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Feasibility Study on One Shot Vapor Compression Systems for Gas Storage Applications Using R-32 in Residential Air Conditioning

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Abstract: This study investigates the technical feasibility and environmental sustainability of R-32 refrigerant in one-shot vapor compression gas storage medium in residential air conditioning systems. R-32 stands out for its low global warming potential (GWP 675), zero ozone depletion potential, and higher energy efficiency compared to traditional refrigerants such as R-410A, making it a leading choice for eco-friendly HVAC applications. The research highlights that, while R-32 enables improved heat transfer and reduced refrigerant charge, its elevated discharge temperatures-reaching up to 30°C-pose operational challenges that demand advanced compressor innovations, such as liquid injection, to ensure system reliability and longevity. Experimental results from cold storage scenarios demonstrate that R-32 systems can achieve evaporator temperatures between 28°C and 31°C under hybrid energy conditions, indicating adaptability to typical residential cooling requirements. The findings underscore the importance of integrating robust data logging and compressor technology advancements to fully leverage R-32's benefits while addressing its thermodynamic challenges. Overall, the study supports R-32 as a technically viable and sustainable solution for modern residential air conditioning, provided that system design prioritizes both performance monitoring and compressor reliability.

Keywords: R-32; HVAC; Energy Storage System

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1. Introduction

Difluoromethane (CH_2F_2), commonly known as Refrigerant R-32, is a modern refrigerant increasingly used in cooling and HVAC systems due to its superior energy efficiency and lower environmental impact compared to older refrigerants such as R-410A and R-22.[1].

The research aims to demonstrate the feasibility of an air conditioning system using refrigerant type R-32 by deactivating the compressor element. Generally, the compressor is a vital component in an air conditioning system and is often the most frequently damaged part due to its critical role in reliable operation [2].Using R-32 refrigerant, which is known for its high latent heat and excellent heat transfer capabilities [3], can improve cooling efficiency and reduce energy consumption compared to older refrigerants. R-32 also has a lower global warming potential and zero ozone depletion potential, making it environmentally friendlier than refrigerants like R-410A or R-22[4].

Since the compressor is responsible for compressing and circulating the refrigerant to maintain the cooling cycle, disabling it challenges the conventional operation of the AC system. This study explores whether the system can maintain acceptable performance without the compressor active, leveraging the efficient thermodynamic properties of R-32. In summary, the research investigates the innovative approach of operating an R-32-based air conditioning system without compressor activation, which could potentially reduce mechanical failures and energy consumption [5], given the compressor's usual role as the most failure-prone and energy-intensive component in AC systems [6]

2. Materials and Experiment Methods

The method used in this research consists of observation and experimentation. The experimental setup includes one storage tank, a ¾ PK air conditioning unit with indoor and outdoor elements, manual valves, and pressure gauges to measure pressure. To record temperature data when the compressor is not operating, a MAX6675 sensor is employed as the measuring indicator, connected to a 1.25-meter Type K thermocouple as the measurement medium [7]. The temperature data is displayed via serial monitor on Arduino IDE software version 2.2.1.

This approach allows precise monitoring of temperature changes in the system during compressor inactivity, enabling analysis of system performance under these conditions. The combination of pressure measurement and temperature sensing provides comprehensive data to evaluate the feasibility of operating an R-32 refrigerant air conditioning system without compressor activation.

3. Results and Discussion

This study analyzes the system’s condition using two methods:

- **Conventional Method**
  Operating the air conditioning system normally with the compressor active to compress and circulate the refrigerant, as in a standard AC setup.
- **Compressor-Off Method**
  Deactivating the compressor and utilizing the refrigerant stored in a storage tank, which contains compressed Freon accumulated during the system’s normal operation.

Temperature changes within the air conditioning system are recorded at 5-second intervals to monitor and compare the performance between these two operational modes.

This dual-method approach allows for a comprehensive evaluation of the system’s behavior both under typical compressor-driven conditions and during compressor inactivity, providing insights into the feasibility of maintaining cooling performance using stored refrigerant alone.

3.1. Materials Use

These materials and instruments enabled direct observation of the refrigeration system's condition under two operational methods: the conventional compressor-driven method and the compressor-off method utilizing stored refrigerant in the tank.

- Compressor
- Condeser
- Evaporator

Mechanical refrigerations part lists look such as:

- Gas storage
- Pressure gauge
- Valve
- Pipe
- Tee and Nepple

3.2. Data Record Method

Using the MAX6675 sensor in combination with an Arduino Uno board and a Type K thermocouple [8], the temperature measurement system operates as follows based on research setup below:

MAX6675 Sensor	The MAX6675 module interfaces with the Arduino Uno via SPI communication, requiring three main signal connections: Serial Clock (SCK), Chip Select (CS), and Serial Out (SO). Typical pin connections are SCK to Arduino pin 8, CS to pin 9, and SO to pin 10, along with power (3.3V or 5V) and ground connections.[9]
Type K thermocouple	Connected to the MAX6675, measures temperature by generating a voltage proportional to the temperature difference, which the MAX6675 converts into a digital temperature reading
Arduino Uno	The Arduino Uno reads the digital temperature data from the MAX6675 module using a dedicated library (such as the Adafruit MAX6675 library), which simplifies communication and data retrieval. Temperature data is sampled at regular intervals (e.g., every 5 seconds as in this research) and transmitted to the Arduino IDE serial monitor for real-time monitoring and recording

3.2.1 Data Record Code for Serial Reading

```
#include <Thermocouple.h>
#include <MAX6675_Thermocouple.h>

#define SCK_PIN 8
#define CS_PIN 9
#define SO_PIN 10

Thermocouple* thermocouple;

// the setup function runs once when you press reset or power the board
void setup() {
  Serial.begin(9600);

  thermocouple = new MAX6675_Thermocouple(SCK_PIN, CS_PIN, SO_PIN);
}

// the loop function runs over and over again forever
void loop() {
  // Reads temperature
  const double celsius = thermocouple->readCelsius();
  const double kelvin = thermocouple->readKelvin();
  const double fahrenheit = thermocouple->readFahrenheit();

  // Output of information
  Serial.print("Temperature: ");
  Serial.print(celsius);
  Serial.print(" C, ");
  Serial.print(kelvin);
  Serial.print(" K, ");
  Serial.print(fahrenheit);
  Serial.println(" F");

  delay(500); // optionally, only to delay the output of information in the example.
}
```

3.3 Schemes

Operate the AC system normally with the compressor active. Record temperature and pressure data at 5-second intervals throughout the testing period to establish baseline system performance.

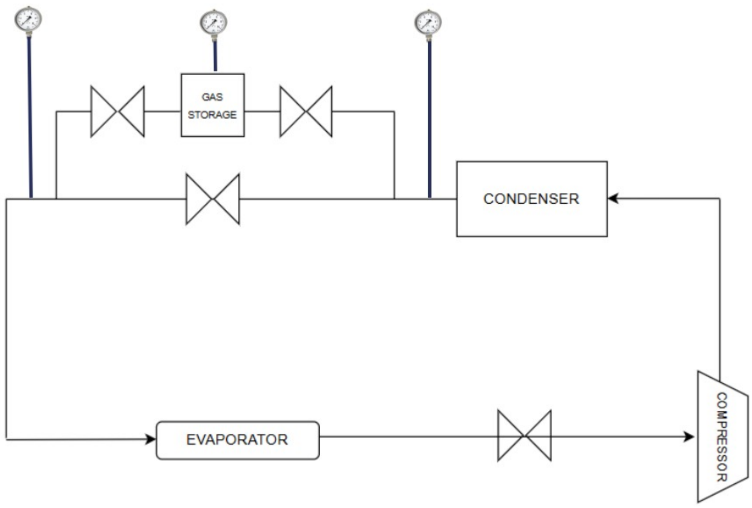


Figure 1. Ilustrasion of First Method

In this scheme, the refrigerant system operates according to its intended function. However, an additional component is introduced: a storage tank. Normally, the refrigerant flows directly from the condenser to the evaporator, but in this setup, a portion of the refrigerant is routed through the storage tank. This allows the refrigerant to be utilized during the switching to the second method, where the compressor is inactive.

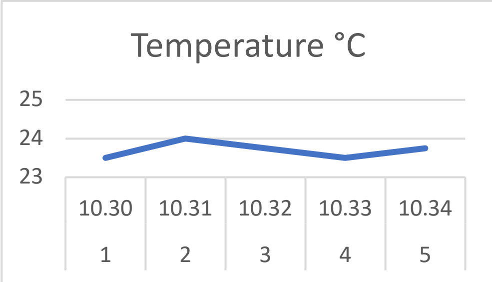
Table 1. This is a table of 5 second data collect from first method

No.	**Time**	**Temperature** °C
1	10.30	23,5
2	10.31	24
3	10.32	23,75
4	10.33	23,50
5	10.34	23,75

The data presented in Table 1 were recorded at 5-second intervals as the average of the experiments, with the air conditioning temperature set to 20°C.

Table 2. This is a table of 5 second data collect from second method

No.	**Time**	**Temperature** °C
1	10.48	28,25
2	10.49	28,25
3	10.50	28,5
4	10.51	30,25



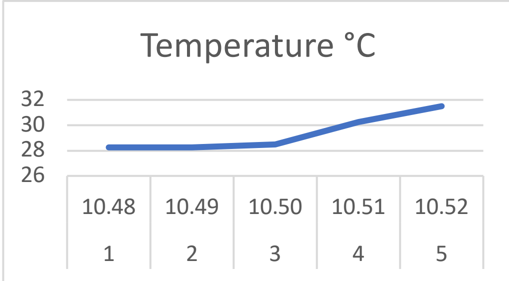


Figure 1 : With active compressor

Figure 2 : Using freon from storage tank

5	10.52	31,5

Table 2 was recorded 5 second as same with table 1, the data shown that without using the compressor, the temperature cannot be stabilized.

The data shown in Figure 2, which corresponds to the scheme without the compressor as the main component, indicate that the temperature remains stable only during the first 2 seconds. After this initial period, the temperature continuously rises significantly.

In contrast, with the method using the compressor, the data show stable temperatures maintained below 24 degrees Celsius.

4. Conclusions

This study investigated the performance of an air conditioning system using R-32 refrigerant under two operational methods: with the compressor active and without using compressor (the compressor deactivated while utilizing stored refrigerant in a storage tank). The experimental data shows that when the compressor was turned off, the system was unable to maintain a stable temperature, with temperature rising significantly after an initial short period of stability. Conversely, when the compressor are were operated, the system maintained a stable temperature below 24°C, indicating effective cooling performance.

These results confirm the critical role of the compressor in sustaining the refrigeration cycle and ensuring consistent cooling. While the concept of using stored refrigerant without compressor activity presents an interesting approach, it proved insufficient to maintain desired temperature stability in this study. Therefore, the compressor remains an essential component for reliable and efficient air conditioning operation.

Future research could explore alternative methods to enhance cooling performance without continuous compressor operation, potentially improving energy efficiency and reducing mechanical wear[10], [11].

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