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Analysis of the Coefficient of Performance (COP) of Water Cooled Refrigeration System

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Abstract— *This research aims to obtain the coefficient of performance (COP) value of the refrigeration system (freezer) TD242 water cooled. The refrigerant used is R-404a. There are two variations of the test carried out, variation I mode freezer no cooling load and variation II mode freezer with cooling load. The test was carried out 3 times with duration of 120 minutes for one test by measuring pressure, amperes, voltage and temperature on the main and supporting components of the TD242 Engine. From the results of data collection and analysis on the TD242 Machine, the value of the Coefficient of Achievement (COP) for variation I mode was obtained refrigerator without cooling load in sample 1 it is 1.843 in sample 2 it is 1.685 in sample 3 it is 1.649 with an average value of 5.177 and variation II mode freezer with the cooling load in sample 1 amounting to 1.427 in sample 2 amounting to 1.384 in sample 3 amounting to 1.386 with an average value of 4.197.*

Keywords— *Freezing machine, COP, water cooled, R-410a.*

I. INTRODUCTION

Freezer is a cooling machine that can reduce the temperature in the room to below 0ºC. Refrigeration system on freezer consists of four main components, namely: compressor, condenser, expansion valve and evaporator, of various food preservation methods, freezing is the most effective, easy, fast, practical and relatively safer method. Low temperatures prevent bacteria or viruses in food from working because the slowing of metabolism means the bacteria and viruses die and there is less risk of contamination.

Coefficient of performance (COP) is an indicator that really determines the work of the system itself. By looking at the COP value of a refrigeration system we can find out the performance of the system, whether the system is working as it should or not (Candela, L. S., & AG, W, 2014). To calculate the Coefficient of Performance (COP) value for the cooling system, the refrigeration effect is divided by the compression work. The greater the COP value, the more optimal the cooling machine will work.

Refrigeration is a combination or combination of equipment that is assembled into one unit to produce a cooling effect, while a refrigerant is a substance used as a cooling fluid that works in the heat absorption process. Cooling in a refrigeration system goes through four main processes. The first process is the absorption of heat from the refrigerant liquid in the evaporator. During the absorption process, the state of the refrigerant changes from liquid to gas. When the refrigerant passes through the evaporator, the gas is heated and becomes a superheated gas.

Next, the hot gas continues to the compressor to receive the compression process, resulting in an increase in working pressure. The transfer of energy from the compression device to the refrigerant results in an increase in the working temperature of the hot gas. The hot gas is then channeled to the condenser. In the condenser, heat is dissipated due to the release of sensible heat and the release of latent heat which causes the gas to change to liquid. The temperature decrease continues in the capillary tube so that the liquid cools before flowing into the expansion device. The expansion device then reduces the pressure and controls the amount of refrigerant flow that can go to the evaporator.

Refrigerators are mainly used in daily life as food storage machines and air conditioners. Another application of refrigerators is for industrial needs, such as freezing large amounts of food. In offices, refrigeration machines act as air conditioners which help office workers work more comfortably. Apart from that, in the transportation system, refrigeration machines also function as air conditioners for private and commercial vehicles and as coolers for storing food when moving from one location to another.

TD242 is a refrigeration machine in the Refrigeration Laboratory, Department of Mechanical Engineering Education, Faculty of Engineering, Makassar State University. The machine can double function as a freezer and air conditioner. The refrigerant used is R-404a. The condenser cooling system used on the TD242 is water cooling. To find out whether the machine is working optimally or not, you need to do calculations to find out the Coefficient of Performance (COP) value. A picture of the machine can be shown in figure 1.

Fig. 1. TD242 Refrigeration system

II. RESEARCH METHOD

The type of research used is descriptive research. According to Sugiyono, D. (2013) descriptive research is

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research conducted to determine the value of independent variables, either one or more variables (independent) without making comparisons or connecting them with other variables to obtain the coefficient of achievement (COP) value for the TD242 refrigeration system. Basically, descriptive analysis techniques are techniques used for testing, measuring and hypothesizing based on mathematical and statistical calculations. The data collection method in this research uses experimental data.

The research procedure begins at the preparation stage, implementation stage, and reporting stage with data collection techniques using literature studies and experimental studies. Data analyses is carried out by collecting all data obtained from measurements using DAQ Express then do the calculations using CoolPack *software* to determine the performance of the vapor compression system heat pump.

The subject of this research is the TD242 vapor compression refrigeration system which can be seen in Fig. .2. This refrigeration system uses R-404a refrigerant.

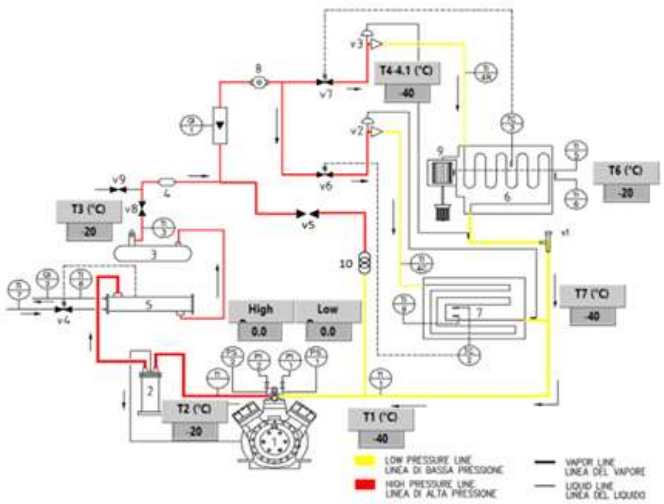

Fig. 2. TD242 Refrigeration system scheme

The components in the TD242 Refrigerating system that is:

1) Compressor (Compressore)
2) Oil Separator (Separatore Ouo)
3) Freon Tank (Serbatolo Freon)
4) Filter (Filtro)
5) Condenser (Condensatore)
6) Air Cooler Evaporator (Evaporatore Condizionatore)
7) Freezer Evaporator (Evaporatore Cella Frigorifera)
8) Humidity Indicator (Indicatore Di Umidita')
9) Centrifugal Fan (Ventilatore Centrifugo)
10) Injection Capillary Tube (Capillare Di Iniezione)
11) Control Valve (Valvola Regolatrice) (v1)
12) Valvola Di Espansione (Expansion Valve) (v2,v3)
13) Economizer Valve (Valvola Economizzatrice) (v4)
14) balance valve (valvola di bilanciamento) (v5)
15) Solenoid Valve (Elettrovalvola) (v6,v7)
16) Filling Valve (Valvola Di Riempimento) (v8,v9)
17) Temperature Indicator (Indicatore Di Temperature) (TI)
18) Pressure Indicator (Indicatore Di Pressione) (PI)
19) Thermostat (Termostato) (TC)
20) Pressure Swich (Pressostato) (PS)
21) Flow Meter (Flussi Metro) (QI)

In this research, data analysis was carried out by collecting all measurement data from the TD242 machine Refrigerating system. The data obtained is in the form of temperature, pressure at several points in the system, flow rate of refrigerant and cooling water, electric current and voltage. The system is run in two variations, namely a freezer without a load and a freezer with a load. The measurement results are then analyzed to obtain the coefficient of performance (COP) system.

III. Results and Discussions

Data collection was carried out using ampere forceps, thermocouple, application Software NI DAQ Express to read voltage, current, high pressure, low pressure and the temperature produced by the main components and supporting components of the refrigeration system in the engine TD242 Refrigerating system.

This research uses two variations, the first variation is mode freezer no cooling load and variations of both modes freezer with a cooling load, using three samples for each variation with data collection duration of 120 minutes. Calculation of Coefficient of Performance (COP) and Electrical Energy Consumption (Wh) on the TD242 machine Refrigerating system as an example using Variation I data for sample 1st at the 5th minute.

The measurement data in Table 4.1 is then processed into Enthalpy (h_1, h_2, h_3, h_4), Refrigeration Effect ($Q_{lt\ \ is}$), compression work (Q_{in}) produces a Coefficient of Achievement (COP), to get a grade h_1, h_2, h_3, and h_4 using interpolation calculations by referring to Freon R-404a thermodynamic properties.

Calculation results on the TD242 machine refrigeration system. F4 Variation I and Variation II of sample 1 at the 5th minute can be seen in Table 1 below:

TABLE 1. Comparison of Coefficient of Performance (COP) and Electrical Energy Consumption of TD242 refrigeration system in variation I and variation II

Variation	(Q_e) (kJ/kg)	(Q_w) (kJ/kg)	Q_{water} (J/s)	COP	Energy Compsumtion (Wh)
I	103,33	34,65	990,104	2,982	69,28
II	110,18	43,68	2287,885	2,522	86,6

Based on Table 1, it shows that the resulting Coefficient of Performance (COP) value influences the electrical energy consumption of the TD242 machine Refrigeration system, can be seen in the following Fig. 3.

Results of calculating the coefficient of performance (COP) TD242 refrigeration system for variation I and variation II can be seen from figure 4 below.

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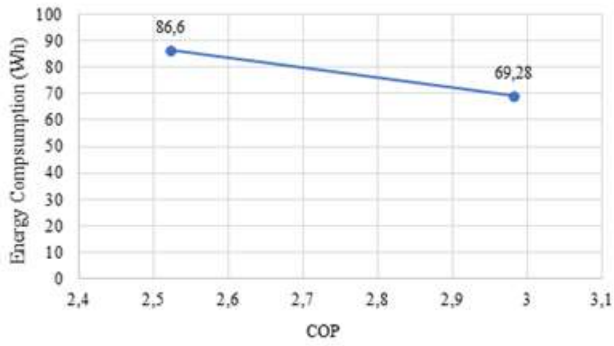

Fig. 3. Comparative graph of Electrical Energy Consumption against the Coefficient of Performance (COP) in Variation I and Variation II Sample 1 at the 5th minute

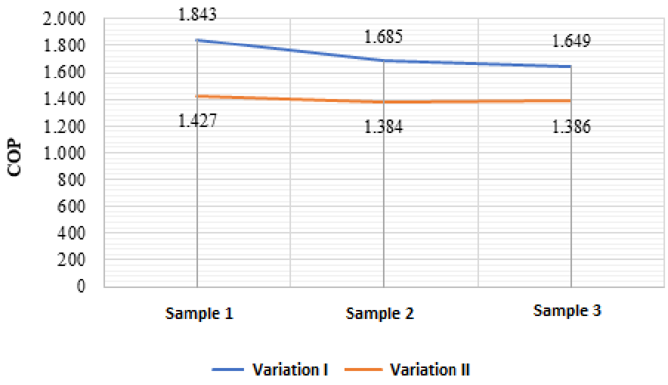

Fig. 4. Comparison graph of the average coefficient of performance (COP) of the TD242 refrigeration system for variation I and variation II samples

From the results of the data analysis carried out, Fig. 4 is a comparison graph of the average coefficient of performance (COP) value against the sample variation showing the I mode variation. freezer without cooling load, sample 1 has a value of 1.843, variation II mode *freezer* with the cooling load of sample 1 having a value of 1.427, this indicates that in sample 1 the performance coefficient value in variation I is greater. In variation I mode freezer without cooling load, sample 2 has a value of 1.685, in variation II mode freezer with the cooling load of sample 2 having a value of 1.384, this indicates that the performance coefficient value in variation I is greater. In variation I without cooling load sample 3 has a value of 1.649, variation II with cooling load sample 3 has a value of 1.386, this indicates that the achievement coefficient value in variation I is greater.

The energy consumption from the TD242 engine refrigeration system can be seen in the following graph at Fig 5.

From the results of data analysis in Fig. 5, comparison diagram of average electrical energy consumption on TD242 refrigeration system variation I mode freezer without cooling load, sample 1 has a value of 6,290,751 Wh, variation II mode *freezer* with the cooling load of sample 1 of 7,510.132 Wh, this shows that the use of electrical energy in variation II of sample 1 is greater. In variation I mode freezer without cooling load, sample 2 has a value of 6,793.163 Wh, variation II mode freezer with the cooling load of sample 2 of 7,706,283 Wh, this shows that the use of electrical energy in variation II of sample 2 is greater. Variation I mode freezer without cooling load, sample 3 has a value of 6,763,800 Wh, variation II mode freezer with the cooling load of sample 3 of 7,699,316 Wh, this shows that the use of electrical energy in variation II of sample 3 is greater. From the results of data analysis, it can be seen that the coefficient of performance value is TD242 refrigeration system If the value obtained is large then the use of electrical energy is small, whereas if the coefficient of performance value obtained is small then the use of electrical energy from the system will be large.

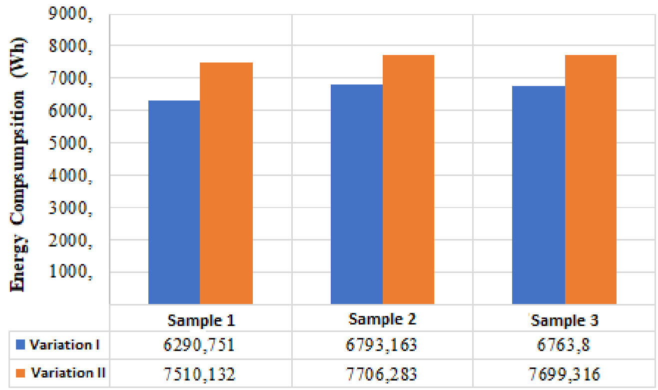

Fig. 5. Comparison diagram of average electrical energy consumption for samples on TD242 refrigeration system for variation I and variation II of each sample

IV. Conclution

From the results of data collection and analysis on TD242 refrigeration system. The coefficient of performance (COP) value for variation I mode is obtained freezer without cooling load in sample 1 it is 1.843 in sample 2 it is 1.685 in sample 3 it is 1.649 with an average of 5.177 and variation II mode freezer with the cooling load in sample 1 amounting to 1,427 in sample 2 amounting to 1,384 in sample 3 amounting to 1,386 with an average of 4,197.

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