Study of Refrigerator Performance Through Variation of Capiler Pipe Length

Jufra D. J. Abanat, Jhon Arnoldos Wabang and Edwin P. D. Hattu
Machine Engineering, State Polytechnics of Kupang, Adisucipto Street, Kupang, Indonesia

Keywords: Cooling System, Capillarity Tube.

Abstract: In the cooling system (AC), there are a series of main components to support the working system, namely the compressor, condenser, filter drayer, capillary pipe or expansion valve and evaporator. The five components of concern in this study are the capillary tube. The function of the capillary tube is to lower the pressure and lower the temperature of the system. The results showed that the performance of the refrigerator with length of capillary pipe 150 cm, diameter 0.031 inch, Coeficient of Performance (COP) was 3.28, Refrigeration Efficiency 86.47%, refrigeration effect 130.17 kJ/kg. and pressure ratio 6,22. For refrigerator with length of capillary pipe 200 cm, diameter 0.031 inch, Coeficient of Performance (COP) was 3.41, Refrigeration Efficiency 79.68%, refrigeration effect 128.66 kJ/kg. and pressure ratio 6,33. In refrigerator with length of capillary pipe 250 cm, diameter 0.031 inch, Coeficient of Performance (COP) was 3.25, Refrigeration Efficiency 77.27%, refrigeration effect 127.02 kJ/kg. and pressure ratio 6,77. Based on the results of the analysis of the three types of capillary pipes, capillaries with a length of 150 mm have better performance than the other two types of capillary pipes.

1 INTRODUCTION

Air conditioning is a condition that continues to be a concern because this system is needed in almost all fields, therefore the application of components that can work effectively and efficiently continues to be researched in order to get an AC working system that can provide comfort for users in their daily activities all day and every where (Anwar et al., 2010).

In the cooling system, a series of main components to support the working system, namely the compressor, condenser, filter drayer, expansion valve or capillary tube and evaporator.The five components that are of concern in this study are the variation of length of capillary tube. this is due to the difference that there are several refrigerators that have capillary pipe sizes that are not the same length (Anwar, 2010); (Bowo, 2013).

In this study using variations of three types of pipe lengths, namely capillary pipes with a length of 150 mm, 200 mm and 250 mm respectively with the same diameter, namely 0.031 inchi.

These three types of capillary tube will be tested using the refrigerators. The refrigerant material used is refrigerant (R234a) (Wang et al., 2017). The basis for choosing this material is because the refrigerators compressor is only suitable for using R134a.

The test model used is to vary the three types of capillary tube to determine the performance of the system in the form of Coeficient of Performance (COP), refrigeration effect, system efficiency and pressure ratio (Wardika, 2018).

2 RESEARCH METHODOLOGY

This research was conducted in the Refrigeration Engineering laboratory, with the set up as follows:

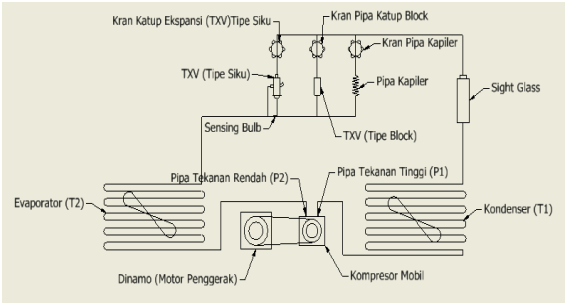

Figure 1: Set Up Experimental.

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The implementation of this research followed the flow chart as shown below in fig.2. From this set up of experiments, a system test is performed with steps such as the following flow chart:

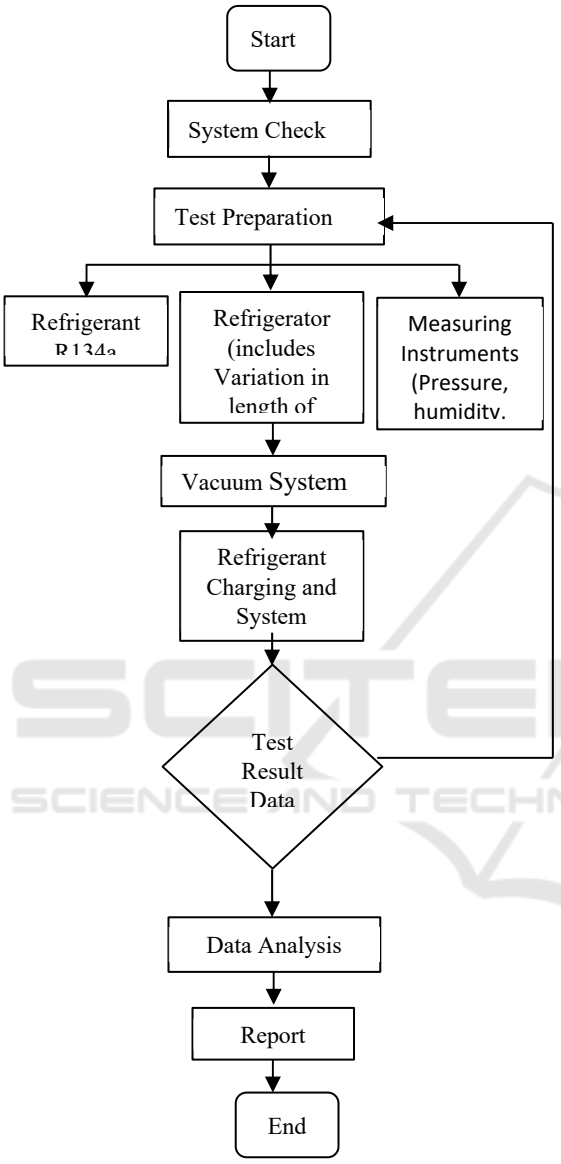

Figure 2: Flow Charts.

3 RESULT AND DISCUSSION

3.1 Result

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

1. The mass of refrigerant = 40gr
2. Testing time = 120 Minutes

Based on the research flow, the test results of the three type of length of capillary pipe can be seen in the following table below :

Table 1: Test results for length of capillary pipe 150 cm, diameter 0.031 inch.

No	Time (Menute)	Mass refrigerant (gr)	Temperature (°C)			Low Pressure (psi)
			Evaporator	Condenser	Environment	
1	30	10	18,5	33,1	30,8	-10
2	30	20	16	34,2	31	0
3	30	30	-11,7	38,8	31,2	3
4	30	40	-13	42,5	31	9

Table 2: Test results for length of capillary pipe 200 cm, diameter 0.031 inch.

No	Time (Menute)	Mass refrigerant (gr)	Temperature (°C)			Low Pressure (psi)
			Evaporator	Condenser	Environment	
1	30	10	15,7	33,5	31	-6
2	30	20	-11,4	38	30,9	0
3	30	30	-16	42,1	30,9	5
4	30	40	-16,5	43,5	30,9	10

Table 3: Test results for length of capillary pipe 250 cm, diameter 0.031 inch.

No	Time (Menute)	Mass refrigerant (gr)	Temperature (°C)			Low Pressure (psi)
			Evaporator	Condenser	Environment	
1	30	10	13,1	33,8	30,7	-8
2	30	20	-6,2	36	30	-2
3	30	30	-18,5	42,6	30,5	5
4	30	40	-19	41,4	30,2	8

3.2 Discussion

The test results based on variations in the length of the capillary tube in the table 1, table 2 and table 3 above can be calculated the performance of refrigerator with R134a refrigerant as follows:

a. Length of capillary pipe 150 cm, diameter 0.031 inch.

Based on the test results in the table 1 above, it appears that at minute 120 with a refrigerant mass of 40 gr, the evaporator temperature reaches a temperature of -13 at a low pressure of 9 Psi.

The data from this test, plotted in the coolpack application, obtained a graph as shown in the figure below:

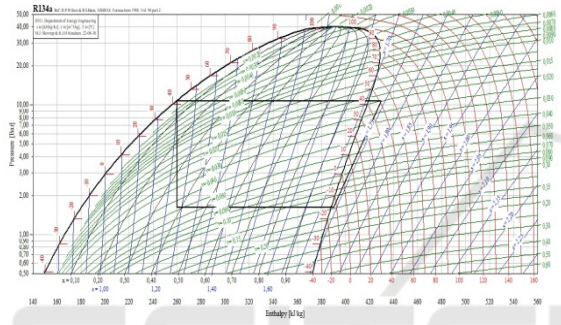

Figure 3: Graph of p-h diagram for Length of capillary pipe 150 cm, diameter 0.031 inch.

The graph in this figure shows the enthalpy values as follows:

h_1 = 390.09 kJ/kg h_3 = 259,92 kJ/kg
h_2 = 429,75 kJ/kg h_4 = 259,92 kJ/kg

The performance of the refrigerator based on the eltalpy values is as follows:

1. Specific work by the Compressor (Q_w).
   39,66 kJ/kg
2. The heat is released by the condenser (q_k)
   169,83 kJ/kg
3. Refrigeration Effect (q_e)
   130,17 kJ/kg
4. Coeffisient Of Performance(COP)
   a. COP_{aktual} = 3,28
   b. COP_{carnot} = 3.79
5. Refrigeration Efficiency (η)
   86,47%
6. Pressure Ratio:
   6,22,

b. Length of capillary pipe 200 cm, diameter 0.031 inch.

The test results in the table 2 above, it appears that at 120 minutes with a refrigerant mass of 40 g, the evaporator temperature reaches a temperature of -16.5 at a low pressure of 10 Psi.

The data from this test, plotted in the coolpack application, obtained a graph as shown in the figure below:

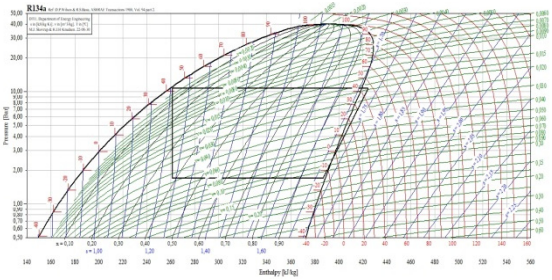

Figure 4: Graph of p-h diagram for Length of capillary pipe 200 cm, diameter 0.031 inch.

The graph in this figure shows the enthalpy values as follows:

h_1 = 386,87 kJ/kg h_3 = 261,43 kJ/kg
h_2 = 424,64 kJ/kg h_4 = 261,43 kJ/kg

The performance of the refrigerator based on the enthalpy values is as follows:

1. Specific work by the Compressor (Q_w).
   37,77 kJ/kg
2. The heat is released by the condenser (q_k)
   163,21 kJ/kg
3. Refrigeration Effect (q_e)
   128,66 kJ/kg
4. Coeffisient Of Performance(COP)
   a. COP_{aktual} = 3,41
   b. COP_{carnot} = 4.28
5. Refrigeration Efficiency (η)
   79,68%
6. Pressure Ratio:
   6,33

c. Length of capillary pipe 250 cm, diameter 0.031 inch.

In the table above, it appears that at minute 120 with a refrigerant mass of 40 g, the evaporator temperature reaches a temperature of -19 at a low pressure of 8 Psi.

The data from this test, plotted in the coolpack application, obtained a graph as shown in the image below:

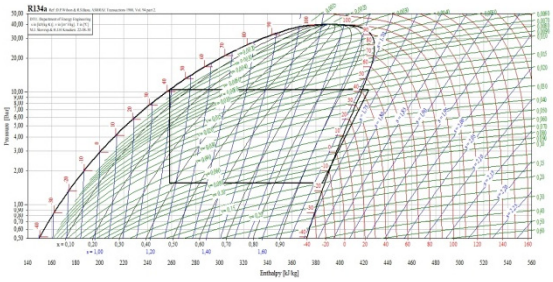

Figure 5: Graph of p-h diagram for Length of capillary pipe 250 cm, diameter 0.031 inch.

The graph in this figure shows the enthalpy values as follows:

h_1 = 385,28 kJ/kg h_3 = 258,26 kJ/kg

h_2 = 424,37 kJ/kg h_4 = 258,26 kJ/kg

Refrigerator performance based on enthalpy values are as follows:

1. Specific work by the Compressor (Q_w). 39,09 kJ/kg
2. The heat is released by the condenser (q_k) 166,38 kJ/kg
3. Refrigeration Effect (q_e) 127,02 kJ/kg
4. Coeffisient Of Performance(COP)

a. COP_{aktual} = 3.25

b. COP_{carnot} = 4.21

5. Refrigeration Efficiency (η) 77,27%
6. Pressure Ratio : 6,77.

4 CONCLUSION

Based on the results of the study in table above, it can be concluded as follows:

1. The results showed that the performance of the length of capillary pipe 150 cm, diameter 0.031 inch, Coeficient of Performance (COP) was 3.28, Refrigeration Efficiency 86.47%,, and refrigeration effect 130.17 kJ/kg.
2. For length of capillary pipe 200 cm, diameter 0.031 inch, Coeficient of Performance (COP) was 3.41, Refrigeration Efficiency 79.68%,, and refrigeration effect 128.66 kJ/kg.
3. In length of capillary pipe 250 cm, diameter 0.031 inch, the Coeficient of Performance (COP) is 3.25, Refrigeration Efficiency 77,27%, and refrigeration effect 127,02 kJ/kg.

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