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ANALYSIS OF AMONIAC REFRIGRANT SYSTEM ON CONDENSER PERFORMANCE AS AN OIL COOLING MEDIA IN TEXTURIZING PLANT

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Abstract

In the oil processing industry, especially in the Texturizing Plant, the use of an ammonia refrigerant system as a cooling medium has a vital role in maintaining temperature stability and product quality. In a cooling system, the refrigerant functions as a heat transfer medium, absorbing heat at low pressure through the evaporator and releasing it at high pressure through the condenser. A refrigerant system is a method to complete the process of removing heat from a product to lower its temperature. An efficient cooling system is the key to ensuring the production process runs smoothly and produces products with high quality standards. One of the main components in the system is the condenser. The ammonia refrigerant system in the texturizing plant is divided into main components such as the compressor, condenser, receiver, expansion valve, perfector and liquid separator. What will be achieved from this research is to obtain factors that influence condenser work efficiency such as (pressure, temperature and cooling medium) and environmental conditions, as well as evaluating their contribution to the overall performance of the cooling system. The recorded data is in the form of pressure and temperature, so the conclusions that can be drawn during the 10 days of collecting data on the performance of the ammonia refrigerant system vary depending on the pressure and temperature. From the data that has been analyzed, it can be concluded that good operation occurred on the 5th day of data collection with the lowest compressor work with a value of 304.1 kJ/kg, the condenser exhaust value was 1414.6 kJ/kg and the cooling system work efficiency value was 91%.

Keywords : Refrigerant ammonia, Temperature, Compressor work, Exhaust heat, Efficiency

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1. Introduction

In the oil processing industry, especially in the Texturizing Plant, the use of ammonia refrigerant systems as a cooling medium has a vital role in maintaining temperature stability and product quality. In a cooling system, the refrigerant functions as a heat transfer medium, absorbing heat at low pressure through the evaporator and releasing it at high pressure through the condenser.[1].

The condenser is used for a heat transfer device that is removed from the hot temperature refrigerant gas to the cooling medium with the aim that the hot temperature refrigerant coolant will make a phase change from gas to fluid (liquid) conditions. The capacity of the condenser to dissipate refrigerant heat by utilizing air media and assisted by the push of the blower (fan), the refrigerant gas entering the condenser has a high temperature before entering the evaporator will be cooled first in the condenser. Water media can be used to help the condenser, increase the COP (Coefficient of Performance) of the cooling machine and allow us to reduce the intensity of the inactivity of the blower.[2]. Certain factors such as operational, and system parameter settings can significantly affect condenser performance. Therefore, an in-depth understanding of the influence of condenser work on the ammonia refrigeration system in the Texturizing Plant is very important.

We can do the aim of this research to achieve this Analyze the ammonia cooling system such as (pressure, temperature, and cooling load), and evaluate its contribution to the overall performance of the cooling system.

2. Calculate compressor work, condenser exhaust value, refrigeration effect value, mass flow rate, actual and ideal coefficient of performance and

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energy efficiency

Based on the background description above in the title of this final project report, it will be discussed about "Analysis Of Amoniac Refrigrant System on Condenser Performance As An Oil Cooling Media In Texturizing Plant" which later this data can be used as a reference for optimizing condenser performance later.

2. Literature review

2.1 *Ammonia Refrigration System*

Refrigeration One method of keeping manufactured products in a condition where their temperature is lower than the surrounding air is by refrigeration. This process involves the heat transfer of the product[3]. Refrigeration systems are used in the industrial sector to maintain the temperature conditions of raw materials or products produced with the aim of extending the storage period through the cooling process. At temperatures below -15ºC, which inhibits the growth of microorganisms, the cooling process can be used to maintain the quality of a raw material before it is used in the production process or to maintain the quality of products that have been produced before being distributed to consumers[4]. Humans have benefited greatly from advances in refrigeration system technology as these systems can maintain the quality of foodstuffs for long periods of time. The refrigerant used in the heat transfer process in the substance to be cooled is the fluid that the refrigeration process uses to do its job[5].

The main operational cycles in a refrigeration system are compression, condensation (condensation), expansion, and evaporation (evaporation). The vapor compression refrigeration cycle applies the heat transfer process through the continuously rotating refrigerant in the refrigeration system to carry out its working process[6]. The refrigerant in the refrigeration machine is directed to the line. To convert the vapor from the blower into advanced hot steam, the refrigerant with saturated vapor is compressed before entering the compressor. The condenser allows the vapor to flow and release heat into the atmosphere, which triggers the condensation process. Saturated vapor is created and passes through the dryer before descending towards the expansion valve and reaching the evaporator pressure. The liquid from the valve evaporates in the evaporator into saturated vapor, which then enters the compressor to be compressed. This cycle continues until the temperature is right.[7]

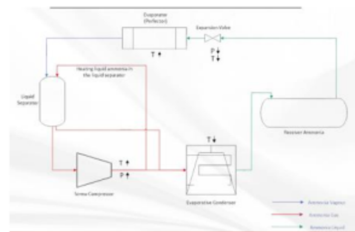

Figure 2.1 Ammonia refrigeration cycle

2.2 *Condenser Working Principle*

Condensing the vapor produced from the compressor is the purpose of the condenser, a heat exchanger. After spinning inside the compressor, the vapor travels directly to the condenser where it is condensed into water. This happens because the vapor is in direct contact with tubes (pipes) fed with cooling water. The capacity of the condenser to condense the compressor output vapor must be carefully calculated, as it is one of the key and most important components. Only then can the heat transfer between the cooling fluid and the compressor output steam be optimized and condensation take place properly.

Maintaining the vacuum of the condenser is essential to allow the vapor to descend smoothly from the last blade of the compressor as it lowers the air pressure inside the condenser. The vapor will be able to move towards the condenser more easily as the pressure inside is lower.

The basic function of the condenser is to convert the residual vapor from the output of the low-pressure compressor back into water. To do this, the vapor is forced into a chamber that has pipes (tubes) in it. RO water cooling water is circulated through these tubes. As the vapor undergoes condensation, it does so from top to bottom. The cooling water usually passes through a debris filter to remove pollutants before entering the condenser.

2.3 *Performance Parameters Of Refrigeration Machine*

2.3.1 Compressor work (Wk)

The amount of heat absorbed by the refrigerant per unit mass is known as the compressor work. By subtracting the enthalpy entering the evaporator from the enthalpy leaving, it can be calculated. It can be calculated using the following formula:

$W_k = h_2 - h_1$

Description :

Wk : Working compressor (kJ/kg)

h1 : Entalphi inlet compressor (kJ/kg)

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h2 : Entalphi outlet Compressor (kJ/kg)

2.3.2 Condenser exhaust heat (qc)

Condenser exhaust heat is the amount of heat released by the condenser to the outside air. This can be calculated by subtracting the enthalpy entering the condenser from the enthalpy that will exit the condenser. It can be calculated with the following equation:

$qc = h_2 - h_3$

Description:

qc : Condenser exhaust Heat (kJ/kg0

h2 : Entalphi inlet condenser (kJ/kg)

h3 : Entalphi outlet condenser (kJ/kg)

2.3.3 Refrigeration Effect (qk)

The quantity of heat that the refrigerant transfers to the surroundings is known as the refrigration effect. It can be calculated by subtracting the condenser exit enthalpy from the condenser entry side enthalpy. This can be calculated using the following formula:

$q_k = h_1 - h_4$

Description :

qk : Refrigeration effect (kJ/kg)

h1 : Entalphi outlet evaporator (kJ/kg)

h4 : Entalphi inlet evaporator (kJ/kg)

2.3.4 Mass flow rate (m)

Mass flow rate refers to the amount of refrigerant that flows continuously per unit of time inside the refrigeration machine. It can be calculated using the voltage and amperage that the compressor uses, as well as the function data of the compressor. calculated using the following formula:

$$m = \frac{w}{wk} = V.\frac{1}{1000}/Win$$

Description :

M : mass flow rate (kg/s)

W : compressor work divided by time (J/s)

Wk : working compressor (kJ/kg)

V :The amount of voltage used by the compressor (V)

I : Compressor electric current consumption (A)

2.3.5 Coeficient of Performance actual (COP)actual

$(COP)aktual$ cooling machine is determined by the ratio of the power consumed to run the compressor to the heat absorbed by the evaporator or the cooling effect. can be calculated using the formula below:

COPactual : $\frac{qk}{wk} = \frac{h1-h4}{h2-h1}$

Description :

Qk : Refrigeration effect (kJ/kg)

Wk : Working Compressor (kJ/kg)

h1 : Entalphi inlet compressor (kJ/kg)

h2 : Entalphi outlet condenser (kJ/kg)

h4 : Entalphi inlet evaporator (kJ/kg)

2.3.6 Coeficient of Performance Ideal (COP)ideal

(COP)ideal The ratio of the temperature produced by the condenser's heat release to the temperature absorbed by the evaporator, or the refrigerant effect, is what makes a refrigeration machine optimal. This can be calculated using the following formula:

COPideal : $T_e/(T_c - T_e)$

Description :

Te : Temperature before inlet condenser (˚C)

Tc : Temperature before inlet evaporator (˚C)

2.3.7 Efficiency of refrigeration machine (n)

Evaluation of the effectiveness of the cooling machine The evaluation of the cooling machine is a type of evaluation derived from the comparison ($COPaktual$ divided by $COPideal$). It can be calculated using the following equation:

$n = (COP_{aktual}/COP_{ideal}) \times 100\%$

Description :

N : efficiency of refrigeration mechine

3. Research Methodology

This research will be carried out with several stages which can be seen in the flow chart.

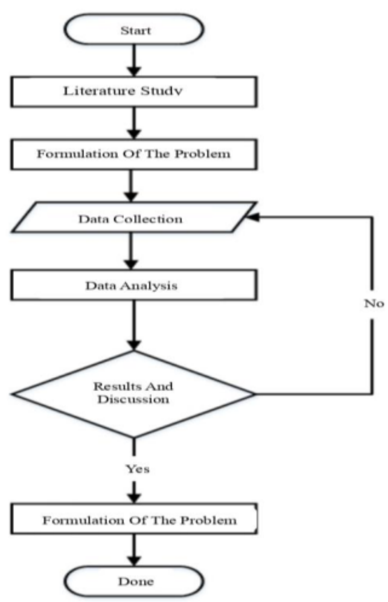

Figure 3.1 Flow Chart

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The literature study can be started by discussing a summary of previous research on the performance analysis of ammonia refrigeration systems, then continued by studying the literature as a support for solving problems in the research. Formulate problems and scope when conducting research. This formulation aims to make the research more focused. Data collection conducted in this study was obtained from the Texturizing Plant of PT Multimas Nabati Asahan Serang. Primary data is obtained after taking data in the field regarding condenser performance parameters, condenser specification/design data and interviews. The parameters related to condenser performance that will be studied are as follows:

1. The amount of water put into the condenser cooling (l)
2. Velocity of water flowing across the condenser (l/m)
3. Initial water temperature (˚C)
4. Inlet temperature to compressor (˚C)
5. Outlet temperature of the compressor (˚C)
6. Outlet temperature of the condenser (˚C)
7. Inlet temperature to evaporator (˚C)
8. Inlet pressure to compressor (bar)
9. Pressure outlet from compressor (Bar)
10. outlet from condenser (Bar)
11. Inlet pressure to evaporator (Bar)

Analysis is carried out on each parameter data from

the test results to determine the performance of the condenser. Data analysis is carried out to obtain:

1. Actual performance of the condenser
2. Performance after condenser optimization

4. Results and Discussion

4.1 Field Observation Data

Based on the results of observations during data collection at the Texturizing plant, the author has collected data for 10 days in April which data is actual data in the field and will be analyzed according to the data that has been collected which we will then calculate according to the relevant formulas.

Table 4.1 Average Compressor Suction and Discharge Pressure Data

Time	P suction (Bar)	P Discharge (Bar)
15-Apr-24	2	12.23
16-Apr-24	2.3	11.47
17-Apr-24	2.47	11.54
18-Apr-24	1.85	11.87
19-Apr-24	2.01	11.1
20-Apr-24	2.23	11.7
21-Apr-24	2.1	11.13
22-Apr-24	2.15	11.24
23-Apr-24	2.38	11.72
24-Apr-24	2.24	11.67
Average	2.173	11.567

In the data table 4.1 above, then, so that the data is easier to read and understand the fluctuations or changes that occur during the data collection process, the average pressure data on the compressor suction and discharge is displayed in graphical form.

Figure 4.1 Compressor Average Pressure Chart

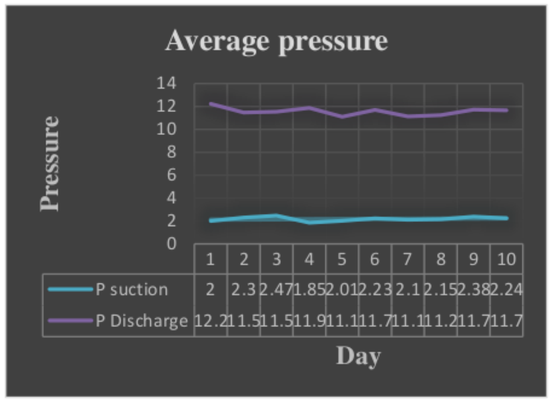

Table 4.2 Average Compressor Suction and Discharge Temperature Data

Time	T suction (˚C)	T discharge (˚C)
15-Apr-24	27.3	70.8
16-Apr-24	26.5	69.7
17-Apr-24	26.3	68.2
18-Apr-24	27.2	69.5
19-Apr-24	25.8	68.3
20-Apr-24	25.5	65.4
21-Apr-24	26.8	67.6
22-Apr-24	25.9	67.2
23-Apr-24	27.7	68.4
24-Apr-24	27.5	68.9
Average	26.65	68.4

In the data table 4.2 above, then, in order to make the

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data easier to understand and identify fluctuations or changes that occur during the data collection process, the average temperature data on the suction and exhaust compressors are displayed in the form of graphs

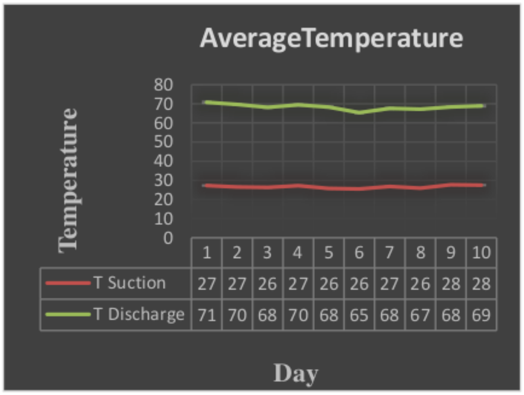

Figure 4.3 Temperature Chart of Evaporator Inlet and Condenser Outlet

4.2 Enthalphi Value of Ammonia Refrigerant System

The enthalpy value was determined by plotting the primary data against the P-h diagram, which was obtained from field measurements of the cooling system process parameters. The result of the interpretation of the enthalpy value on the P-h diagram is the following graph.

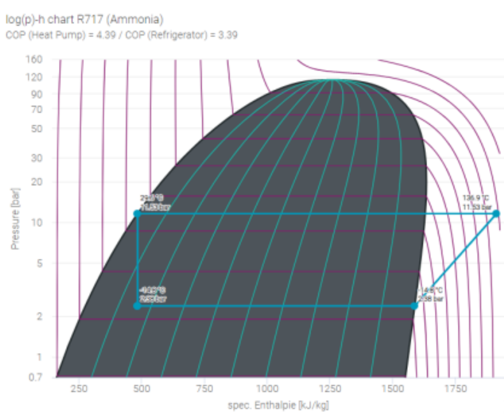

Figure 4.4 Enthalphi Value Reading on P-h Diagram

This information is obtained by interpreting the enthalpy values on the P-h diagram:

h1 : 1587.8 kJ/kg

h2 : 1913.4 kJ/kg

h3 : 482.9 kJ/Kg

h4 : 482.9 kJ/kg

Based on data for 10 days, the enthalpy value of each day is obtained based on the following table:

Table 4.4 Ammonia Refrigerant Enthalphi Value Data

Time	Entalphi value (kJ/kg)		
	h1	h2	h3 = h4
15-Apr-24	1588.8	1911.4	486
16-Apr-24	1589.2	1903.4	482.6
17-Apr-24	1586.6	1933.6	491.3
18-Apr-24	1585.3	1935.8	487.3
19-Apr-24	1590	1894.1	479.5
20-Apr-24	1586.4	1923.5	483.9
21-Apr-24	1587.6	1911.7	481.2
22-Apr-24	1588.5	1902.6	479
23-Apr-24	1587.1	1916	481.8
24-Apr-24	1588.1	1900.7	476.1

4.3 Compressor Work Calculation (Wk)

Based on the tests carried out, it is known that the enthalphi value for 10 days from the existing data is known to calculate the compressor work using the existing formula, namely :

$$Wk = h2 - h1$$

Table 4.5 Ammonia Compressor Working Data

Time	Working Compressor (kJ/kg)
15-Apr-24	322.6
16-Apr-24	314.2
17-Apr-24	347
18-Apr-24	350.5
19-Apr-24	304.1
20-Apr-24	337.1
21-Apr-24	324.1
22-Apr-24	314.1
23-Apr-24	328.9
24-Apr-24	312.6

From the data in table 4.5 above, then the compressor work data To facilitate reading and understanding of the fluctuations or changes that occur during the data

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collection process, the data is presented graphically.

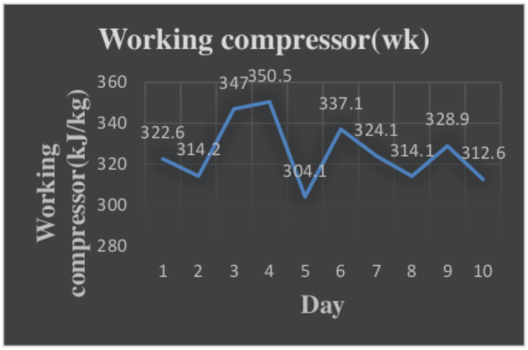

Figure 4.5 Compressor Working Chart During Data Collection

The lower the initial temperature in the type of cooling medium so that the compressor needs to exert less power to compress the operating fluid of the cooling machine, or refrigerant. where the condensation process causes the refrigerant to cool to the desired room temperature. This will cause a decrease in compressor work. From the explanation above, it can be concluded that the greater the cooling rate in the refrigerant which is influenced by the initial temperature of the cooling medium, the smaller the compressor work, and the better the use in the cooling machine.

4.4 Condenser Exhaust Heat Calculation (qc)

In the test, it is found that the enthalpy value for 10 days from the existing data is known to calculate the condenser exhaust heat using the existing formula, namely:

$$qc = h2 - h3$$

Table 4.6 Condenser Exhaust Heat Data

Time	Condenser Exhaust Heat(kJ/kg)
15-Apr-24	1425.4
16-Apr-24	1420.8
17-Apr-24	1442.3
18-Apr-24	1448.5
19-Apr-24	1414.6
20-Apr-24	1439.6
21-Apr-24	1430.5
22-Apr-24	1423.6
23-Apr-24	1434.2
24-Apr-24	1424.6

To facilitate reading and understanding of the fluctuations or changes that occurred during the data collection process, the data is presented graphically.

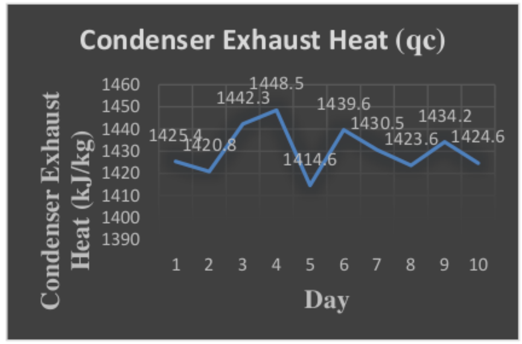

Figure 4.6 Condenser Exhaust Heat Chart

From the explanation above, it can be concluded that the decrease in refrigerant temperature will result in an increase in the value of exhaust heat in the condenser. The exhaust heat of the condenser is influenced by the initial temperature of the cooling medium, the lower the temperature of the cooling medium, the more exhaust heat the condenser produces, the better it works as a cooling medium for the engine.

4.5 Calculation of Refrigeration Effect (qk)

From the test results, it is known that the enthalpy value for 10 days from the existing data is known to calculate the refrigeration effect using the existing formula, namely:

Teble 4.7 Effect refrigeration

Time	Effect Refrigeration (kJ/kg)
15-Apr-24	486
16-Apr-24	482.6
17-Apr-24	491.3
18-Apr-24	487.3
19-Apr-24	479.5
20-Apr-24	483.9
21-Apr-24	481.2
22-Apr-24	479
23-Apr-24	481.8
24-Apr-24	476.1

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From the data in table 7 above, then the refrigeration effect data to facilitate reading and understanding of the fluctuations or changes that occur during the data collection process, the data is presented graphically.

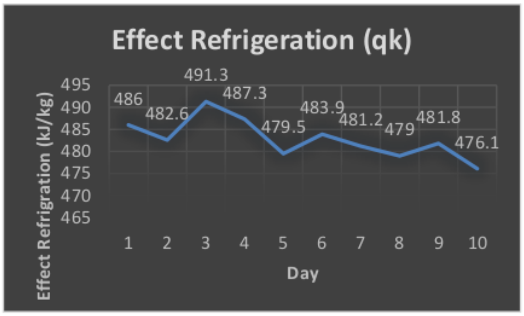


Figure 4.7 Refrigeration Effect Chart

When the refrigerant temperature is lower than the room temperature, a heat absorption process can occur as a result of the refrigerant absorbing heat from the room. As a result of this process, the room temperature decreases. Due to the ability of the refrigerant to absorb heat from the room, a larger refrigerant also results in a larger decrease in room temperature.

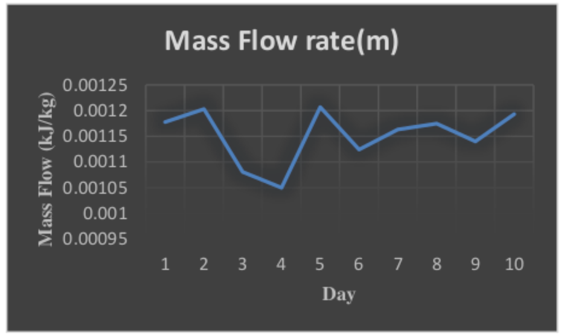
4.6 Calculation of mass flow rate (m)

Based on testing, it is found that the mass flow rate value for 10 days from the existing data is known to calculate the mass flow rate using the existing formula, namely:

Table 4.8 Mass Flow Rate Data

Time	Mass Flow Rate (kJ/kg)
15-Apr-24	0.001177929
16-Apr-24	0.001203055
17-Apr-24	0.001080692
18-Apr-24	0.001049929
19-Apr-24	0.00120684
20-Apr-24	0.001124295
21-Apr-24	0.001163221
22-Apr-24	0.001174785
23-Apr-24	0.001140164
24-Apr-24	0.001193218

From the data in table 8 above, then the mass flow rate data to facilitate reading and understanding of the fluctuations or changes that occur during the data collection process, the data is presented graphically.



If the refrigerant mass unit changes the temperature in the refrigeration machine faster, the refrigerant flowing in the refrigeration machine slows down because the refrigerant mass unit moves more temperature during the evaporation and condensation process, which results in a low mass flow rate.

4.7 Calculation of actual COP

From the test results, it is known that the actual COP value for 10 days from the existing data is known to calculate the actual COP using the existing formula, namely:

Table 4.9 Actual COP Value Data

Time	COP aktual
15-Apr-24	1.506509609
16-Apr-24	1.535964354
17-Apr-24	1.415850144
18-Apr-24	1.390299572
19-Apr-24	1.576783953
20-Apr-24	1.435479086
21-Apr-24	1.484726936
22-Apr-24	1.524992041
23-Apr-24	1.464882943
24-Apr-24	1.52303263

From the data in table 9 above, then the actual COP data to facilitate reading and understanding of the fluctuations or changes that occur during the data collection process, the data is presented graphically.

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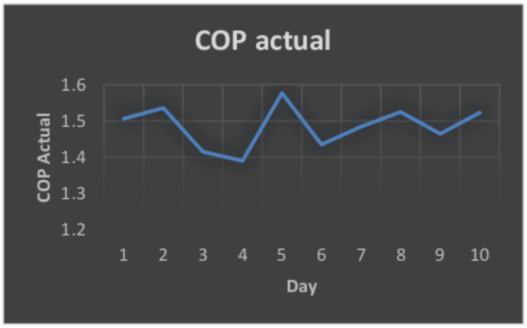

Figure 4.9 Graphic COP actual

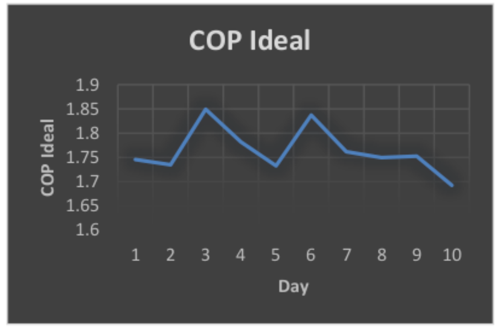

Figure 4.10 Graphic COP Ideal

$(COP)aktual$ is a form of assessment of a cooling machine. $(COP)aktual$ is affected by the type of condenser cooling medium in both the condenser exhaust heat (condensation) and the heat absorption process (evaporation). The lower the (COP)aktual value, the more favorable it is to use in refrigeration equipment.

4.8 Ideal COP calculation
From the test results, it is known that the COPideal value for 10 days from the existing data is known to calculate COPideal using the existing formula, namely:

Table 4.10 Actual COP Ideal data

Time	COP ideal
15-Apr-24	1.74556213
16-Apr-24	1.734693878
17-Apr-24	1.849240781
18-Apr-24	1.782051282
19-Apr-24	1.732623034
20-Apr-24	1.837078652
21-Apr-24	1.761793068
22-Apr-24	1.749544389
23-Apr-24	1.752498078
24-Apr-24	1.692458855

From the data in table 10 above, then the ideal COP data to facilitate reading and understanding of the fluctuations or changes that occur during the data collection process, the data is presented graphically.

$(COP)ideal$ is the form used to evaluate the cooling machine. The lower the value of $(COP)ideal$, the more the cooling machine is in line with its function.

4.9 Efficiency Calculation (n)
From the test results, it is known that the efficiency value for 10 days from the existing data is known to calculate the efficiency using the existing formula, namely:

Table 4.11 Efficiency Value Data

Time	Efficiency (n)
15-Apr-24	86%
16-Apr-24	89%
17-Apr-24	77%
18-Apr-24	78%
19-Apr-24	91%
20-Apr-24	78%
21-Apr-24	84%
22-Apr-24	87%
23-Apr-24	84%
24-Apr-24	90%

From the data in table 11 above, then the efficiency data to facilitate reading and understanding of the fluctuations or changes that occur during the data collection process, the data is presented graphically.

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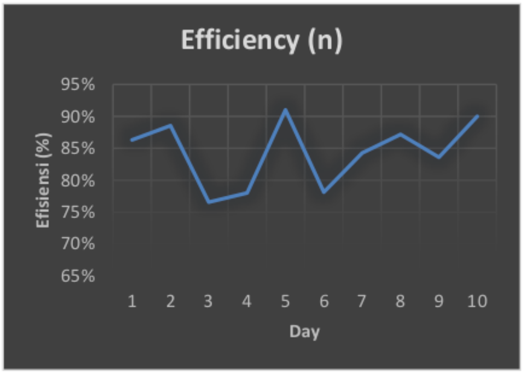

Figure 4.11 graphic efficiency

The efficiency was highest on day 5 of data collection at 91% and lowest on day 3 at 77%. The performance of the refrigeration machine, namely, compressor work, heat from condenser exhaust, cooling effect, and temperature affect this.

5. Conclusions and Suggestions

5.1 Conclusions

1. The fluctuating temperature and pressure during data collection for 10 days greatly affected the performance of the ammonia cooling machine in the texturizing plant. This fluctuation is caused by the workload of a system, the melting point of the oil product to be produced, the temperature of the surrounding environment and the condition of the components of this system which also greatly influences the performance of the condenser in the texturizing plant. Where the efficiency value of the cooling system of this texturizing plant is quite good at on day 5, it was 91% based on calculations and what was less good was on day 3, namely 77%.
2. The compressor work value, condenser exhaust and cooling efficiency were the best on the 5th day of operation with a compressor work value of 304.1 kJ/kg, the condenser exhaust value was 1414.6 kJ/kg and the cooling system work efficiency value was 91%. For the best refrigerant effect value on the 3rd day of operation with a value of 491.3 kJ/kg. For the mass flow rate value, the actual COP was good on the 4th day of operation with a mass flow rate value of 0.001049929 kJ/kg and an actual COP value of 1.390299572. For the best ideal COP value in operation on day 10 with a value of 1.692458855. From the results of the calculations above, the way to optimize condenser work for efficiency can be done by controlling temperature and pressure, optimizing air or water flow and carrying out regular maintenance and optimizing operational loads. If the cooling system works optimally, the oil products produced will comply with the standard oil product filling temperature

5.2 Suggestions

The effect of this ammonia refrigerant system is strongly influenced by the performance of the condenser. This is what we have to do monitoring the operation of the condenser work, if the condenser does maximum heat absorption, the ammonia refrigeration efficiency results will also be good, therefore do monitoring and if it happens that the temperature achievement in the product to be produced is not achieved, try to blow down the condenser and do cleaning in the condenser basin so that the heat absorption in the condenser is maximized.

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