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Performance Air Conditioner On Retrofitted Refrigerant Hydrocarbon

Muhammad Edi Pujianto[1], Agung Nugroho[2*]
[1]Mechanical Engineering, Universitas Muhammadiyah Semarang, Semarang, 50273, Indonesia
[2]Mechanical Engineering, Universitas Wahid Hasyim, Semarang, 50224, Indonesia
*Corresponding author: agung.nugroho@unwahas.ac.id

Abstract
Synthetic refrigerants used in Air Conditioners (AC) are very important in depleting the ozone layer and prohibiting global warming. This has led to the application of R32 and Musicool 22 (MC22) as a substitute for R22 because refrigerant is considered more environmentally friendly. Therefore, this research was aimedto compare the performance of applying both R32 and MC22 refrigerants in 1 PK split AC using the Coefficient of Performance (COP) as the indicator for AC performance and compressor power consumption. MC22 filling mass was varied at 90% (202.14 grams), 100% (224.6 grams), and 110% (247.6 grams) of R32 mass, and condenser inlet temperatures at 28°C, 30°C, 32°C, and 34°C. The results showed that MC22 could be used as a viable alternative to R32 due to the higher refrigeration effect value of 332.36 kJ/kg recorded for refrigerant.

Keywords:
R32, MC22, power consumption, refrigeration effect.

1 Introduction

The performance of a split Air Conditioner (AC) is normally influenced by three main factors, including the environment, refrigerant (cooling fluid), and AC components. The environmental factors include outside air temperature, air humidity, and other weather conditions influencing the ability of AC to produce cold air. This is associated with the fact that extremely high outside air temperature or air humidity can make AC to struggle cool the indoor air. Moreover, refrigerant factors comprise the type and quality of the cooling fluid used in AC systems [1]. The application of poor quality or inappropriate types of refrigerant for the workload specifications can affect AC performance, leading to issues such as leaks or component damage [2]. AC component factors cover all parts and elements used in AC system [3], such as the compressor, condenser, evaporator, and others [4]. The damage or inappropriate functioning of any of these components can affect AC performance, resulting in the inability to produce cold air effectively. Therefore, regular maintenance and repairs are important to ensure optimal performance in the system [5].

Refrigerant is a substance normally used in refrigeration and AC systems to absorb and transfer heat from indoor air to outside. Some refrigerants, such as R22 or Chlorofluorocarbon (CFC) [6], are known to damage the ozone layer and harm the environment. Several others also have high Global Warming Potential (GWP), indicating the ability to contribute to global temperature rise and climate change [7]. This has made different countries adopt regulations limiting or prohibiting the use of environmentally harmful refrigerants with high GWP. Different types of environmentally friendly alternatives with lower GWP, such as R32 [8], have also been developed and used worldwide. Furthermore, energy-saving technologies are continuously being developed to reduce energy consumption in refrigeration, cold storage, and AC systems [9][4].

The introduction of environmentally friendly refrigerants and energy-saving technologies is to assist in reducing greenhouse gas emissions and addressing global climate change. Extensive research is observed to have been conducted on the replacement of refrigerants. For example, hydrocarbon HCR134 [10,11] was used as a substitute for halocarbon refrigerant R134a in vehicle AC systems, thereby doubling the cooling capacity compared to HFC at the same temperature[11]. It was also discovered that the effect of R32 and Musicool 22 (MC22) refrigerants on AC performance had been studied.Radjah, Y. I., Dwinanto, M. M., and Nurhayati, (2019) reported that R32 outperformed R22 [12]. A similar observation was made bySupriatno (2018) that the application of R32 enhanced AC performance compared to R22 [13]. However, Wahyu. D, Nasrullah, and Amri (2014) showed that R410A produced a higher COP than R22 at nearly the same flow rate [14]. A 1 PK split AC designed using MC22 was also reported to have shown lower electrical energy consumption compared to R32 and R410A [15].

The refrigerant most commonly used in the world is halocarbon R22. However, it has been replaced by more environmentally friendly alternatives due to its ozone-depleting properties. According to the Montreal Protocol, the use of R22 is proposed to be entirely prohibited starting from January 1, 2030. Therefore, there is a need to find a replacement with the ability to enhance the cooling performance of AC. This has led to the current adoption of R410A in different types of AC and refrigerators [16]–[18]. However, the demand for more environmentally friendly refrigerants has made R32 a more popular choice due to the faster cooling rate than the previous two [19]. Some research has compared the performance of R32 and MC22, but there is a need to explore certain aspects such as the influence of refrigerant mass on AC efficiency. Therefore, the purpose of this research is to compare the impact of using R32 as the benchmark to replace MC22 split AC performance.

2 Method

The test equipment used in this research is presented in Fig. 1. Moreover, a 1 PK split AC was used as the object as specified in Table 1. The test machine was initially filled with two different refrigerants, R32 and MC22, and condenser performance data were obtained using thermometers with dry and wet bulb cores. The aim was to determine the actual heat transfer on condenser and evaporator components.

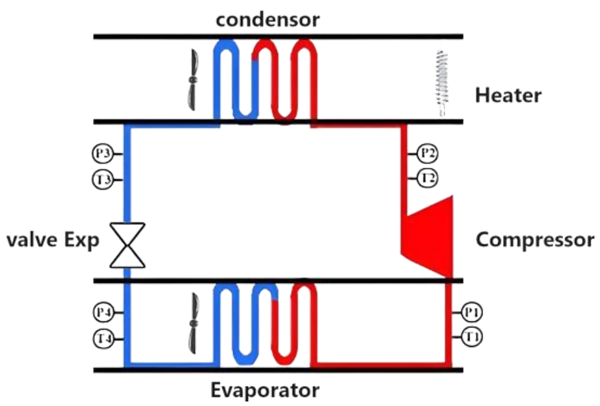

Fig. 1. Apparatus set up.

The specifications of the cooler unit used are presented in the Table 1.

Table 1. Specifications of cooler unit

Item	Specification
Model	AH-A9SEY
Electrical power	860 watts
Dimensions (length×width×height)	86×30×20
PK power	1 PK
Refrigerant type	R32
Inlet flow	4.0 Ampere
Voltage	220V
Manufacturer	Thailand
Cooling capacity	9000/hour

The vacuum process conducted on the unit was followed by the filling of 420 grams R32 with a mass of 224.6 grams. Moreover, MC22 was varied at 90% (202.14 grams), 100% (224.6 grams), and 110% (247.6 grams) of R32 mass. Condenser inlet temperatures were also in the variations of 28°C, 30°C, 32°C, and 34°C for both refrigerants. It was important to note that no refrigerant system component replacements were required during the test. Furthermore, the enthalpy results obtained were used to calculate the refrigeration effect, work compression, and Coefficient of Performance (COP).

3 Results and Discussion

The influence of the changes in refrigeration on condenser inlet temperatures is presented in Fig. 2. R32 was observed to have a lower effect compared to MC22 based on the latent heat score of hydrocarbons. The highest refrigeration effect was recorded in 90% MC22 mass with a value of 332.36 kJ/kg while the highest in R32 was 259.58 kJ/kg. This showed that an increase in condenser inlet temperature led to a reduction in the refrigeration effect. However, the scores recorded without the refrigeration were not influenced by the properties of refrigerant.

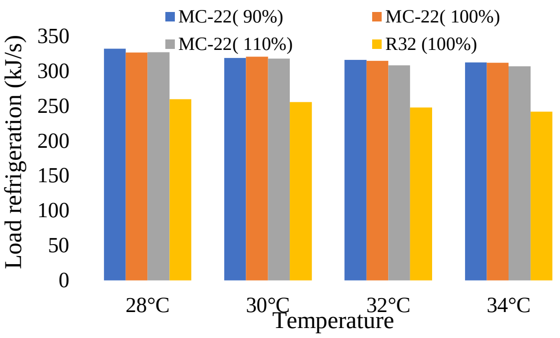

Fig. 2. Graph of refrigeration effect for R32 and MC22.

The heat energy released by R32 and MC22 was compared in Fig. 3 and MC22 was observed to have the highest of 363.31 kJ/kg. This was believed to be influenced by the absorption heat yield or refrigeration effect. Meanwhile, R32 had a higher cooling capacity and was considered a more efficient and environmentally friendly choice in modern AC and refrigeration systems. The phenomenon was associated with the ability of the refrigerant to deliver superior cooling performance with lower energy consumption [8].

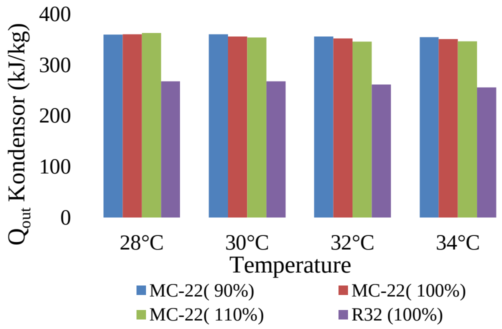

Fig. 3. Graph of heat release for R32 and MC22.

Fig. 4 shows P-h for R32 at different condenser inlet air temperatures of 28°C, 30°C, 32°C, and 34°C. It was discovered that both evaporation and condensation temperatures increased with the rise in inlet air temperatures on the condenser.

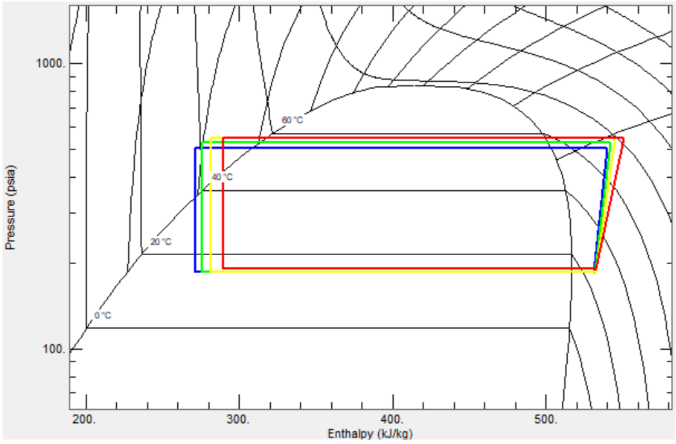

Fig. 4. P-h diagram for R32 with 100% mass fraction.

P-h diagrams in Fig. 5 - Fig. 7 show condenser performance with the usage of MC22 with a focus on the 90%-110% differences in the mass fraction from the default filling standard as well as the variations in condenser inlet air temperatures of 28°C, 30°C, 32°C, and 34°C. The evaporation and condensation temperatures tended to rise with the increase in inlet air temperatures on the condenser. However, there was no temperature glide in MC22 as observed in the figure. One of the main reasons for this phenomenon is the stable chemical and thermal properties of MC22 in the given operational conditions range. Temperature glide typically occurs in mixed refrigerants with components having different boiling points. In the case of MC22, the variation in the mass fractions between 90% and 110% did not have significant differences between evaporation and condensation temperatures at a specific point in the cooling cycle.

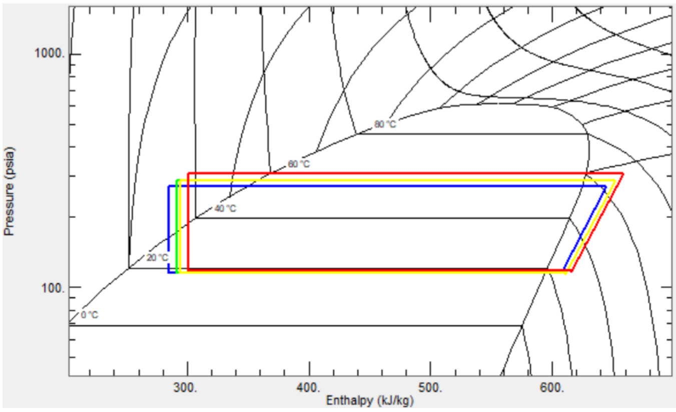

Fig. 5. P-h diagram for MC22 with 90% mass fraction.

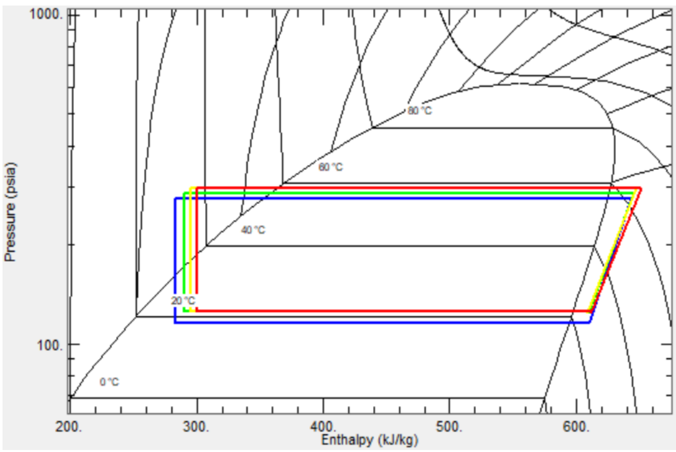

Fig. 6. P-h diagram for MC22 with 100% mass fraction.

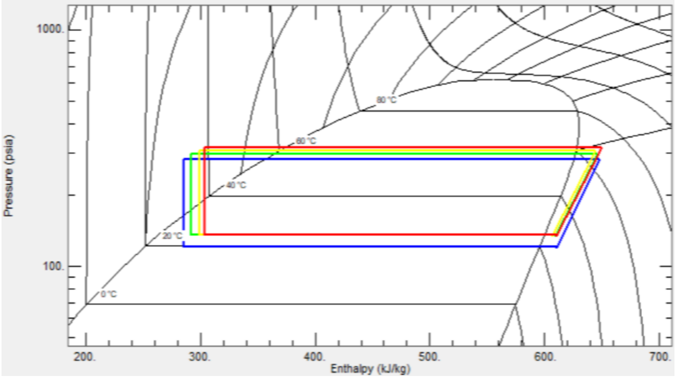

Fig. 7. P-h diagram for MC22 with 110% mass fraction.

The increase in the evaporation and condensation temperature due to condenser inlet air temperatures was expected in line with the basic principles of thermodynamics. This was associated with the influence of the increase in the temperatures at several points in the cooling cycle. Moreover, the stability of temperatures in MC22 in the given operational conditions range was attributed to the consistent chemical and thermal properties of the refrigerant. This understanding was considered to be important in designing and optimizing refrigeration systems, enabling engineers to make more informed decisions regarding operational conditions and refrigerant selection.

Fig.8 shows the power consumption required by the refrigerant. The results showed that R32 required a significantly higher value than MC22. Moreover, the most efficient power rating was obtained with MC22 at 422.4 watts.

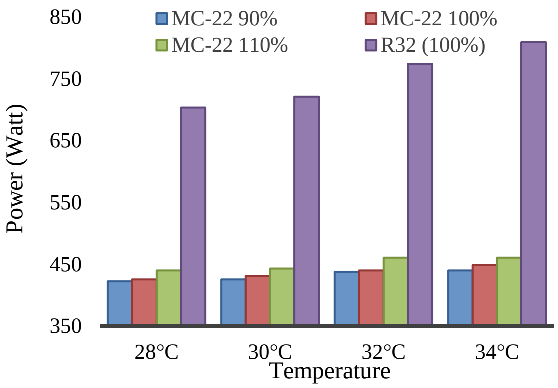

Fig. 8. Power consumption of R32 and MC22.

The high power consumption rate of R32 was attributed to the higher density value compared to M22. The refrigerant also had higher working pressure which needed a stronger system to compress, leading to the consumption of more power to generate the required pressure. Another important fact was that R32 had different thermal characteristics compared to MC22 as observed from the higher cooling capacity but a lower COP. Therefore, R32 was found to have better cooling capacity but lower efficiency compared to MC22, leading to increased power consumption.

4 Conclusion

In conclusion, MC22 was found to have superior performance in terms of higher refrigeration effect, greater heat release, and more energy-efficient power consumption which was approximately 40% lower. It was also found to be more efficient and environmentally friendly. Moreover, 90% MC22 variation showed an optimal combination of refrigeration effect and low power consumption. The evaluation of COP also confirmed that MC22 had better efficiency in producing cooling with less energy consumption compared to R32. Therefore, the selection of refrigerant type and specific parameter settings such as mass and inlet temperature of the condenser was found to be a key strategy in improving the efficiency and performance of split AC. The process led to the preference for MC22 as a more optimal alternative refrigerant in AC systems.

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