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Coeficient Performace of Refrigerator Single Peltier with Waterblock Cooling

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Abstract. A cooling machine (refrigator) is a series of machines that are capable of working to produce cold temperatures. In a cooler, the refrigerant is flowed in processes that will form a standard vapor compression cycle. This practicum will discuss the refrigerator temperature reduction graph and the resulting COP, both COPmax and COPactual based on the design of the tool that has been made. The dimensions of the refrigerator used are 33.5 cm x 24.5 cm x 30.5. The cooler uses a TEC-12706 peltier with a peltier cooler using a water block. Based on the processing of the temperature data obtained, it is followed by calculating COPmax resulting in the largest being 6.0870 and the smallest being 4.2381. The largest COPactual result is 2.1812 and the smallest is 1.5926.

Keyword: Refrigerator; COP and standard vapor compression cycle.

1. Introduction

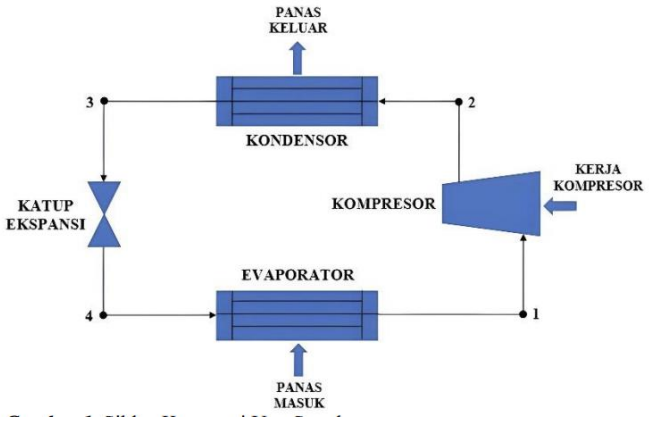
A cooling machine is a machine that has the main function of cooling substances so that the temperature is lower than the ambient temperature. The main components of a cooling machine are the compressor, condenser, expansion device and evaporator, as well as refrigerant as the working fluid that circulates in these parts. Cooling machines can be refrigerators, freezers, chillers and air conditioning. The most common use of refrigeration machines is for air conditioning and preserving food or beverages [1]. Each cooling machine certainly has different cooling performance determined by COP.

The coefficient of performance (COP) is an expression of the efficiency of a heat pump. When calculating the COP for a heat pump, the heat output from the condenser is compared with the power supplied to the compressor. One of the indicators in a refrigeration system that really determines the working of the system itself. The work of the compressor in a refrigeration system really depends on the COP value, the higher the COP value of a refrigeration system, the better the system works [4].

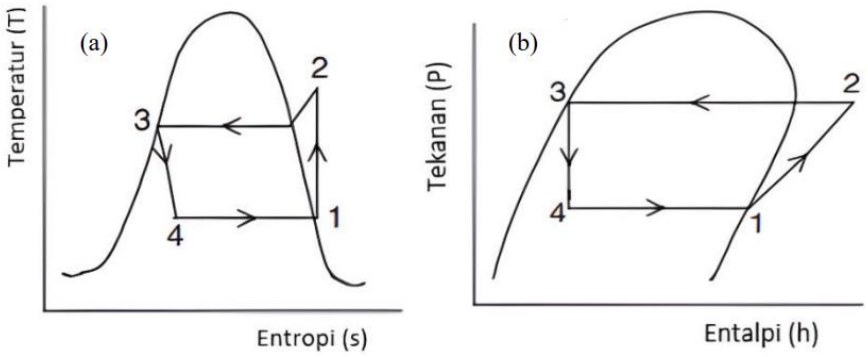
This practicum will discuss the refrigerator temperature reduction graph and the resulting COP, both COPmax and COPactual based on the design of the tool that has been made. The dimensions of the refrigerator used are 33.5 cm x 24.5 cm x 30.5. The cooler uses a TEC-12706 peltier with a peltier cooler using a water block. The data obtained is room temperature, refrigerator temperature in increments of 5 minutes, the data obtained will be visualized using graphs to determine the increase or decrease in refrigerator temperature and to determine the COP value. The practicum is carried out experimentally.

A cooling machine (refrigator) is a series of machines that are capable of working to produce cold temperatures. Basically, the main parts of a cooling machine consist of a driving motor, compressor, condenser, evaporator, filter and expansion valve. The compressor is the determination of pressure differences in a cooling system. Therefore, the coolant in the system flows from one part to another. In a cooling system, the form of the cooling medium used is always changing. From gas to liquid or vice versa. In the cooling system changes in the state of substances occur due to differences in pressure. So that the cooling medium can circulate.

The working principle of the refrigeration machine refers to the standard vapor compression cycle. In a cooler, the refrigerant is flowed in processes that will form a standard vapor compression cycle. The following are processes that show the standard vapor compression cycle and an image showing the ph and ts diagram of the vapor compression cycle [5].



(a)



(b)

Figure 1. (a) Refrigeration system workflow (b) Standard Vapor Compression Cycle

The process that occurs in the cycle is as follows

a. Process 1-2 is a compression process, where the refrigerant is still in the form of steam or gas at high pressure.
b. Process 2-3 shows the condensation process, where the refrigerant will change from vapor to saturated liquid at high pressure.
c. Process 3-4 shows the expansion process, where the refrigerant is in the form of a high-pressure saturated liquid into a low-pressure saturated liquid.
d. Process 4-1 shows the evaporation process where liquid refrigerant turns into low pressure vapor.

The coefficient of performance (COP) is an expression of the efficiency of a heat pump. When calculating the COP for a heat pump, the heat output from the condenser is compared with the power supplied to the compressor. One of the indicators in a refrigeration system that really determines the working of the system itself. The work of the compressor in a refrigeration system really depends on the COP value, the higher the COP value of a refrigeration system, the better the system works [3]. To find out how much COP is in the chiller system, the following equation can be used.

$$COP_{max} = \frac{Q_L}{Q_h - Q_L} = \frac{T_L}{T_h - T_L}$$
$$COP_{aktual} = \frac{Q_L}{W}$$
$$Q_L = m.C_p.\Delta T$$

2. Method

In order to produce good analytical data, of course a framework or research framework is needed. The research framework for refrigerator design can be seen in Figure 1.

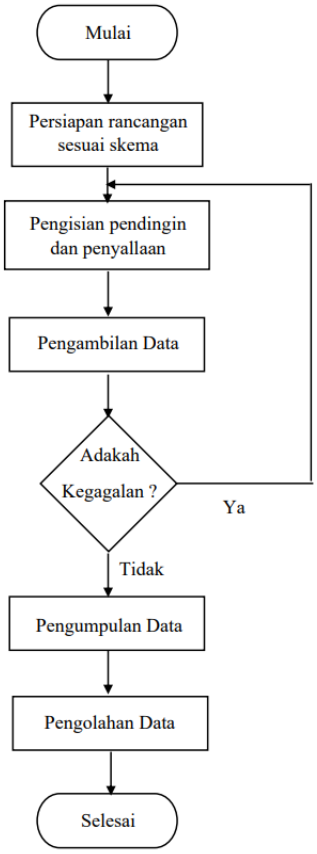


Figure 1. Diagram Alir

The independent variable for data collection is the time of data collection, the dependent variable for data collection is environmental temperature and refrigerator temperature, finally the control variable for data collection is the cooling water used. The specifications of the refrigerator design can be seen in Table 1.

Table 1. Refrigerator Design Specifications

No.	Alat dan Bahan	Parameter	Besaran
1.	*Power supply* 12v	Voltase	12V
		Ampere	10A
2.	*Powes supply* 6v	Voltase	6V
		Ampere	2A
3.	*Fan*	Voltase	12V
		Ampere	0,1A
4.	*Water pump*	Voltase	6V
5.	Botol	Kapasitas	800ml
6.	Peltier TEC-12706	Voltase	12V
		Ampere	6A
7.	*Waterblock*	Dimensi	40mm x 40mm
8.	*Heat sink*	Dimensi	40mm x 40mm
9.	Box strerofoam	Dimensi	335mm x 245mm x 305 mm

3. Result and Discussion

3.1 Refrigerator Design

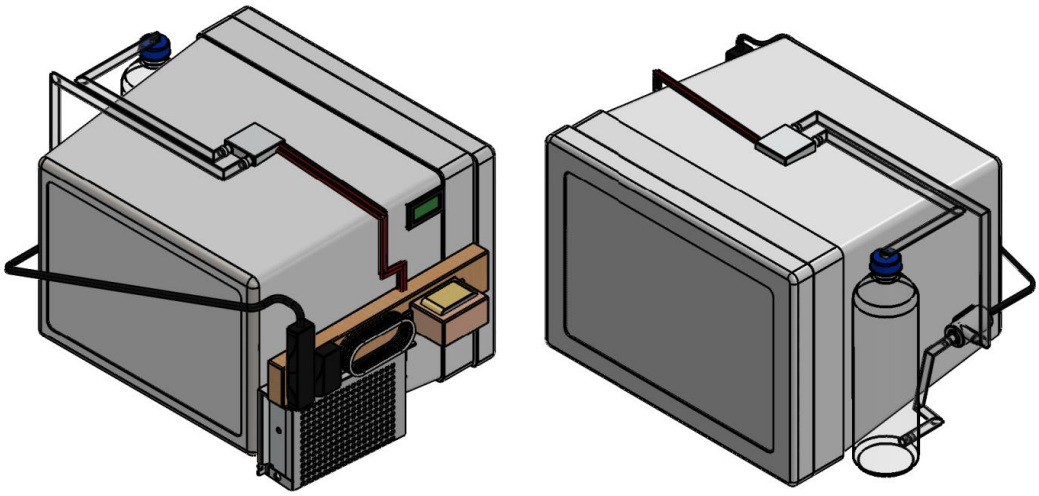


Figure 2. Refrigerator Design

3.2 Observation Data

The results of the observation data that have been carried out can be seen in table 2. There are 6 of them with a data collection interval of 5 minutes.

Table 2. Experiment Results

Data Ke	Menit	Suhu Refrigerator	Suhu Lingkungan
0	0	33,1	33,1
1	5	27,2	33
2	10	26,7	33
3	15	26,8	32,9

Data Ke	Menit	Suhu Refrigerator	Suhu Lingkungan
4	20	27,1	32,7
5	25	27,4	32,7
6	30	28	32,6

3.2 Data Processing

Data processing from raw practicum data can be seen in table 3. Calculations were carried out to determine the COP of the refrigeration design.

Table 3. Data Processing

Data Ke	ΔT	COP_{max}	Q_L	COP_{aktual}
1	5,8	4,6897	120,4847	2,0081
2	6,3	4,2381	130,8714	2,1812
3	6,1	4,3934	126,7167	2,1119
4	5,6	4,8393	116,3301	1,9388
5	5,3	5,1698	110,0981	1,8350
6	4,6	6,0870	95,5569	1,5926

The results of the data processing above can be analyzed for the performance of the refrigerator design. In terms of temperature, the performance of the refrigerator decreases from data 0 to data 2, then there starts to be a slight increase in temperature from data 2 to data 6. In terms of COP calculations for COPmax has The pattern is similar to refrigerator temperature but has a quite significant increase, but the actual COPcalculation data has a different reverse pattern from the COPmax calculation where there is a quite visible decrease when COPmax is increasing. Factors that can influence refrigerator performance include the number of cooling machines (peltiers), the amperes used in the power supply, the type of hot side cooling (waterblock or fan), environmental temperature, refrigerator volume, cooling water volume (for waterblocks), water temperature cooling (for water blocks), as well as whether or not there is a fan to distribute cold temperatures.

3.3 Comparison Chart

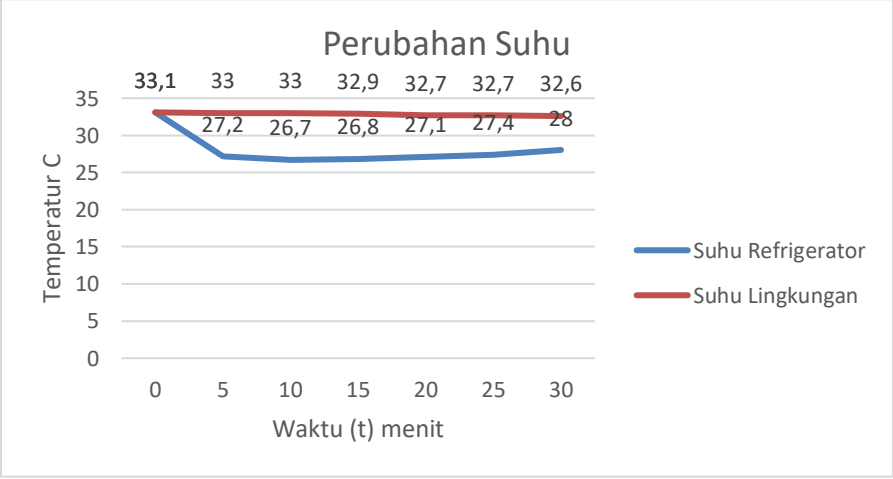


Figure 3. Temperature Change Graph

The graph of temperature changes above shows that the refrigerator temperature decreased from data 0 to data 2 and began to increase until data 6, while the ambient temperature tended to be stable or experienced a very slight decrease. This is caused by the water block cooling water volume being too

small, as evidenced by the cooling water temperature which was originally 11^o c to 〖42.9〗^o c which can be clearly seen that the cooling water was originally cold until the dew changed to warm.

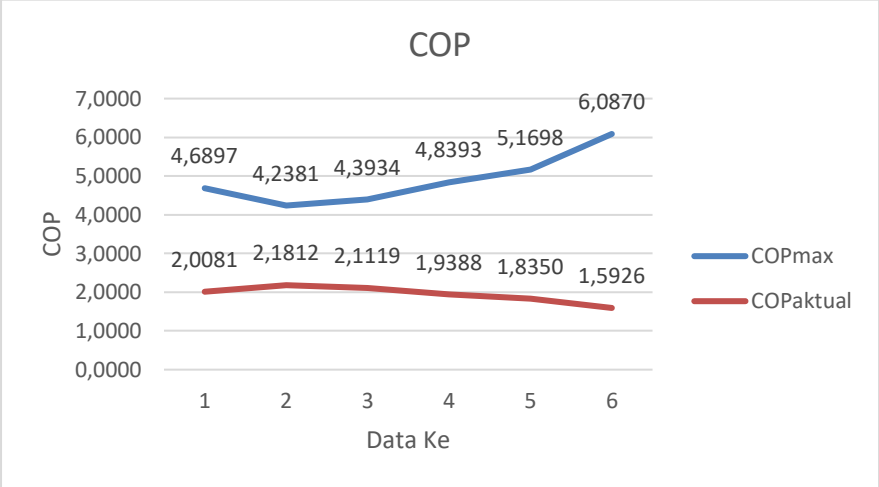


Figure 4.. COP Comparison Chart

The COP comparison graph above shows that below the COPmax graph has decreased from data 1 to data 2 and increased from data 2 to data 6 which is quite significant. Meanwhile, the COPactual data experienced a slight increase in data 1 to data 2 and a decrease in data 2 to data 6. This difference can occur due to differences in calculation formulas, COPmax calculates based on temperature only while COPactual calculates temperature, the power used, mass, and specific heat of the substance itself.

4. Kesimpulan

Kesimpulan yang dapat diambil dari data diatas sebagai berikut

1. Based on the processing of the temperature data obtained, continued by calculating COPmax, resulting in the largest being 6.0870 and the smallest being 4.2381. The largest COPactual result is 2.1812 and the smallest is 1.5926.
2. Factors that can influence refrigerator performance include the number of cooling machines (peltier), amperes used in the power supply, type of hot side cooling (waterblock or fan), environmental temperature, refrigerator volume, cooling water volume (for waterblock), cooling water temperature (for water blocks), as well as whether or not there is a fan to distribute the cold temperature.

References

[1] Anwar, K. (2010). Efek beban pendingin terhadap performa sistem mesin pendingin. *Jurnal SMARTek*, *8*(3), 203–214.

[2] Effendi, E., Herawati, S. and Simanjuntak, P.D. (2022) 'Mempertahankan Kinerja Sistem Mesin Pendingin Guna Menjaga Temperatur Ruang Refrigerated Cargo Container Tetap Stabil', *Meteor STIP Marunda*, 15(2), pp. 503–516. Available at: https://doi.org/10.36101/msm.v15i2.258.

[3] Irawan, R., & Basri, I. Y. (1900). *PERBANDINGAN COEFFICIENT OF PERFORMANCE (COP) REFRIGERANT R-134a DENGAN REFRIGERANT MC-134*. 1–8.

[4] Irawan, R., & Basri, I. Y. (2015). PERBANDINGAN COEFFICIENT OF PERFORMANCE (COP) REFRIGERANT R-134a DENGAN REFRIGERANT MC-134. *Automotive Engineering Education Journal*, *4*(2), 1–8.

[5] Pranoto, A., Kindi, H. Al, & Pramono, G. E. (2023). Analisis Pengaruh Cleaning Tubing Kondensor Terhadap Performa Sistem Refrigerasi Mesin Water Cooled Chiller Kapasitas 650Tr. *Jurnal Rekayasa Mesin*, *14*(1), 351–362. https://doi.org/10.21776/jrm.v14i1.1337