Performance Analysis Of Car Cooling System Based On Variation Of Expansion Valve

Jufra D.J. Abanat, Edwin P.D. Hattu, Nasaruddin Nasaruddin, Aris Samule, Marselinus Doreng, Duran Hore, Fransisko P. Niron, Amirudin Abdullah, Jhon Arnoldos Wabang

State Polytechnics of Kupang Adisucipto Street, Kupang, Indonesia
abanatjuf@mail.com

Abstract. Refrigeration technique is a technique for regulating air temperature in accordance with desired needs, covering the needs of rooms in offices, in industry, shops and others such as processing needs for food preservation, including service/production, maintenance and quality control. In a cooling system (AC), there are a series of main components to support the working system, namely the compressor, condenser, filter drainer, expansion valve and evaporator. The five components that are of concern in this study are the capillary tubes. The function of the capillary tube is to reduce the pressure and reduce the temperature of the system. The purpose of this study was to determine the performance of the refrigeration system in a refrigerator machine through capillary tube variations for a diameter of 0.026 inches, 0.028 inches and 0.031 inches. By varying the diameter of the capillary tube, it can be seen that the coefficient of performance (COP) and Energy Efficiency Ratio (EER) values, cooling capacity (Cooling Capacity), refrigeration effect and system efficiency.The refrigerator used in this study uses a vapor compression cycle and uses a compressor with a power of 1/8 PK. The method used is the experimental method where experiments are carried out on the refrigerator by changing the capillary tube for three types of diameter sizes that are planned to determine the performance of the refrigerator with each size of the capillary tube. The research results show that in a capillary tube with a diameter of 0.026 inches, Coeficient of Performance (COP) was 6.43, Refrigeration Efficiency 87.11%, cooling capacity 3.87 kW, and refrigeration effect 175.94 kJ/kg. For capilarry tube with a diameter of 0.028 inches, Coeficient of Performance (COP) was 7.72, Refrigeration Efficiency 90.29%, cooling capacity 4.03 kW, and refrigeration effect 183.16 kJ/kg. In a capillary tube for a diameter of 0.031 inches, Coeficient of Performance (COP) was 6.47, Refrigeration Efficiency 75.69%, cooling capacity 3.99 kW, and refrigeration effect 181.57 kJ/kg.

Keywords: Capillary Tube, Air Conditioning System.

1 Introduction

The cooling system is a series consisting of several components that work in principle using a working fluid in the form of a refrigerant, which in principle works as the

M. U. H. Al Rasyid and M. R. Mufid (eds.), *Proceedings of the International Conference on Applied Science and Technology on Engineering Science 2023 (iCAST-ES 2023)*, Advances in Engineering Research 230,
https://doi.org/10.2991/978-94-6463-364-1_54

refrigerant is pressed by the compressor and condensed on the evaporator to become a liquid with a cooler temperature. This process occurs continuously so that this system in a few minutes already produces very cold temperatures.

Refrigeration technology is currently affecting the life of the modern world, not only limited to improving the quality and comfort of life, but also touching essential things for the longevity of human life. This technology is needed for food preparation, food storage and distribution, air conditioning for room comfort in industry, offices, transportation and households.

Refrigeration machine (refrigerator) is a tool used to transfer heat from indoors to outdoors to make the temperature of objects/rooms lower than the temperature of the environment so as to produce cold temperatures/temperatures [5]. So that the working process of the cooling machine is always related to the processes of heat flow and heat transfer.

On the other hand, refrigerator is a cooling device that can maintain the freshness of the food inside. In the process of working the refrigerator produces conditions of cold air temperature, it becomes difficult for the microbes inside the refrigerator to breed so that the food lasts longer and does not change the taste. With a refrigerator, it is hoped that vegetables, meat, eggs, fruits can last longer and last longer. With a refrigerator, people can also enjoy cold and fresh drinks

One very important component in the cooling system in the refrigerator is the capillary tube. According to Vincent Rio Pangestu Bowo (2013) the components of this refrigeration machine function to reduce pressure and regulate the liquid refrigerant flowing towards the evaporator. The size of the capillary tube depends on the capacity of the refrigeration machine used in the refrigerator which regulates refrigerant flow, namely the capillary tube.

In this study it was carried out on one refrigerator unit, in which the capillary tube was varied for diameters of 0.026 inches, 0.028 inches, and 0.031 inches, and then data was taken to see the value of the Coefficient of Performance (COP) and find out the efficiency of the system and the cooling load.

2 Research Methodology

This research was carried out in the energy conversion laboratory with a sketch of the research object as shown in Figure 1 below.

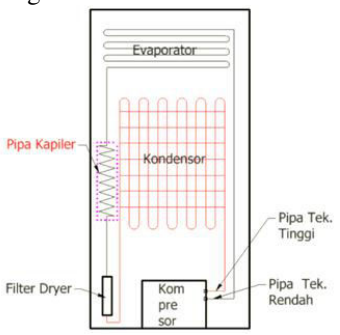

Fig. 1. Set Up Experimental

The success of this research requires the sequence of its implementation so that it is directed and obtains maximum results. The sequence of implementation can be seen in the flowchart in Figure 2 below.

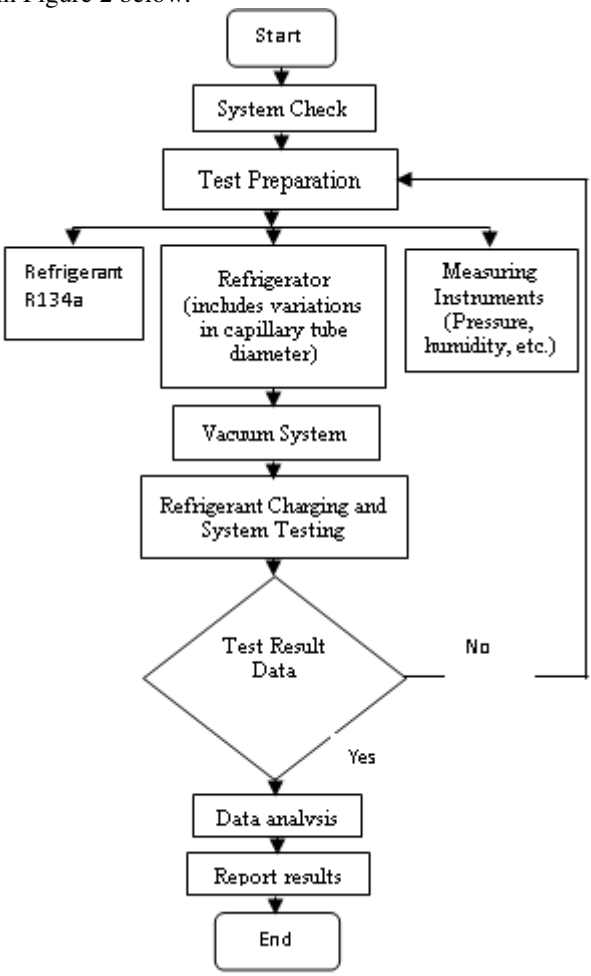

Fig. 2. Flow Charts

3 Result And Discussion

3.1 Result

This test is carried out on a refrigerator with the following specifications:

1. The mass of refrigerant = 60 gr
2. Testing time = 180 Minutes

Based on the planned system design and the research flow, the test results of the three capillary tube can be seen in the following table below :

Table 1. Test Results for three diameters capillary tube

No	Diameter of Capilary Tube (Inch)	Temperature (^{0}C)				
		Evaporators		Kondenser		Environment
		Evaporating	Superheat	Kondensation	Sub cooling	
1	0.026	-2.8	21.1	33.8	29.9	29.1
2	0.028	-1.9	20.3	29.8	24.2	22
3	0.031	-6	14.7	31.3	22.4	17.5

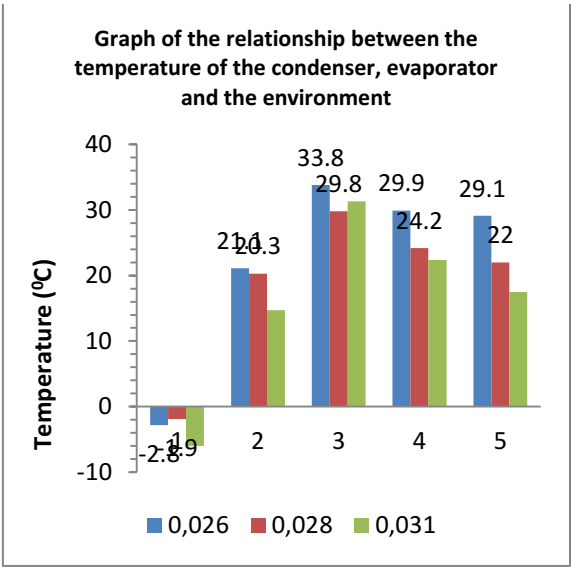

Fig. 3. Graph of relationship between three capillary tube temperature

3.2 Discussion

The test results in the table and graph above can be calculated the performance of refrigerator with R134a refrigerant as follows:

a. Diameter 0.026 inch for length of 1.5 meters

On the dimension of a capillary tube of this size, testing for 180 minutes, the evaporator temperature shows the number -2 ^{0}C and the condenser temperature is 33.8^{0}C at the ambient temperature condition of 29.1 ^{0}C.

Test result data through coolpack software are as follows :

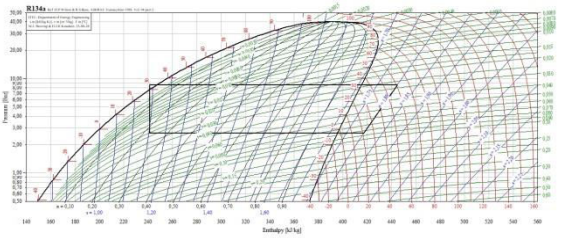

Fig. 4. Graph of p-h diagram for a capillary tube with a diameters of 0.026 inches

h_1 = 417.26 kJ/kg h_2= 444.62 kJ/kg
h_3 = 241.32 kJ/kg h_4 = 241.32.36 kJ/kg

1. Specific work by the Compressor (Q_w).
   27.36 kJ/kg
2. The heat is released by the condenser (q_k)
   203.30 kJ/kg
3. Refrigeration Effect (q_e)
   175.94 kJ/kg
4. Coeffisient Of Performance(COP)
   a. COP_{aktual} = 6.43
   b. COP_{carnot} = 7.38
5. Refrigeration Efficiency (η)
   87.11%
6. Cooling Capacity (Q_e) :
   3.87 kW.

b. Diameter 0.028 inch for length of 1.5 meters

For the dimension of a capillary tube, testing for 180 minutes, the evaporator temperature shows the number 2.9 ^{0}C and the condenser temperature is 29.8 ^{0}C at the ambient temperature condition of 22.0^{0}C.

Test result data through coolpack software are as follows :

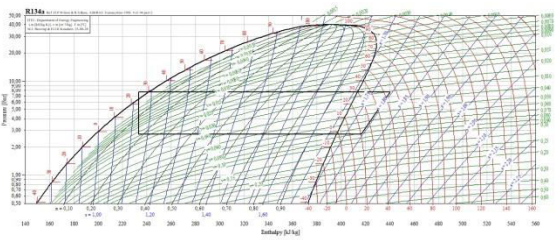

Fig. 5. Graph of p-h diagram for a capillary tube with a diameters of 0.028 inches

h_1 = 416.32 kJ/kg h_2= 440.04 kJ/kg
h_3 = 233.16 kJ/kg h_4 = 233.16 kJ/kg

1. Specific work by the Compressor (Q_w).
   23.72 kJ/kg
2. The heat is released by the condenser (q_k)
   206.88 kJ/kg
3. Refrigeration Effect (q_e)
   183.16 kJ/kg
4. Coeffisient Of Performance(COP)
   a. COP_{aktual} = 7.72
   b. COP_{carnot} = 8.55
5. Refrigeration Efficiency (η)
   90.29%
6. Cooling Capacity (Q_e) :
   4.03 kW.

c. Diameter 0.031 inch for length of 1.5 meters

In the capillary tube, the test was carried out for 180 minutes, the evaporator temperature was -6.0 ^{0}C and the condenser temperature was 31.3 ^{0}C at the ambient temperature of 17.5 ^{0}C.
Test result data through coolpack software are as follows :

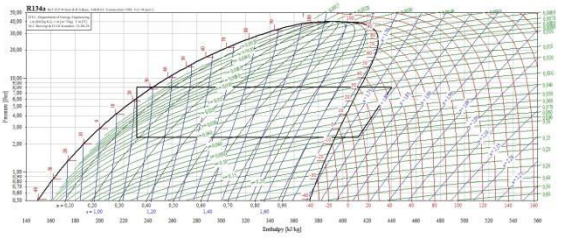

Fig. 6. Graph of p-h diagram for a capillary tube with a diameters of 0.028 inches

h_1 = 412.18 kJ/kg h_2= 440,23 kJ/kg
h_3 = 230.61 kJ/kg h_4 = 230.61 kJ/kg

1. Specific work by the Compressor (Q_w).
   28.05 kJ/kg
2. The heat is released by the condenser (q_k)
   209.62 kJ/kg
3. Refrigeration Effect (q_e)
   181.57 kJ/kg
4. Coeffisient Of Performance(COP)
   a. COP_{aktual} = 6.47
   b. COP_{carnot} = 8.55
5. Refrigeration Efficiency (η)
   75.69%

6. Cooling Capacity (Q_e) :
   3.99 kW.

4 Conclusions

Based on the results of data, it can be concluded as follows:

1. In a capillary tube with a diameter of 0.026 inches, Coeficient of Performance (COP) was 6.43, Refrigeration Efficiency 87.11%, cooling capacity 3.87 kW, and refrigeration effect 175.94 kJ/kg.
2. For capilarry tube with a diameter of 0.028 inches, Coeficient of Performance (COP) was 7.72, Refrigeration Efficiency 90.29%, cooling capacity 4.03 kW, and refrigeration effect 183.16 kJ/kg.
3. In a capillary tube for a diameter of 0.031 inches, Coeficient of Performance (COP) was 6.47, Refrigeration Efficiency 75.69%, cooling capacity 3.99 kW, and refrigeration effect 181.57 kJ/kg.

Acknowledgements

The authors would like to thank State Politeknik of Kupang for the financial support through the RUTIN Research Programme. A thank you also goes to Wilmar as a technician in the energy conversion machine laboratory for their help to record the values of performance of refrigerators system based on variation of capillary tube diameter using manifold gauge and electrical equipments.

References

1. Analysis of the Effect of Capillary Tube Diameter on the Coefficient of Performance in Refrigerators, Gunadarma University, 2016.
2. Analysis of the Effect of Capillary Tubes Wrapped on the Suction Line on the Performance of Cooling Machines, URNAL MECHANICAL ENGINEERING Vol. 4, No. 2, October 2002: 94 – 98
3. ASHRAE, (2010), Refrigeration, American Society of Heating, Refrigeration And Air Conditioning Engineers, USA.
4. Effect of thermostatic expansion valve tuning on the performance enhancement and environmental impact of a mobile air conditioning system, Rajendran, Journal of Thermal Analysis and Calorimetry, DOI: 10.1007/s10973-019-09224-2
5. Gunawan Terry, (2014), Experimental Tests of Water-Cooled Engine With Uses R22 refrigerant and R407c Refrigerant, Poros, Volume 12 Nomor 2, November 2014, 165 – 172
6. Muslih, N. (2020). Analysis of Air Conditioner (AC) Performance Against Changes in Compressor Pressure and Rotation Speed On Xenia Type R Cars, PISTON VOL. 4 No. 2 MAY 2020 ISSN : 2548-186X (Print) ISSN : 2548-1878 (Online)
7. Rajendran, Effect of thermostatic expansion valve tuning on the performance enhancement and environmental impact of a mobile air conditioning system, Journal of Thermal Analysis and Calorimetry, DOI: 10.1007/s10973-019-09224-2

8. The Effect of Changing Filter-Drier Dimensions and Capillary Tubes on the Coefficient of Performance (COP) of 2-Door Refrigerator Refrigerators, JTT (Journal of Applied Technology) | Volume 7, Number 1, March 2021, p-ISSN 2477-3506 and e-ISSN 2549-1938.