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# Performance of Split Air Conditioner with Capillary Pipe Variations with R32 Refrigerant on Ships

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***Abstract*— The hot temperature on the ship will interfere with the comfort of the crew, so an air conditioning machine is needed to cool down. Hot conditions make air conditioning needed on the ship as a means of cooling when the ship sails. Split AC performance is very necessary so that the temperature released remains optimal. Split air conditioners have many components, for example, capillary pipes, capillary pipes play a very important role in obtaining low temperatures. Therefore, it is necessary to research variations in the length and diameter of capillary pipes. As a pressure-lowering device and regulating the amount of refrigerant liquid flowing, the length and diameter of capillary pipes greatly affect the cooling process. If you find the right and right variation, you will get a temperature lower than the standard Therefore, to get extra cooling for split air conditioners, research is proposed on the effect of variations in the length of capillary pipes on the work performance of split air conditioner machines using R32 refrigerant for ship accommodation room. To know the effect of cooling more extra because with changes in capillary pipes further maximize cold temperatures by using additional capillary pipe length. This study uses an experimental method with a split air conditioner 0.5 Hp as the main object and variations in capillary pipe length. the temperature after the capillary pipe is varied is lower than the standard, namely the standard achievement of 55.9 for a variation of 72 cm, which is 26.4, and the last variation of 159 cm, which is 29.***

*Keywords*— *COP, refrigeration effect, freon pressure*

## I. Introduction

The hot temperature on board will disturb the comfort of the crew and will reduce the effectiveness of the crew's work, so an engine or air conditioning aircraft is needed that can maintain the comfort of the crew. In its implementation, the operation of sea transportation depends on the management of human resources (HR) and the welfare and comfort of the crew, so it is expected that the crew can work optimally. The cooling machine can function as a refrigerator, *freezer*, and *chiller* both for *air conditioning needs* and to support the production process. Ships that are sailing are directly exposed to sunlight at sea which makes the condition of the ship up hotter. The air is getting hotter due to global warming, making the use of air conditioning or air conditioning and refrigerators increasingly popular.

Split air conditioning is the most widely used air conditioning tool in the community. But in its users, some know technically about air conditioning, and some do not know about the system used. With ignorance of users, can cause inefficient energy use by the system (Ardita, Wirajati, and Susila 2020).

Split air conditioners require optimal components such as capillary pipes that play an important role. Therefore, it is necessary to research capillary pipes. Next research conducted by (Maulana 2019) on the effect of the number of capillary pipe windings on car air conditioners on the coefficient of performance (COP) by varying 8, 10, and 13.

The winding obtained results that the COP and efficiency in the cooling system change due to the number of different windings and the analysis of the coolant is obtained more efficiently its work performance when using capillary pipes with a smaller number of windings.

Furthermore, variations in the length of capillary pipes wrapped around the suction line on the performance of refrigeration machines using LPG refrigerant (Kusuma 2015). From the results of the study using variations in capillary pipe length of 1.5 meters, 1.8 meters, and 2.1 meters with LPG as refrigerant, it can be known that the average COP value when reaching stability for a capillary pipe length of 1.5 meters is 3.3. The average COP value when it reaches stable for a capillary pipe length of 1.8 meters is 3.4. While the average COP value when it reaches stable for a capillary pipe length of 2.1 meters is 3.9. It can be concluded that the effect of using capillary pipes on cooling machines with a length of 2.1 meters is better than the length of capillary pipes of 1.5 meters or 1.8 meters because it produces the largest COP every minute. The increase in the length of the capillary pipe in the cooling machine is expected to increase the COP value because of faster cooling. Broadly speaking, the longer the capillary pipe, the lower the compression work, thereby increasing the higher COP value.

Research on the analysis of the effect of capillary pipes wrapped around the suction line on the performance of cooling machines by (Lukito and Handoyo 2002) was conducted by Research using experimental methods. As a result, the COP of the cooling engine decreases when the load room temperature is lower. The COP of the cooling machine increases if the capillary pipe is wound on the

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suction line. Based on the purpose of the effect of winding capillary pipes on the suction line on the performance of a refrigeration machine, in this experiment, a freezer was used.

The observed performance is COP and cooling time. The cooling time is obtained from the time to reduce the 1oC of brine from 6ºC to 5ºC and so on to -3ºC. Then the test results prove that it is still lacking.

Unchanged cooling time if capillaries are wound around the suction line in 2009, Suryono and Hendri conducted a study entitled "Experimental Review of Comparative Performance of Steam Compression Cooling Machines Using Capillary Pipes and Expansion Valves". The experiment was conducted using an air conditioner trainer consisting of a hermetic reciprocating compressor, condenser, and evaporator-type finned-tube heat exchanger made of copper, as well as TXV and pipes Comparison of system performance with the use of capillary pipes and expansion valves was observed with fan voltage variations of 120, 140, 150, 180, 200 and 220 volts. The experimental results showed that the energy absorbed with the use of expansion valves can reach a higher capacity than capillary pipes. Where with the use of capillary pipes the value achieved ranges from 3.03-4.1 kW, while with expansion valves the cooling impact value is between 3.74-8.74 k.

Research on Analysis of the influence of the shape of capillary pipe curves on refrigerators by (Dwinanda 2003) This research uses literature study methods and field studies. This study also presents a list of tools and materials used to make refrigerators and the manufacturing process sequentially. The results of the third experiment of capillary pipes, which produced the lowest cold temperatures and the largest COP were those given spiral notches. However, the influence of the spiral indentation shape on the temperature drop in the Evaporator only applies in the 30th minute after the refrigerator is turned on, after passing from it the temperature will gradually rise.

## II. METHOD

This research will use an experimental approach to test the performance of split air conditioners with a focus on capillary pipes. The method used in this study is the Experimental method, which uses a split air conditioner 0.5 Hp with testing equipment including temperature sensors, electric power measuring devices, manometers, and measurement software. This tool will be used to monitor the performance of split air conditioners during testing. with different capillary pipe length variations, the data obtained during the test will be statistically analyzed to determine the effect of capillary pipe variations on the performance of split air conditioners with the aim of different additions, one of which can produce lower and optimal temperatures.

### 2.1 Working Principle of Cooling System

The main components of the cooling system are the compressor, condenser, expansion valve, and evaporator. The compressor functions to drain and increase the pressure of gas which is then liquefied in the condenser. The function of the condenser is to condense refrigerant gas by lowering the temperature and constant gas pressure, then the liquid refrigerant flows into the evaporator (Arismunandar and Wo, 1986). In general, the principle of refrigeration is the process of absorbing heat from a closed room and then transferring and removing heat from the room. The process of refrigerating the room needs power or energy, the most suitable energy for refrigeration is electric power to drive the refrigeration unit compressor (Wilis, 2011). While (Loegimin et al. 2020) work to maintain or lower the temperature at ideal conditions by transferring heat from a field to water or air. Heat transfer is the transfer of energy from one place to another and there is a temperature difference between the two parts of an object. The heat will move from high temperature to low temperature. Refrigeration is an effort to maintain low temperatures, which is a process of cooling the air so that it can reach temperature and humidity. Vapor compression cycle refrigeration machines are the most widely used type of refrigeration machine today. A vapor compression cycle refrigeration machine consists of four main components. The division of the main components aims to distinguish the function of each component, namely the compressor, condenser, expansion device, and evaporator. The arrangement of the four components is schematically shown in Figure 1.

Basic principles of refrigeration in general, the principle of refrigeration is the process of absorbing heat from a closed room and then transferring and dissipating heat out of the room. The process of refrigerating the room needs power or energy, the most suitable energy for refrigeration is electric power to drive the refrigeration unit compressor (Wiboaami, 1993). Refrigeration takes advantage of the thermal properties of refrigerants as they change state from liquid to gaseous and vice versa from gas to liquid. According to IIyas (1993), some of the processes that take place in refrigeration machine units are as follows:

a. Evaporation

Evaporation is the process of liquid refrigerant that is in an evaporator evaporating at a fixed temperature. Although it has absorbed heat from the product or the room it cools, the absorption of heat during such evaporation is not accompanied by a rise in temperature.

b. Compression

Compression is a refrigerant process in the form of cold steam from the evaporator sucked by the compressor and then compressed so that the temperature and pressure change to high. After being compressed, the refrigerant is pressed into the condenser.

c. Condensation

The condensation process is basically to remove heat from high-temperature and pressurized refrigerant in the condenser where the condensation medium can be water or air so that the heat of the refrigerant is absorbed by the medium.

d. Harvesting

Expansion is a process of regulating the shape of refrigerant so that it expands or fogs to accelerate the occurrence of cold refrigerant vapor in the evaporator. The way it works is that the refrigerant liquid pressure is dropped, press on the expansion valve so that the temperature becomes below the refrigerated room temperature.

The principal components are the components that must be present or installed in the refrigeration machine. The main components include a compressor, condenser, receiver tank, expansion valve, and evaporator. Each component in a vapor compression system has its properties (Stoecker, 1989).

2.2 Examples of important components in coolers are as follows:

1. Compressor

A compressor is a mechanical device used to provide energy to a gaseous or air-fluid so that gas or air can flow from one place to another continuously. The addition of this energy can occur due to mechanical movement, in other words, the function of the compressor is to convert mechanical energy (work) into pressure energy (potential) and useless heat energy. Centrifugal compressors, included in the dynamic compressor group, are compressors with a working principle of converting the energy of 15 gas speeds generated by the action of the rotating impeller from the mechanical energy of the drive unit into potential energy (pressure) inside the diffuser. The compressor is the heart of a mechanical refrigeration system, functioning to drive the refrigeration system to maintain the pressure difference between the low-pressure side and the high-pressure side (Fatchur, 2018).

2. Condenser

A condenser is a part of refrigeration that receives hot high-pressure refrigerant vapors from the compressor and dissipates the heat of condensation. Because refrigerant leaves the compressor in the form of high-pressure steam, a way is needed to convert steam into liquid again. This is the function of the condensing unit (condensing unit) condensing (to condeance) steam into liquid so that it can be reused in the cooling cycle.

The condenser serves to remove heat and change the form of refrigerant from gas to liquid. In addition, condensers are also used to make condensing gas refrigerants from compressors with high temperatures and high pressure (Poernomo, 2015).

At the moment when the coolant steam is pumped into the condenser by the compressor, its temperature and pressure increase. That high temperature facilitates effective heat propagation from the condenser surface to the surrounding space. Part of the heat transferred to the air chamber is latent absorbed refrigerant in the evaporator, the release of heat into the chamber is enough to condense the cooling vapor into a liquid. How to cool hot high-pressure refrigerant vapor to its dew point by removing the sensible heat. The subsequent chewing of latent heat causes the vapor to condense into a liquid (Ridhuan and Juniawan 2014)

3. Evaporator

The evaporator serves to absorb heat from the air or objects in the refrigerator and cool it. Then remove the heat through the condenser in an uncooled room. The compressor that is working sucks gas refrigerant from the evaporator, so that the pressure inside the evaporator becomes low and the vacuum of the evaporator functions the opposite of the condenser, which is to dissipate heat to the surrounding air but to take heat from the nearby air. Evaporator planning should include effective evaporation of the refrigerant with minimum pressure drop and efficient heat extraction of the cooled substance. The planning of the evaporator depends on its placement and the substance to be immediately cooled whether it is gaseous, liquid or solid. At all load conditions, the refrigerant will evaporate as time to flow along the evaporator pipe or evaporator surface and try to keep the liquid alkaline in all parts of the evaporator (Poernomo 2015). In most evaporators, refrigerant boils inside the pipe and cools the fluid that passes outside the pipe Evaporators that boil refrigerant inside the pipe are commonly called direct expansion evaporators. In an indirect expansion evaporator, the air is cooled by a secondary refrigerant such as water or salt solution flowing through the pipe.

4. Expansion Valve

Another major component of refrigeration machines is the expansion valve. This expansion valve is used to lower the pressure and to the adiabatic expansion of the pressurized and high-temperature liquid until it reaches a low level of pressure and temperature, or to expand the liquid refrigerant from condensing pressure to evaporation pressure, the liquid refrigerant is injected out through the orifice, the refrigerant immediately turns into a mist of low pressure and temperature. In addition, the expansion valve is also a refrigeration control device that functions as a

a. Regulates the amount of refrigerant flowing from the liquid pipe to the evaporator according to the evaporation rate on the evaporator.
b. Maintain the pressure difference between the condenser and evaporator so that evaporation on the evaporator takes place at its working pressure.

Expansion valves are used to adiabatically expand high-pressure liquid refrigerants to reach low-pressure and temperature states (Choirudin and Prayogi 2019). Expansion valves commonly used are expansion thermostatic expansion valves used to super biotically expand high-pressure liquid refrigerants until they reach a state of pressure and

which can regulate the flow rate of refrigerant, which is so that the degree of superheat of refrigerant vapor in the evaporator can be kept constant. In small air fresheners, capillary pipes are used instead of expansion valves. The inner diameter and length of the capillary pipe are determined based on the magnitude of the desired pressure difference between the high-pressure and low-pressure sections, and the amount of refrigerant in circulation. The refrigerant liquid flows into the evaporator, the pressure drops and receives evaporation heat from the air, so it evaporates gradually. (Poernomo 2015)

5. Refrigerant

Refrigerant is a heat transfer medium in the refrigeration system, where the refrigerant absorbs heat at low pressure through the evaporator and releases heat at high pressure through the condenser. The evaporator absorbs heat from the conditioned room so that the room temperature becomes cold and the low-pressure refrigerant inside the evaporator experiences boiling. The refrigerant vapor is then compressed by a high-pressure compressor so that the temperature of the refrigerant vapor also increases so that the heat of the refrigerant can be released into the environment through the condenser while the refrigerant is condensed so that the refrigerant changes phase into a liquid at high pressure. The refrigerant liquid is then expanded into the evaporator puzzle for the next cycle by an expansion device (Poernomo 2015)

4. Process 4-1: There is an addition of heat from the environment to the evaporator at a constant evaporator pressure, causing evaporation

III. Research variations

Variations of this study use several variations, namely standard capillary pipes, 72 cm and 159 cm, The size of ac capillary pipes is different, but the function remains the same, namely flowing refrigan. Refrigan is a component that has a liquid form in the refrigerator, so the transfer process must use capillary pipes. Not infrequently, when the refrigan flows, you will hear a sound like flowing water. As a refrigan diverter, the size of the capillary pipe must be well adjusted. The capillary pipe they use for the length and diameter of the capillary pipe are taken in the picture

Figure 1. Cooling System

| Tube id | .026 | .031 | *.036* | .042 |
|---|---|---|---|---|
| .024 | 1.44 | - | - | - |
| .025 | 1.20 | - | - | - |
| .026 | 1.00 | 2.24 | - | - |
| .027 | .72 | 1.59 | - | - |
| .028 | .52 | 1.16 | - | - |
| .030 | .45 | 1.00 | 2.00 | - |
| .031 | - | .86 | 1.75 | - |
| .032 | - | .75 | 1.54 | - |

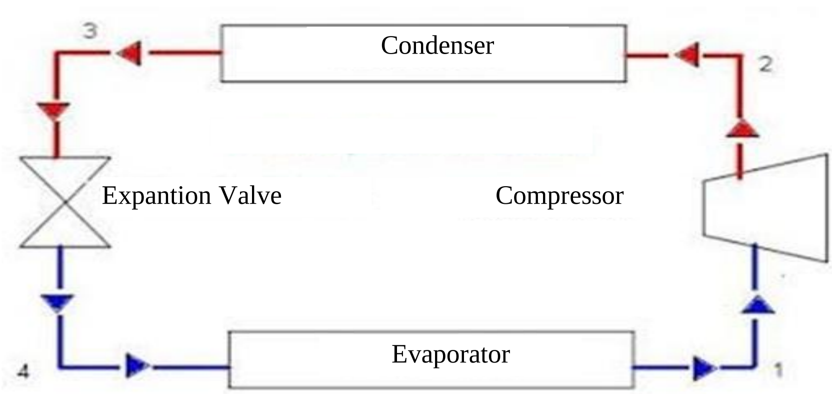


Figure 2. Capillary selection

1. Process 1-2: Adiabatic and reversible compression, from the condition of hot steam directly the fluid in compression to the working pressure of the condenser.
2. Process 2-3: Reversible heat release at constant pressure, causing further heat desuperheating and condensation of refrigerant.
3. Process 3-4: The expansion process, occurring at constant enthalpy, which lowers the fluid pressure from condenser pressure to evaporator pressure.

IV. Test Samples

Capillary pipe testing in this study uses an experimental method on a 1/2 PK split AC machine to determine the effect of capillary pipe length which will increase the cooling effect and further maximize heat absorption.

V. Sample taken plan from test results:

T1 : Temperature out of the evaporator.

Data retrieval us a thermogun to measure t out after evap.

T2 :Compressor out temperature.

Data retrieval using a thermogun to measure t out out after coming out of the compressor

T3 : Temperatur out kondensor.

Data retrieval using a thermogun to measure t out out after condenser.

T4 : Temperature after expansion.

Data capture uses a thermogun to measure t out after passing through the expansion valve

– P1 Low Preasure

The low-pressure retrieval uses a preasure gauge before entering the compressor.

–P2 : High Preasure

High pressure retrieval uses a preasure gauge after entering the compressor.

VI. Testing steps

The steps that must be done are to record some data from capillary pipe variation testing to find out the performance of Split Ac.

The data tested is with the 1/2 PK Split AC standard, the experiment used is 3x to get the most detailed and optimal data. The test steps are as follows:

- First, prepare the tools and materials to be used.
- Next, install the pressure gauge/ preasure gauge at the point you want to test
- After that, the refrigerant is charged using R32 with a manifold gauge
- Before the tool is tested, a leak detector is checked to anticipate leaks in the pressure gauge installation
- Testing was conducted 3 times with a gap of 1 hour
- After collecting data on standard capillary pipes, vacuum is carried out to remove the remaining refrigerant that is still in the air conditioner for the installation of variation capillary pipes.
- After that, cut the capillary pipe using a pipe cutter, measure the capillary pipe according to the table and install the capillary variations using welding.
- After welding capillary pipe variations, refrigerant R32 disi
- Once there are no leaks, the tool is ready to be tested again.

VII. RESULTS AND DISCUSSION

A. Result pipe capillary standard

After obtaining data from standard capillary pipe testing, the data is averaged and entered in the table to facilitate analyzing the results obtained after testing can be seen in table 1.

B. Capillary pipe yield variation 72 cm

After obtaining data from testing again with a capillary pipe variation of 72 cm, the data can be flattened and entered in the table to make it easier to analyze the results obtained after testing can be seen in table 2.

C. Capillary Pipe Results Variation 159 cm

After obtaining data from testing again with capillary pipes with a variation of 159 cm, the data can be flattened and entered in the table to facilitate analyzing the results obtained after testing can be seen in table 3.

TABLE 2
STANDARD AVERAGE

| Time /minute | 15 minutes | 30 minutes | 45 minutes | 60 minutes |
|---|---|---|---|---|
| Current | 1,3 A | 1,3 A | 1,3 A | 1,3 A |
| Voltage | 220V | 220V | 220V | 220V |
| T out evaporator | 16,1℃ | 15,4℃ | 14,3℃ | 13,9℃ |
| T out Compressor | 44,4℃ | 46,7℃ | 47,6℃ | 49,7℃ |
| T out condenser | 31,3℃ | 32,3℃ | 33,5℃ | 34,9℃ |
| T out Expansion | 19,9℃ | 18,4℃ | 17,3℃ | 16,8℃ |
| Low Preasure | 140 psi | 141 psi | 141 psi | 141 psi |
| High Preasure | 352 psi | 352 psi | 352 psi | 352 psi |

TABLE 3
FLAT AVERAGE VARIATION OF 72 CM

| Time /minute | 15 minutes | 30 minutes | 45 minutes | 60 minutes |
|---|---|---|---|---|
| Current | 1,3 A | 1,3 A | 1,3 A | 1,3 A |
| Voltage | 220 | 220 | 220 | 220 |
| T out evaporator | 18,7 ℃ | 17,8 ℃ | 17,2 ℃ | 16,5 ℃ |
| T out Compressor | 32,3 ℃ | 34,6 ℃ | 36,0 ℃ | 37,6 ℃ |
| T out condenser | 29,8 ℃ | 31,0 ℃ | 32,4 ℃ | 33,3 ℃ |
| T out Expansion | 24,1 ℃ | 21,3 ℃ | 20,1 ℃ | 18,3 ℃ |
| Low Preasure | 135 psi | 135 psi | 138 psi | 140 psi |
| High Preasure | 344 psi | 344 psi | 350 psi | 350 psi |

TABLE 4
STANDARD AVERAGE

| Time /minute | 15 minutes | 30 minutes | 45 minutes | 60 minutes |
|---|---|---|---|---|
| Current | 1,5 A | 1,5 A | 1,5 A | 1,5 A |
| Voltage | 221 V | 221V | 221 V | 221 V |
| T out evaporator | 18,5°C | 17,4 °C | 16,5°C | 15,5°C |
| T out Compressor | 46,8°C | 52,7°C | 55,5°C | 57,3°C |
| T out condenser | 32,4°C | 35,2°C | 36,6°C | 37,2°C |
| T out Expansion | 20,3 °C | 19,1°C | 17,4°C | 16,8°C |
| Low Preasure | 130 psi | 130 psi | 130psi | 131 psi |
| High Preasure | 401 psi | 401 psi | 403 psi | 404 psi |

D. Performance Efficiency Gain (COP)

After the calculation is carried out to determine the COP, according to the results that have been obtained on the graph

The Coefficient of Performance (COP) is a key measure of energy efficiency in split air conditioning systems. The COP value reflects how efficient the air conditioner is at producing cooling compared to the energy it consumes. The higher the COP value, the more energy efficient the system will be. Split air conditioners with high COP provides several advantages. First, they produce the same cooling with less energy, reducing monthly electricity costs. Secondly, they reduce the carbon footprint, helping to protect the environment. Third, they provide a more comfortable experience for users with consistent coolness.

Factors that affect the COP of Split AC include technical design, size, and quality of components differences in size and diameter Capillary pipes have different COP differences as well. Standard capillary pipes still have the highest COP compared to the 2 variations of capillary pipes, because according to Indartono (2006), performance or COP is a comparison between refrigeration capacity (KR) with power (Pk) needed to drive the compressor.

E. COP calculation

After obtaining data results from standard testing and variations in tables 1, 2 and 3 above, it can be continued by analyzing the necessary data such as COP. After being tested using a 1/2 PK split air conditioner,

The COP calculation is obtained from the Entalphy Diagram, cooling capacity is measured in BTU units per hour or watt, and input power is measured in watts. It is important to note that a high COP value indicates good efficiency, as air conditioners are able to provide more cooling by Uses less power.

The calculation of the Coefficient of Performance (COP) in a 1/2 PK split AC involves a comparison between the cooling power produced by the AC with the electrical power used. In split air conditioners 1/2 PK is the key to optimizing energy efficiency. COP measures the ratio between the cooling power produced by the air conditioner and the electrical power used.

COP 15 minutes

- T1 = 18,7 °C
- T2 = 32,3 °C
- T3 = 29,8 °C
- T4 = 24,1 °C
- P1 = 135 Psi / 9,30 Bar
- P2 = 344 Psi / 23,7 Bar
- P3 = 344 Psi / 23,7 Bar
- P4 = 135 Psi / 9,37 Bar
- H1 = 520 kj/kg
- H2 = 528 kj/kg
- H3 = 250 kj/kg
- H4 = H3 = 250 kj/kg

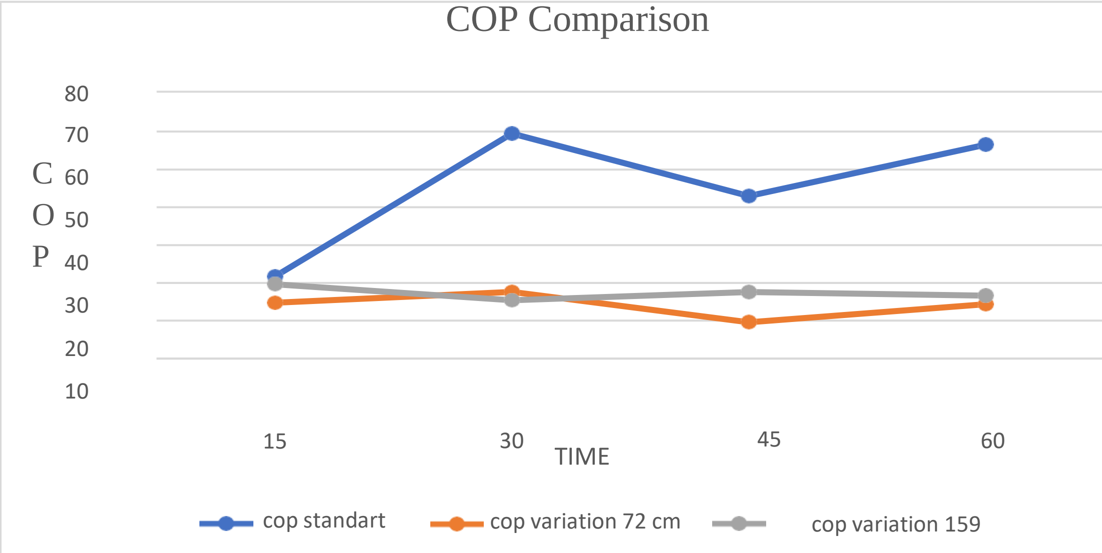


Figure 2 COP Chart

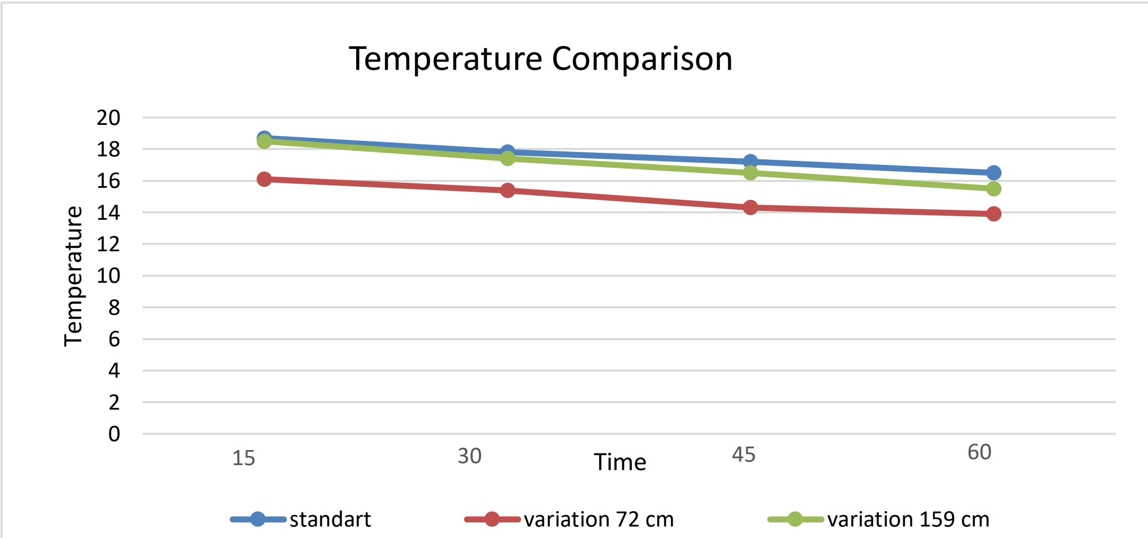


Figure 3 Temperature graph

Working Compressor ($W_k$)

$W_k$ = H2 – H1

= 528 Kj/Kg – 520 Kj/Kg

= 8 Kj/Kg

It is known that the current acting on the compressor is 1.3 A, 220 V. Compressor Power = I x V

Wk = I x V

= 1,3 A x 220 V

= 286Watt made into Kj/s = 0,286 Kj/s

$W_k = m$ (H2 – H1)

$$m = \frac{\mathrm{wk}}{(\mathrm{H2}-\mathrm{H1})} = \frac{0{,}286\ \mathrm{Kj/s}}{8\ \mathrm{Kj/KG}} = 0{,}0357\ \mathrm{Kg/s}$$

Cooling Capacity ($Q_{in}$)

$Q_{in} = m$ (H1 – H4)

= 0,0357 Kg/s Kg/s (520 Kj/Kg – 250 Kj/Kg)

= 0,0357 Kg/s . 270 Kj/Kg

= 9,639 Kw

COP (Coefficient of Performance)

COP = $Q_{in}/\ W_k$

= 9636,0 W / 286 W

= 33,7

temperature produced by a 1/2 Pk split ac with standard capillary pipes having the lowest average temperature of 16.5 ° C while capillary pipes with smaller and shorter diameters have.

the lowest temperature is 13.7°C which is the shorter the capillary pipe and has a smaller diameter compared to the standard suction pressure is smaller which can make the evaporator temperature lower the flow Capillary pipes are very short, if the length is reduced just a little, the capillary pipes will cause a very large change in the flow of refrigerant. Systems with capillary pipes that are too long or the size of the deep holes are too small, the resistance becomes large and the coolant that flows is reduced, for longer variation temperatures capillary pipes also have a trendline temperature evaporator which decreased also to 15.5 °C. In Figure 5 standard capillary pipes the T out compressor rises with t out condenser because it works continuously pumping refigerant with high pressure, to t ou expansion to reduce refrigerant pressure and temperature drastically. This occurs after the refrigerant leaves the condenser which is at high pressure and high temperature, this expansion process is important because it creates optimal conditions for the performance of the evaporator. Refrigerants that have undergone rapid expansion have low temperatures and pressures, so they can absorb heat from indoor air more efficiently in the evaporator.

Capillary pipes have a crucial role in determining the performance of a 1/2 PK Split AC. By choosing the right variety of capillary pipes, we can significantly improve cooling efficiency. From refrigerant flow control to optimal distribution, capillary pipes are an important element in maximizing AC Coefficient of Performance (COP) The selection of capillary pipes thatmatch the characteristics of the AC unit and its operational environment can yield substantial profits. Variations in diameter, length, and material of capillary pipe construction can provide better control over refrigerant flow, optimize heat transfer, and reduce energy losses. By using the latest capillary pipes, can improve the performance of 1/2 PK Split AC to be more efficient and environmentally friendly. Investment in innovative capillary pipes opens the door to continuous cooling.

In figure 6 of the component performance with a capillary pipe variation of 72 cm T out compressor higher than standard If the capillary pipe is too short, then the pipe

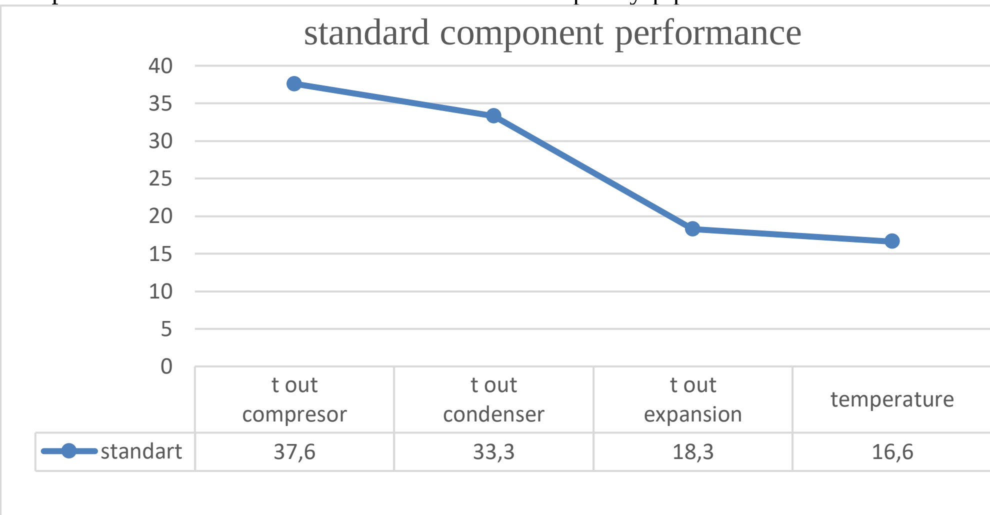


Figure 5 performance of standard components

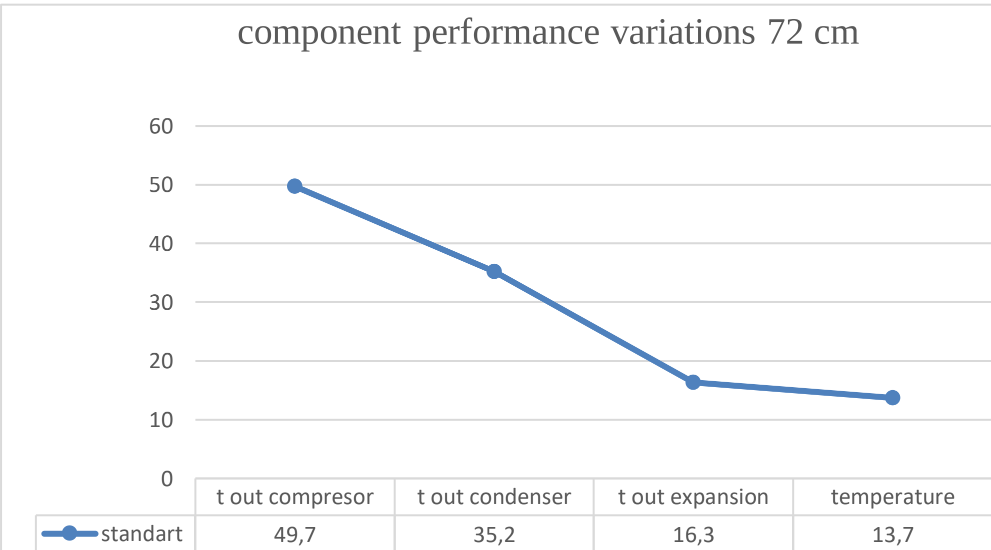


Figure 6. 72 cm variation component performance

friction resistance will be smaller. This will certainly make the pipe capacity to channel liquid refrigerant from the condenser to the evaporator higher when compared to the compression pressure capacity. Refrigerant that is in the form of high-pressure and high-temperature gas flows into the condenser. In the condenser, the refrigerant releases heat to the outside environment, undergoes condensation, and turns into a high-pressure liquid. As the refrigerant passes through the expansion device, its pressure drops significantly. This process causes the refrigerant to undergo rapid expansion and turn into a mixture of gas and liquid. At this point, the refrigerant reaches a state lowest in cycle. compared to the gain of compression capacity. As a result, the pipe to the evaporator lacks liquid refigerant, the pressure will drop. On the other hand, the liquid refigerant in the condenser rises, so the condensation pressure will also rise. This large condenser pressure makes the compressor work which will make the compressor overheat. This will make the compressor life shorter, the beginning of the refigerant from the evaporator to the compressor, the refigerant gas is pressurized and the low temperature is increased in pressure so that the temperature rises. In this compression process, the refigerant experiences very high superheat. When entering the condenser there is a change in form from gas to liquid, in the sub cooling process on the refigerant condenser

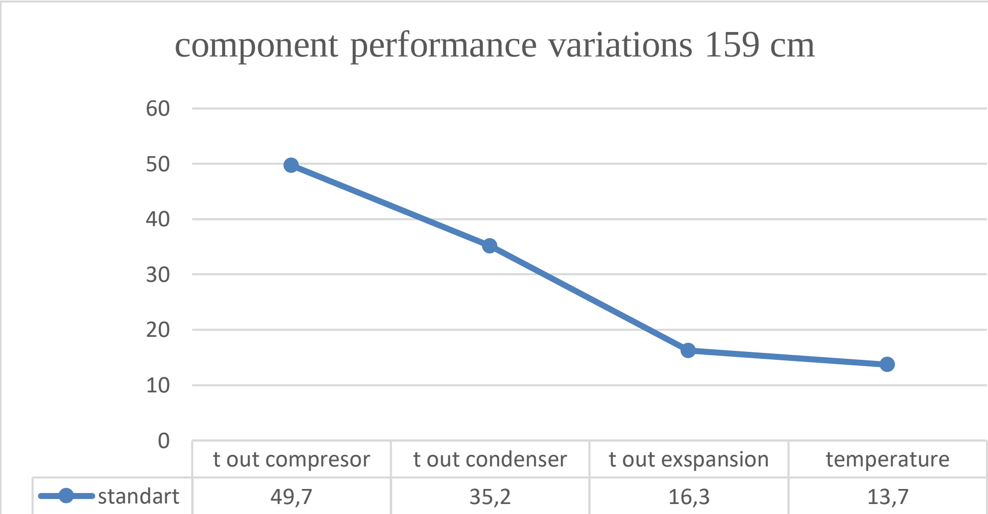


Figure 7 component performance 159 cm variation

In the graphic figure 7 T out, compressor is higher than standard and a variation of 72 cm because longer capillary pipes require the compressor to pump 2x harder refigerant. The same is true when the refigerant enters the condenser, The longer the pipe, the greater the resistance to the flow of refrigerant. This can lead to a decrease in efficiency in transferring heat from the condenser to the refrigerant takes longer to reachthe evaporator upon entry Expansion tools are one of the key elements in the refrigeration cycle. By lowering the refrigerant pressure and temperature, the expansion device ensures that the refrigerant returns to the appropriate condition to absorb heat in the evaporator and begins the cooling cycle again. Current and voltage in AC compressors have a direct influence on high pressure and low pressure. Increased current in compressors tends to increase high pressure because more energy is given to the refrigerant compression process. On the low-pressure side, high currents can also cause pressure drops as more refrigerant is sucked into the compressor.

F. Discussion

After anaslisa can be seen in the graphic figure 4,5,6,7 temperature produced by a 1/2 Pk.

If the friction resistance of the capillary pipe is too large, because the capillary pipe is too long, the capacity in the pipe to channel liquid refigerant from the condenser to the evaporator becomes smaller, when which is already in liquid form still throws heat into the air, around so that it experiences a decrease in temperature. In the standard capillary pipe trendline T out compressor rises with t out condenser because it works continuously pumping refigerant with high pressure.

In standard capillary pipes the T out compressor rises with t out condenser because it works continuously pumping refigerant with high pressure, to t ou expansion to reduce refrigerant pressure and temperature drastically. This occurs after the refrigerant leaves the condenser which is at high pressure and high temperature, this expansion process is important because it creates optimal conditions for the performance of the evaporator. Refrigerants that have undergone rapid expansion have low temperatures and pressures, so they can absorb heat from indoor air more efficiently in the evaporator

Higher voltage can increase compressor efficiency, causing increased pressure on high side, on low pressure side, high enough voltage can also help in attracting refrigerant into compressor, affecting low pressure. Simultaneous changes in current and voltage can result in significant changes in high and low pressure in an AC compressor, affecting the overall performance of the cooling system. High pressure occurs on the outside of the system, in the condenser unit. Here, the refrigerant that has been compressed by the compressor becomes a hot gas and is under high pressure. In condensers, outside air takes heat away from the refrigerant, causing the refrigerant gas to condense into a liquid. High pressure is maintained to ensure the refrigerant liquid can undergo subsequent evaporation and compression processes in the refrigeration chamber. Low pressure relates to the inside of the system, in the evaporator unit. The condensed, high-pressure refrigerant enters the evaporator unit as a liquid. In the evaporator, refrigerant absorbs heat from the surrounding air, evaporates and turns back into a gas. At this time, the refrigerant pressure becomes low. The low-pressure refrigerant gas is then re-compressed by the compressor, starting the cycle again. This cycle repeats constantly, creating a high- and low-pressure difference that allows the air conditioning system to absorb heat from inside the room, expel it outside, and cool the air in the room.

## VIII. CONCLUSION

After testing and regarding AC Split 1/2 PK by comparing 3 variations of capillary pipes, namely standart, 72 cm and 159 cm, it can be concluded that:

1. The shorter and smaller the diameter of the capillary pipe, the cooling capacity of the evaporator and the temperature value in the evaporator of the system will be smaller, which is 13.7 ° C, resulting in a greater cooling effect due to the flow of refrigerant in the short capillary pipe, becoming very fast which makes the short capillary pipe have the lowest temperature.
2. The longer and larger the diameter of the capillary pipe, the cooling capacity of the evaporator and the temperature value on the evaporator of the system will be smaller, which is 15.5 ° C, resulting in a greater cooling effect, capillary pipes with a larger diameter make the flow faster and make cooling cooler, but the pipe compiler that is too long makes a lot of friction that occurs and makes the compressor have to pump refrigerant with extra.

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