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### Experimental Study on Performance of Condenser of Two Different Types Used in Window Air Conditioner

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#### Abstract

In this study, two heat exchangers were used as condensers in the same air-conditioning system, one with round tubes and the other with flat micro channel tubes. The window air conditioning systems was designed for R-22 and its alternative R-410A, with the micro channel and round tube condensers were constructed and investigated between the atmospheric temperatures 35°C to 41°C. This work presents the difference measured in the performance for both condensers. The performance of the air conditioner with R-410A was compared with the baseline performance with R-22. The COP of micro channel condenser with R-22 is 4.52% and with R-410A is 11.3% higher than the round tube condenser. For R-22, the heat transfer in the round tube condenser is 0.75% and for R-410A is 2.39% higher than the micro channel condenser

**Keywords:** Window Air Conditioner, micro channel, Refrigerant, R-410A, and COP

#### Introduction

The condenser is a heat exchanger that usually rejects all the heat from the refrigeration system. This includes not only the heat absorbed by the evaporator but also the energy input to the compressor. The condenser accept hot, high - pressure refrigerant, usually a super heated gas, from the compressor and reject heat from the gas to some cooler substance, usually air or water. As energy is removed from the gas it condenses and this condensate is drained so that it may continue its path back through the expansion valve or capillary to the evaporator. The condenser is usually made of copper or steel tubing with fins attached which increase the effective area of heat dissipation surface, for domestic use the condenser is usually air cooled by natural or forced convection using motor driven fan to force air over the condensing tubing and to increase the cooling effects on the condenser. In the condenser, three zones, corresponding to refrigerant desuperheating, condensation and Sub cooling are considered. In the superheating zone the surface temperature is above the saturation temperature so there is no condensation in this region. Hrnjak [1] studied the effects of different type of condensers on the performance of R410A for the residential air conditioning systems. Two R-410A residential air-conditioning systems, one with a micro channel condenser and the other with a round-tube condenser, were experimentally

examined, while the other components of the two systems were identical except the condensers. The COP of the system with the micro channel condenser was 13.1% higher than that with the round condenser. Haiyan Zhang[2] found that the performance of the LSC system having the greatest cooling capacity and energy efficiency ratio (EER) was then compared with that of the system having a baseline fin-and-tube condenser for various ambient temperatures from 29 °C to 43 °C. The results showed that both the Cooling capacity and EER of the two systems were almost the same, with the LSC having just 67% of the heat transfer area of the baseline condenser.

Two heat exchangers were used as condensers in the same air-conditioning system, one with round tubes and the other with flat micro channel tubes in a parallel-flow arrangement. The differences were recorded and are explained here in. The micro channel heat exchanger was made to have nearly an identical face area, depth and consequently volume, plus the same fin density as the baseline, round tube heat exchanger with plate fins. In this study, the window air conditioning systems using the micro channel and round tube condensers will be constructed and investigated by varying the condenser air inlet temperatures between 35°C and 41°C. The test results (condenser heat rejection rate, mass flow

rate, and COP) of the micro channel condenser system will be compared with that of the round tube condenser system.

**Experimental setup**

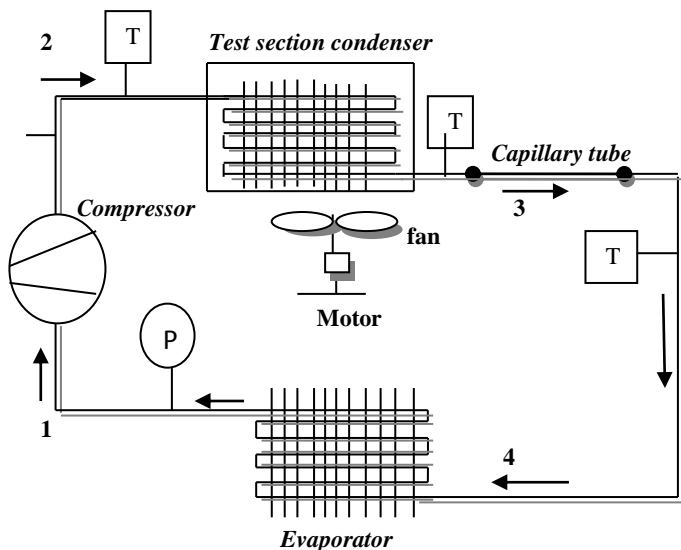
A window air conditioner of 1 ton refrigeration capacity is composed of the basic components of a vapour compression system: a reciprocating compressor, a condenser, a capillary tube and an evaporator, and such attachments as accumulator and fan. In this experiment a window air conditioner was selected for testing the performance of two different types of condenser. Two heat exchangers were used as condensers in the same air-conditioning system, one with round tubes and the other with flat micro channel tubes. The overall physical dimensions of the window air conditioning system are (60 × 56 × 38) cm and 42 kg weight. The unit was retrofitted with refrigerant R-410A. In order to have a uniform temperature throughout the room, a ceiling fan of 70 watts power installed in the centre of the room was used to circulate the air inside the room. The evaporator and condenser of the refrigeration unit were finned-plate air heat exchangers. Both evaporator and condenser fins were made of aluminum. The air conditioner accommodates a three speed motor to run the condenser fan. The straight capillary tube used as an expansion device. The temperature was measured by a digital temperature meter with a maximum uncertainty of ±0.5°C temperature meter were placed at the inlet and outlet of the capillary tube, evaporator and condenser. The temperature meter bulb was taped tightly with foam at the outer surface of the tubes. The experimental air-conditioner is shown in Fig. 1.1

*Table 1 Specification Of Air Conditioner Test Unit*

Compressor	Reciprocating
Condenser	1. Round -tube 2. Micro channel
Evaporator	Fin -and - tube
Fan motor	1/10 hp 1050 rpm
Capillary tube	Straight capillary tube
Refrigerant	R-22 (HCFC) R-410A (HFC)

**Selection of condenser**

It is widely known that micro channel heat exchangers have an advantage over RTPF (Round Tubes and Plate Fins) heat exchangers in compactness. The micro channel and round tube condensers were selected with the conditions to have the same fin area and volume. The detail characteristics of both condensers are shown in Table. 2. The photographs of micro channel and round tube condensers, illustrated in Fig. 2 (a) and (b).



*Figure 1.1 Layout of the Experimental Setup*



*Fig 2 (A) Micro Channel Condenser*



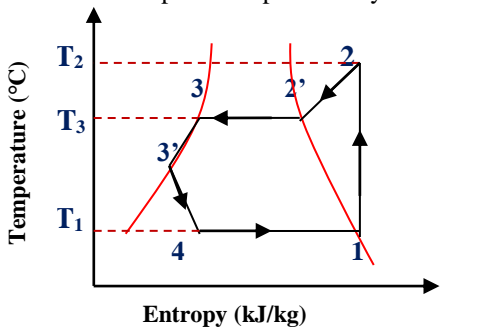
*Fig 2 (B) Round Tube Condenser*

Table 2 Specification Of condenser

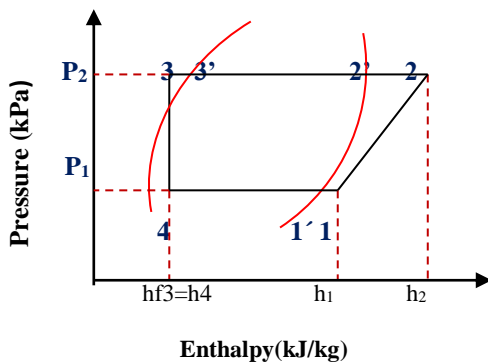
	Micro channel condenser	Round tube condenser
Fin density (fins/cm)	6	7
Tube material	Aluminum	Copper
Fin type	Louver fin	Offset strip
Fin material	Aluminum	Aluminum
Size (Inch)	14"×21"	22"×16"
No. of tubes	40	30

**Test description**

At the incipience of the test, the system was kept running at least 45 minutes to reach the steady state conditions. This was done by monitoring the temperature and pressure gauge for the circulated refrigerant. After that achievement, the refrigerant side measurements, temperature and pressure, and air side measurements, dry bulb temperature, were recorded. These readings were taken at ambient temperature i.e., 35 °C DBT to detect the performance of the window air conditioner. This procedure was repeated for the refrigerants R-22 and R-410A. Fig 3 shows the theoretical vapour compression cycle of the refrigerant.



(a) T-s diagram



(b) p-h diagram

Fig 3: Theoretical vapour Compression Cycle of the refrigerant

**Performance Parameters Analysis:**

The data reduction of the theoretical results can be analyzed below.

**Refrigeration Effect:**

$$R_E = (h_1 - h_4) \text{ kJ/kg}$$

Where  $h_1$  and  $h_4$  are the specific enthalpies (kJ/kg) at the exit and inlet to the evaporator, respectively.

**Refrigerant mass flow rate:**

The mass flow rate of refrigerant was measured by using this formula:

$$m_r = \frac{3.5}{R_E} \text{ kg/s}$$

**Compressor Work Done:**

The power input to the compressor,  $W_c$  is given by:

$$W_c = m_r (h_2 - h_1) \text{ kW}$$

Where  $h_2$  and  $h_1$  are the specific enthalpies (kJ/kg) at the exit and inlet to the compressor respectively.  $(h_2 - h_1)$  is known as specific work of compression or simply work of compression, which is equal to the work input to the compressor per kilogram of refrigerant.

**Heat Rejected In The Condenser:**

The heat rejected in the condenser,  $Q_c$  is given by:

$$Q_c = m_r (h_2 - h_{f3}) \text{ kW}$$

Where  $h_2$  and  $h_{f3}$  are the specific enthalpies (kJ/kg) at the inlet and exit to the condenser, respectively. For the isenthalpic expansion process,  $(h_{f3}=h_4)$ .

**Coefficient of Performance (COP):**

$$COP = \frac{(h_1 - h_4)}{(h_2 - h_1)}$$

**Results and discussion**

Fig 4 represents the influence of various outdoor temperatures on the heat rejected in the condenser for refrigerant R-22 and R410A. The outdoor temperature varied from 36°C to 40°C. This fig shows that the heat rejected in the condenser increases as outdoor temperature increases. The heat rejected in the micro channel condenser is lower than the round tubes. The heat rejected by micro channel condenser system with refrigerant R-410A is 11.6 % higher with refrigerant R-22. Similarly, round tube condenser with refrigerant R-410A is rejects heat 13.07% higher than with refrigerant R-22.

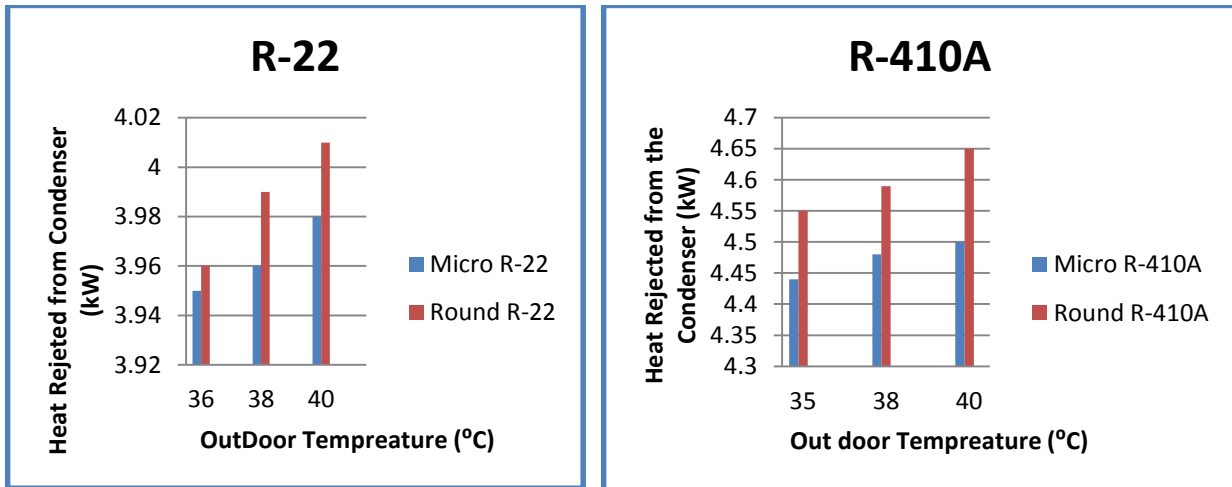


Fig 4: Variation of heat rejected in the condenser versus outdoor temperature for R-22 & R410A

Fig.5 shows the variation of the compressor power and the outdoor temperature of refrigerant R22 and R410A. From the fig.5 the outdoor temperature increases compressor power also increases. Increases in the outside temperature increased the load on the system which increased the compressor power. The

compressor work by micro channel condenser system with refrigerant R-410A is 52.2 % higher with refrigerant R-22. Similarly, compressor work by round tube condenser with refrigerant R-410A is 55.5 % higher than with refrigerant R-22. The compressor power with R-410A is higher than those with R-22.

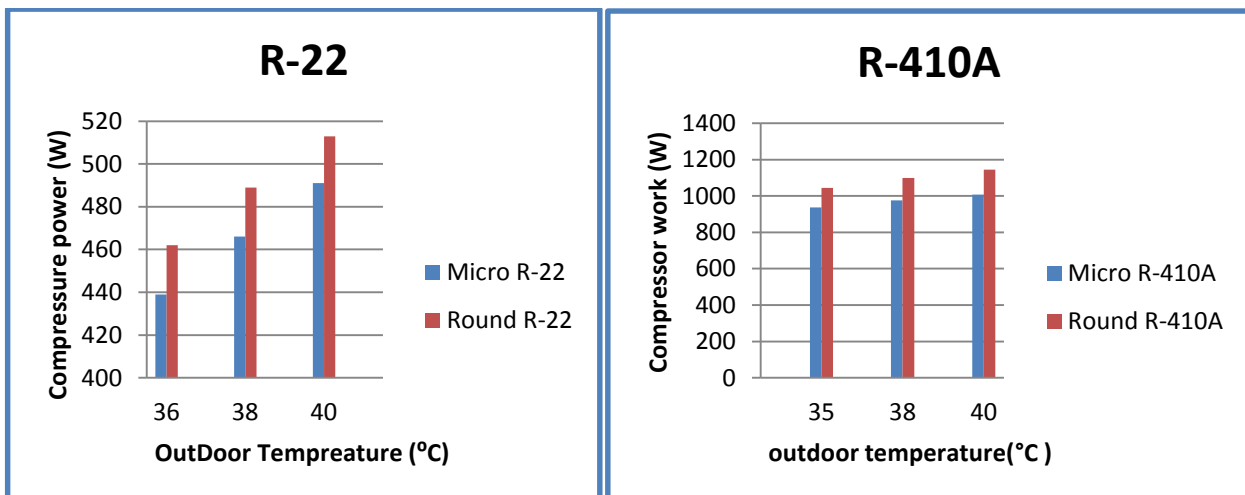


Fig. 5 : Variation of compressor power with outdoor temperature for R-22 & R410A

Fig 6 represents the influence of various outdoor temperatures on the mass flow rate of refrigerant R-22 and R410A. The out door temperature varied from 36°C to 40°C. The mass flow rate of micro channel condenser is lower than the round tube condenser. The

mass flow rate of micro channel condenser system with refrigerant R-410A is 0.94 % higher with refrigerant R-22. Similarly, the mass flow rate of round tube condenser with refrigerant R-410A is 0.91 % higher than with refrigerant R-22.

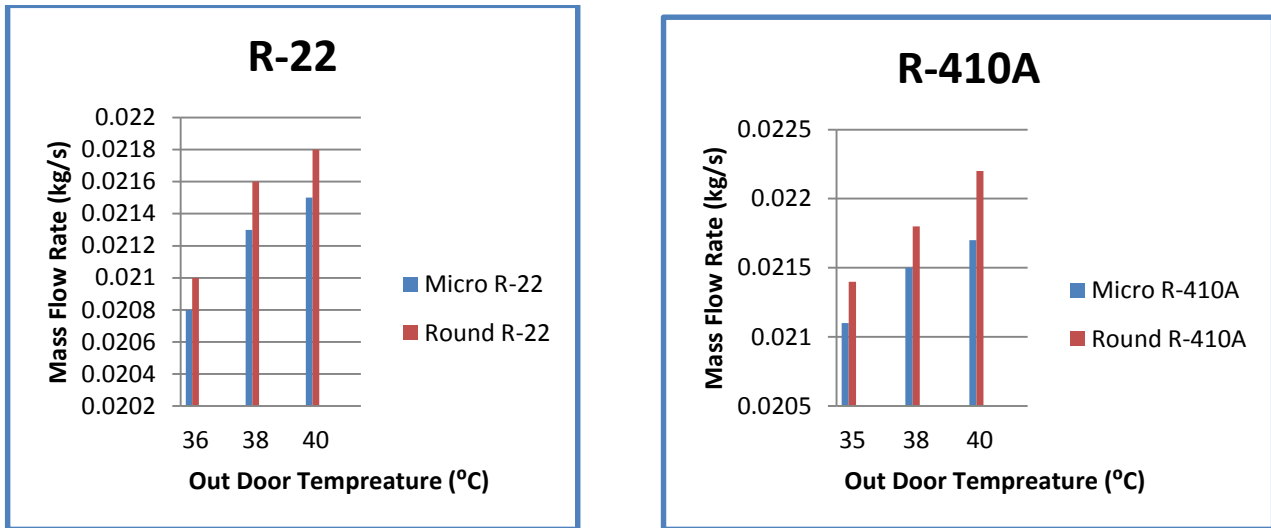


Fig. 6: Variation of mass flow rate versus outdoor temperature for R-22 & R-410A

Fig.7 shows the variation of COP with varying outdoor temperature for the investigated refrigerants R-22 and R410A. The COP of the micro channel condenser with refrigerant R-22 is 4.52% higher than the Round tube condenser

system at 38°C outdoor temperature. The COP of the micro channel condenser with refrigerant R-410A is 11.67% higher than the Round tube condenser system at 38°C outdoor temperature.

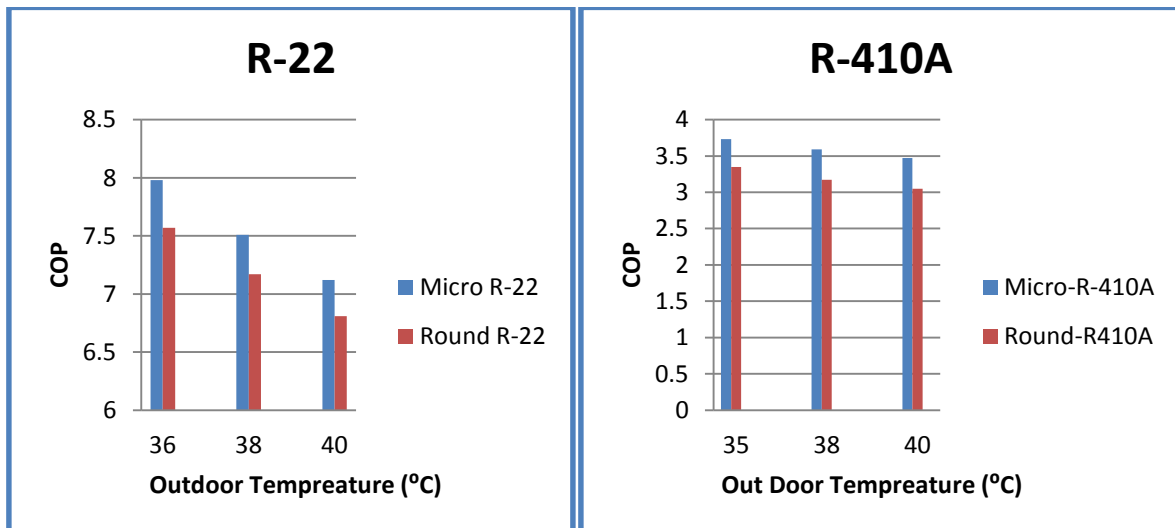


Fig.7: Variation of COP versus outdoor temperature for R-22 & R410A

**Conclusions**

In this study, air conditioning systems with a micro channel condenser and a round tube condenser were experimentally examined. From this study to evaluate the influences of condenser on ITR

window air conditioner with refrigerant R-22 and R-410A, the following conclusions are drawn:

- a) For both types of condenser systems (micro channel and a round tube condenser), the COPs decrease with increasing outdoor temperatures. While

the heat rejected in the condenser, compressor power and mass flow rates increase with increasing outdoor temperatures.

- b) The mass flow rate, heat rejected in the condenser and the compressor power of the system with micro channel condenser is lower than the system with the round tube condenser.
- c) The COPs of the system with micro channel condenser is higher than the system with the round tube condenser.
- d) The pressure for the system with the micro channel condenser was 4.5% smaller than that with the round-tube condenser.

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