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The Effect of Variation in Expansion Valve Capacity on Cooling Performance in Cold Storage Machines

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A B S T R A C T

The rapid development of the food storage industry in Indonesia, especially for basic ingredients, is very influential in the business world, such as the business of supplying food, fresh meat, and vegetables, all of which require a storage device that can maintain the freshness and quality of the food. These various products. One example of such a tool is cold storage. The increasing demand for food products makes suppliers have to meet the great demand for food by increasing the supply of products. With such conditions, many suppliers or owners of cold storage complain that the cooling performance of cold storage is not being achieved as needed. The effect of variations of the three expansion valves shows that the 2.8 TR expansion valve has cooled, whereas the 2.8 TR expansion valve has a higher refrigeration effect, and the compressor work on the 3.7 TR expansion valve and 4.4 TR expansion valve has a significant increase. This can be caused by the increased refrigerant flow so that the compressor makes a greater effort to compress the refrigerant, and from that, the system workability (COP) has decreased. The effect of the variation of the three expansion valves shows that the expansion valve 4.4 TR has a faster decrease in room temperature, where the initial room temperature is considered uniform. The 4.4 TR expansion valve opens the valve gap earlier, and the refrigerant flow that flows is greater when the engine is started so that heat is absorbed by the evaporator faster.

1. Introduction

The fast development of the food storage industry in Indonesia, especially for basic ingredients, has greatly affected the business world, such as the business of supplying food, fresh meat, and vegetables. All these businesses need a storage device to maintain the freshness and quality of these various products. One example of such a tool is cold storage. Seeing the reality on the ground that the existing cold storage units are designed in such a way with cooling performance that is already standard in theory. Bali is often visited by foreign tourists as a tourist destination because of the many attractions that can be visited by foreign tourists. The boom in tourists who come to Bali makes suppliers have to fulfill many orders for food ingredients by increasing product inventory. With such conditions, many suppliers or owners of cold storage machines complain that the cooling performance of cold storage is not achieved according to the desired needs due to a large number of stored products (overload). As a result, the number of food products stored exceeds the capacity of cold storage, so the food product will be damaged the product or item is rejected in the market. These phenomena may be caused by improper refrigeration performance or relatively long cooling time due to the amount of product stored and the extreme outside air temperature.[1,2]

From such conditions, the supplier can replace a new engine unit with greater cooling performance so that the stored product is not damaged. Actually, there are various options that can be used to improve cooling performance in cold storage so as not to replace it with a new engine unit, including replacing refrigerant, increasing condenser area, increasing compressor power, adding heat exchanger, and increasing expansion valve capacity. Several studies to improve cold storage performance have been carried out. A study conducted a distance adjustment between food storage crates in cold storage with variations in the distance (gap) of 10 cm, 20 cm, and 30 cm.[3] The study showed that the larger the gap between the crates, the lower the temperature in cold storage.[4] This is because the larger the gap between the crates will result in an increase in the air passage to each crate so that cooling is more evenly distributed. Then another study used alternative refrigerants R-407A and R-407F as a substitute for refrigerant R-404A for testing the cooling performance of cold storage units.[5] The results showed that the use of R-407A and R-407F resulted in a higher annual energy effect ratio than the use of R-404A.[6] Furthermore, it was also found that power consumption, operating costs, and the total equivalent of the heating effect were respectively lower by 2.5%, 2.2%, and 7.9%. Another study conducted research to maintain the temperature in the refrigerated truck compartment at temperatures below minus 8°C (-8°C) using latent heat energy storage in freezing weather conditions. The latent heat energy storage system is made of plates arranged in parallel, where the plates are filled with phase change material (PCM) which is able to absorb heat from the flow of hot water vapor. The results showed that the performance of the energy storage unit is strongly influenced by the turbulence of the airflow.[8] However, the unit can still operate well in conditions of 100% relative humidity. Another study on the effect of the guide plate (buffle) on the temperature distribution of small-scale cold storage, where the results showed that the angle of the buffle greatly affects the temperature distribution and the lowest cold storage temperature of around 16.3°C occurred at an air volume flow rate of 30 mL/s. Many technicians in the field are taking the alternative of increasing the capacity of the expansion valve in search of a faster cooling rate and cooling time to cool products from suppliers.[9] This study aims to determine the effect of variations in the capacity of the expansion valve on the cooling performance of the cold storage machine so that the cold storage room temperature is achieved as desired by the suppliers.

2. Methods

This study is an experimental study, observing the performance of cooling cold storage by varying the capacity of the expansion valve. The cold storage dimensions used are length: 5 meters, width: 4 meters, and height: 3.5 meters. Refrigerant with a capacity of 10 kg and the type of refrigerant used in cold storage (R-404a). Pressures suction, and discharge are obtained from variations of the 2.8 TR expansion valve, 3.7 TR expansion valve, and 4.4 TR expansion valve. The parameters assessed are the effect of refrigeration, compressor work, coefficient of performance (COP), heat released condenser (Qout), and the temperature of the cooling room.

The test procedure is as follows: prepare the equipment that will be used in the study (system in standard condition with 2.8 TR expansion valve). The system is vacuumed using a vacuum pump. Next, fill Refrigerantin in the-404a cold storage (10 kg). Next, turn on the cold storage. The stopwatch is turned on simultaneously with the operation of the cold storage machine. After an interval of 5 minutes, read the suction pressure (P1) and discharge pressure (P2) on the manifold and read the temperature at points (T1, T2, T3. T4), obtained for the expansion valve capacity of 2.8 TR. The experiment was carried out for an interval of 30 minutes. Machine cold storage. Open the door of the cold storage so that the room temperature is the same as the ambient temperature. Discard refrigerant or suck it up with recycle refrigerant. Then repeat the above steps for the 3.7 TR and 4.4 TR expansion valves.

3. Results and Discussion

The temperature value of the 2.8 TR expansion valve from the points: T1, T2, T3, and T4 and the pressure value of the refrigerant: P1, P2 with an average of T1: 25.2°, T2: 63.9°, T3: 40°, T4: -5.6° and P1: 2.8 $\frac{kg}{cm^2}$, P2: 22 $\frac{kg}{cm^2}$. The temperature value of the expansion valve is 3.7 TR from the points: T1, T2, T3, T4, and the pressure value of the refrigerant: P1, P2 with an average of T1: 21.7°, T2: 66.8°, T3: 40.2°, T4: -4.3° and P1: 2.7 $\frac{kg}{cm^2}$, P2: 21 $\frac{kg}{cm^2}$. Temperature value on expansion valve 4.4 TR from the point: T1, T2, T3, T4 and pressure value of Refrigerant: P1, P2 with average T1: 21.8°, T2: 67.4°, T3: 40.2°, T4: -4.1° and P1: 2.7 $\frac{kg}{cm^2}$, P2: 22 $\frac{kg}{cm^2}$.

Table 1. Value enthalpy with expansion valve capacity 2.8 TR. 3.7 TR, 4.4 TR

Capacity Expansion Valve	**Enthalpy Value *(kJ/kg)***			
	h1	**h2**	**h3**	**h4**
2.8 TR	376.32	461.85	260	260
3.7 TR	374.93	511.62	260.34	260.34
4.4 TR	531.87	374.9	260.51	260.51

Table 2. Compressor work (w)

Capacity expansion valve	**Compressor work**
2.8 TR	$85.53 (kJ/kg)$
3.7 TR	$136.69 (kJ/kg)$
4.4 TR	$156.97 (kJ/kg)$

Table 3. Condenser work (q_c)

Capacity expansion valve	**Condenser work**
2.8 TR	$201.85 (kJ/kg)$
3.7 TR	$251.28 (kJ/kg)$
4.4 TR	$271.36 (kJ/kg)$

Table 4. Refrigeration effect (q_e)

Capacity expansion valve	**Refrigeration effect**
2.8 TR	$116.32 (kJ/ kg)$
3.7 TR	$114.59 (kJ/kg)$
4.4 TR	$114.39 (kJ/kg)$

Table 5. System workability (COP)

Capacity expansion valve	System Workability (COP)
2.8 TR	1.35
3.7 TR	0.83
4.4 TR	0.72

In expansion valve variations 2.8, The TR has a lower compressor work than the 3.7 TR expansion valve and 4.4 TR expansion valve. This can be caused because the performance of the compressor is affected by the increase in the size of the expansion valve, where the greater the capacity of the expansion valve, the flow rate of refrigerant that flows will be more, and the more effort the compressor will have to compress the refrigerant.[10]

In the 2.8 TR valve variation, the heat released is lower than the 3.7 TR expansion valve and 4.4 TR expansion valve. This can be caused by the effect of increasing compressor work so that the heat released by the condenser is greater so that the phase change of the refrigerant is better.[10]

The variation of the 2.8 TR valve variation has a higher refrigeration effect than the 3.7 TR expansion valve and 4.4 TR expansion valve. This can be caused by the effect of increasing the capacity of the expansion valve. Whereas the capacity of the expansion valve increases, the effect of refrigeration on the system decreases.[11]

The variation of the 2.8 TR valve has higher workability than the 3.7 TR expansion valve and 4.4 TR expansion valve. This can be caused by the effect of increasing the capacity of the expansion valve. The increasing capacity of the expansion valve, the greater the flow rate of the refrigerant being circulated so that the work of the compressor increases. This resulted in the ability to work on the system is decreased.[12]

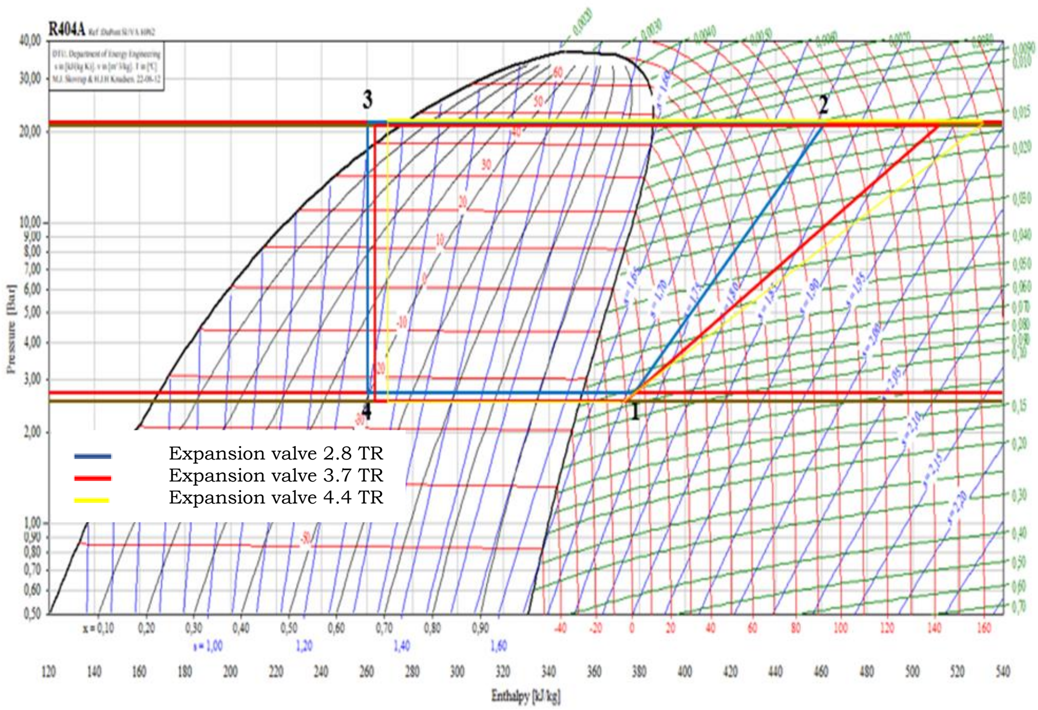

Figure 1. P-H diagram of variation of expansion valve 2.8 TR, expansion valve 3.7 TR, - 4.4 TR.

Figure 1 shows the p-h diagram of expansion valve 2.8 TR, valve 3.7 TR, and expansion valve 4.4 TR. Where there is an increase in compressor work along with an increase in the capacity of the expansion valve. This can be caused because the flow of refrigerant that enters the evaporator is getting bigger, and the refrigerant flow is getting bigger, resulting in a low refrigeration effect on cold storage. This can be caused because the process of heat absorption in the evaporator decreases so that the refrigerant cannot change phase to vapor, and the occurrence of further cooling by refrigerant leaves the evaporator. There is a decrease in system workability (COP) on the 3.7 TR expansion valve and 4.4 TR expansion valve, the decrease in cop is caused by the increasing effect of compressor work and the lower refrigeration effect in the cold storage.[10]

The 4.4 TR expansion valve experienced a faster decrease in room temperature. This can be caused by an increase in the capacity of the expansion valve where the 4.4 TR expansion valve variation opens the valve gap earlier when the engine is started than the 2.8 TR expansion valve and 3.7 TR expansion valve, so the greater the refrigerant flow rate that flows in the evaporator, absorption of heat in the room is faster so that the room temperature becomes cold, which in this study the initial temperature of the room is considered to be uniform with the ambient temperature.[13]

4. Conclusion

The 2.8 TR expansion valve has more cooling than the 3.7 TR expansion valve and 4.4 TR expansion valve. The 4.4 TR expansion valve has a faster reduction in room temperature than the 2.8 TR expansion valve and 3.7 TR expansion valve variations.

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