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Experimental Study of Performance AC Split R32 Retrofitted with R290 at 50% Mass

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***Abstract* - Split air conditioners are now widely used by the general public as air conditioners, but the refrigerants used, one of which is the refrigerant R32, are still not environmentally friendly. The AC machine used in this study uses R32 before replacing it with R290, which has a capacity of 1 PK and is installed in a duct. The purpose of this research is to evaluate the performance of the low-GWP refrigerant R290. The mass of R290 charged to the AC engine is 50%, and temperature variations resulted in a 40.24 percent reduction in power consumption from R290 to R32. R290 has a 34.33 percent lower cooling capacity than R32 due to the lower cooling capacity, which affects the compressor's lower power consumption. From R290 to R32, the COP decreased by 29.74%. Overall, the performance of replacing R32 refrigerant with R290 refrigerant has not been optimized.**

Keywords: Energy Conversion, Air Conditioning, R32, R290.

I. INTRODUCTION

Cooling machine technology is currently having a significant impact on modern life, one of which is split AC, which is an air conditioner that is commonly found in offices, homes, and commercial spaces such as restaurants, supermarkets, hotels, apartments, and hospitals[1]. This tool is extremely important for creating thermal comfort for people in a room and effectively supporting walking activities, not only for improving the quality and comfort of life but also for touching the essential things that support human life[2].

Global warming and the destruction of the ozone layer are two of the most pressing environmental issues facing the world today. The destruction or depletion of the ozone layer is caused by Ozone Depleting Substances (ODS), which are emitted from a variety of activities, including the use of or production of goods containing ODS. Chlorofluorocarbons (CFCs) and hydrochloro carbons are two of the known threats to the ozone layer (HFCs). CFC refrigerants deplete the ozone layer, and HFC refrigerants emit greenhouse gases. Chlorofluorocarbons (CFCs) are synthetic chemical compounds that are commonly used as refrigerants in cooling systems[3].

Chlorofluorocarbons (CFCs) are synthetic chemical compounds used in cooling systems, also known as refrigerants. There are many different types of refrigerants used in cooling systems, one of which is HCFC (Hydro-Chloro-Fluoro-Carbon) refrigerant, an example of which is R22 (HCFC-22). Because this ozone-depleting chemical is very stable, it can reach the stratosphere in its entirety. The ozone layer in the stratosphere serves to prevent ultraviolet-B rays from reaching the earth's surface. When these chemicals reach the stratosphere, they are converted by ultraviolet radiation from the sun into ozone-depleting chlorine atoms[4].

The use of environmentally friendly refrigerants is critical to supporting government programs aimed at reducing the impact of ODS on the ozone layer and materials with a high GWP. According to the 1987 Montreal Protocol, which was later revised by the London Amendment in 1990 and again by the Copenhagen Amendment in 1992, the use of CFC 12 and HCFC 22 in the world must be limited in order to be declared as prohibited refrigerants[5].

Alternative refrigerants include hydrocarbon refrigerants. Hydrocarbon refrigerant is a refrigerant that is currently being researched because it is environmentally friendly, non-toxic, cheaper, does not cause ozone depletion (ODP of 0), and does not cause global warming (GWP of less than 3) R290 is a natural material that has zero ODP and low to negligible GWP. It is not harmful to the environment[6].

Many studies have shown that the R290 performs on par with or even better than the R22. Furthermore, R290 is highly compatible with HVAC materials and lubricants, as well as being low-cost and widely available. The only issue with R290 is that, like any other flammable substance, its high flammability can lead to dangerous incidents if not handled properly. As a result, the international community has always taken it seriously and banned its use[7].

Berkah and colleagues'renovation a small-capacity air conditioner from R22 to R290. The results showed that the maximum improvement in AC performance was obtained when the mass of R290 was 50% of that of R22. Cooling capacity decreased by 2.8 percent while EER (energy

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efficiency ratio) increased to 12.6 percent at this optimal charge[8].

A study using the refrigerant R22 and a window air conditioner with a cooling capacity of 2.4 kW and an energy efficiency ratio (EER) of 3.2 installing a compressor with a capacity that is 20% greater to fill R290. The results show that the R290 will perform better if it adopts a larger displacement compressor at the same time. When the outdoor temperature drops, all alternative systems have higher upgrade rates and greater increases in cooling capacity and EER than the R22 system. The R290 system has significantly increased cooling capacity while decreasing EER[9].

The efficiency of a split-type air system using R22 and R290 The results show that the mass flow rate for R290 is only 44% and 47% when compared to R22, which is due to different mass density factors. When compared to R22, the cooling capacity of the system using R290 is 4.7 percent to 6.7 percent lower, as is the input power, but the EER of R290 is 8.5 percent higher, demonstrating one of the benefits of using R290[10].

An experimental retrofit study on a domestic split type AC system with R-32 inverter refrigerant using a 70 percent: 30 percent by weight mixture of R-32 and R290 refrigerant without system replacement. A comparison of the performance or COP of mixed refrigerants R32 and R290 reveals a 14 percent increase in COP and a 47 percent decrease in power usage when compared to the use of refrigerant R32, but a 33 percent decrease in cooling capacity[11].

II. EXPERIMENTAL DEVICE

2.1 Model Test

The experimental equipment is a split-type air conditioning unit with a cooling capacity of 9000 BTU. A split air conditioner consists of a compressor, condenser, evaporator, and capillary tube. After this major component is removed from its original design, the condenser and evaporator are installed in a split-AC unit. Because of the component's connection to the refrigerant pipe, performance data for the compressor, condenser, and evaporator are easily accessible. On each component, temperature and pressure are recorded.

By measuring the refrigerant flowing in the capillary tube, the mass flow rate of the refrigerant in the system is calculated. Compressor power is measured using electric current, voltage, and power factor. Data acquisition devices and measurement instruments include desktop computers, data acquisition (DAQ NI), temperature sensors (LM35), pressure gauges, and digital scales. Figure 1 depicts the universal testing machine and measuring instruments used in the experiment.

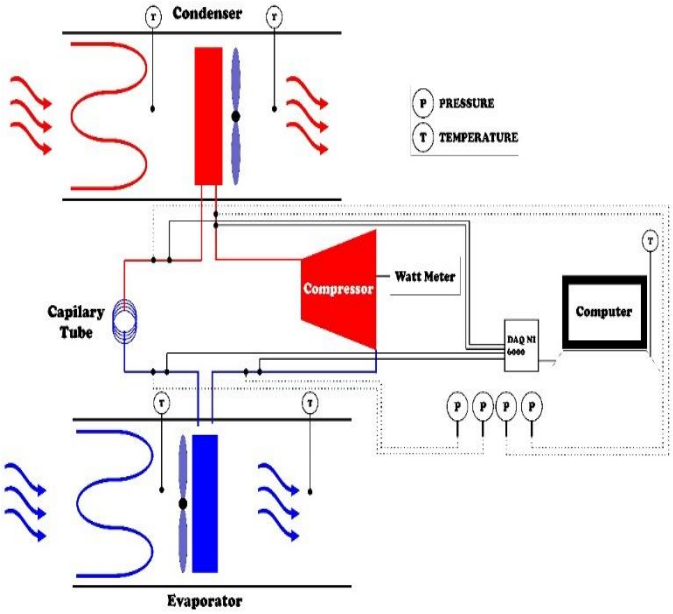

Figure 1: Schematic diagram

2.2 The Procedure for the Experiment

The experiment was conducted in two stages, the first using a split AC filled with R32 and the second with R290. The experiment began with an R32 mass of 430 grams (according to the label AC R32). Experiments were carried out at temperatures ranging from 23°C to 30°C, 25°C to 30°C, (27°C to 30°C), (25°C to 35°C), and (27°C to 35°C). R290 is filled with 50% (215 grams) of the total mass of R32, in accordance with the hydrocarbon filling reference (MC22/R290).

With a 5-minute delay between measurements, the measurements were taken after the system had been stable for 60 minutes. The experiment starts with 430 grams of mass. The vacuum process is repeated after the R32 refrigerant data collection system has been completed.

III. RESULTS AND DISCUSSIONS

3.1 Cooling Capacity

The cooling capacity of R32 is compared to that of R290 in Figure 2. The cooling capacity of an air conditioner is a measurement of its ability to dissipate heat. The greater the cooling capability, the sooner the room temperature rises to the required level. R290 has a lower cooling capacity than R32 due to a decrease in compression work (Figure 2).

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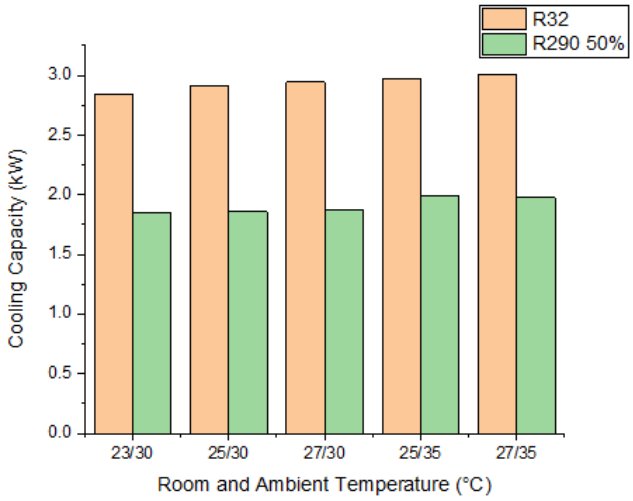

Figure 2: Cooling capacity

3.2 Power Consumption

Figure 3 shows that the power consumption of the R290 refrigerant compressor is lower than that of the R32 refrigerant compressor at all room and environmental temperatures. This is because R290 has a lower mass than R32. Because the compressor's work becomes lighter, less power is required.

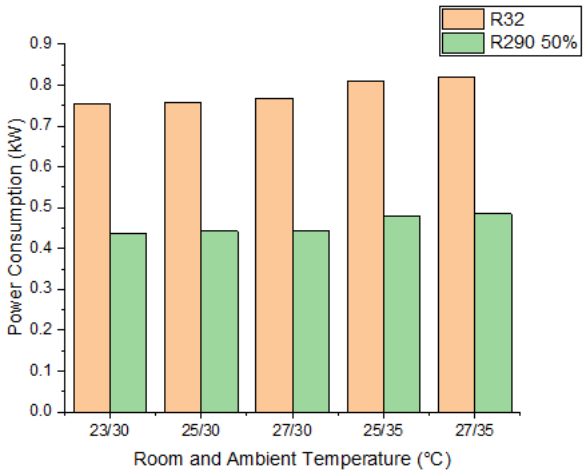

Figure 3: Power consumption

3.3 Coefficient of Performance

Figure 4 depicts the performance coefficients of the refrigerants R32 and R290. The diagram shows a drop in COP. Overall, the results show that the COP of refrigerant R290 is lower than the COP of R290 for all room and environmental temperature conditions. The cooling capability and power consumption of R32, which is greater than that of R290, have an impact on the COP value of each refrigerant used.

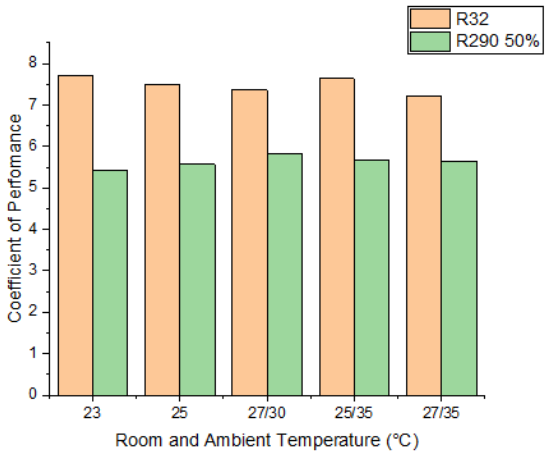

Figure 4: Coefficient of performance

IV. CONCLUSION

According to the findings of this study, the use of refrigerant R290 retrofitted R32 with a mass of 50% and variations in room temperature and ambient temperature resulted in a 40.24%decrease in power consumption from R290 to R32. The cooling capacity of R290 is 34.33% lower than that of R32 because the cooling capacity is lower, affecting the compressor's lower power consumption. The COP decreased by 29.79 % from R290 to R32. Overall, the performance of using R290 refrigerant to replace R32 refrigerant has not been optimized.

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