[5] Dongsoo Jung*,1, Chunkun Park, Byungjin Park , Capillary tube selection for HCFC22 alternatives, International Journal of Refrigeration 22 (1999) 604±614

[6] M.K. Mittal, Ravi Kumar*, Akhilesh Gupta, An experimental study of the flow of R-407C in an adiabatic helical capillary tube, international journal of refrigeration 33 (2010) 840 – 847

[7] Guobing Zhou a,*, Yufeng Zhang b, Performance of a split-type air conditioner matched with coiled adiabatic capillary tubes using HCFC22 and HC290, Applied Energy 87 (2010) 1522–1528

[8] Guobing Zhou a,*, Yufeng Zhang b, Yongping Yang a, Xi Wang a, Numerical model for matching of coiled adiabatic capillary tubes in a split airconditioner using HCFC22 and HC290, Applied Thermal Engineering 30 (2010) 1477e1487

[9] Chasik Park, Sunil Lee, Hoon Kang, Yongchan Kim*,Experimentation and modeling of refrigerant flow through coiled capillary tubes, International Journal of Refrigeration 30 (2007) 1168e1175