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### Experimental study on performance of condenser of two different types used in window air conditioner

Madhu Jhariya<sup>1\*</sup>, P.K.Jhinge and R.C. Gupta<sup>2</sup>

<sup>1</sup>Jabalpur Engineering College, Jabalpur-482011, MP, India

<sup>2</sup>Department of Mechanical Engineering, Jabalpur Engineering College, Jabalpur-482011, MP, India

\*Corresponding author

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COP; and  
Cooling Capacity

#### A B S T R A C T

This research paper presents the experimental performance of a window air conditioner with two different types of condensers, single channel and multi channel condenser. The air-conditioner is a 1 TR unit designed for R-22. The performance of the air-conditioner with R-410A is compared with the baseline performance with R-22. The performance parameters considered are cooling capacity, coefficient of performance, energy consumption, and compressor work done. Test results shows that for R-22 the COP of multi channel condenser is 6.6% efficient than the single channel condenser. The cooling capacity of multi channel condenser is 38.4 % higher than the single channel condenser.

### 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.

Chang Yong Park and Pega Hrnjak (2008) 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. Xueqing Chen et al., (2013) 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.

Lee et al., (2002) shows the test results of a fin and tube condenser was performed using two different configurations of condenser paths (U and Z type) and two kinds of refrigerants (R-22 and R-407C) as working fluids. R-22 performed better than R-407C for the Z-type path configuration, but no significant difference was found between results using either refrigerant in the U-type path configuration. On average, the numerical results obtained with R-22 were 10.1% greater than experiment data; using R-407C, results were 10.7% less than experiment data.

Two heat exchangers were used as condensers in the same air-conditioning system, one with flat single channel tubes and the other with round multi channel tubes in a parallel-flow arrangement. The differences were recorded and are explained here in. This paper presents the difference measured in the performance for both condensers only as well as the effects on the system. The multi channel heat exchanger was made to have nearly an identical face area, depth and consequently volume, plus the same fin density as the baseline, single channel heat exchanger with plate fins.

The window air conditioning systems are widely used in houses, little offices and buildings for cooling the occupants in the building. Normally, the heat exchangers of the window air conditioning system are fin and tube heat exchangers. While, a multi channel heat exchanger is widely used in the automotive air conditioning system. The enhanced performance and efficiency improvement of multi channel technology were the results of higher air-side heat transfer, higher refrigerant side heat transfer, and high fin-to-tube surface contact.

In this study, the window air conditioning systems using the single channel and multi channel condensers will be constructed and investigated by varying the condenser air inlet temperatures between 35°C and 41°C. The test results (cooling capacity, condenser heat rejection rate, mass flow rate, and energy efficiency ratio) of the single condenser system will be compared with that of the multi channel condenser system.

### **Experimental setup**

A window air conditioner of 1 ton refrigeration capacity was selected for testing. The overall physical dimensions of the window air conditioning system are (60 X 56 X 38) cm and 42 kg weight. The unit is having single electricity phase reciprocating compressor. The condenser and evaporator coils are made of copper with smooth inner tube surface. The interrupted type of fin used in the experiment is very widely accepted method of increasing the heat transfer coefficient and creating more turbulent mixing on the air side of heat exchangers. Both evaporator and condenser fins were made of aluminums. The window air conditioner utilizes refrigerant R-22 and mineral lubricating oil. In order to provide superior lubrication with chlorine refrigerants poly ester lubricants were used. The air conditioner accommodates a three speed motor to run the condenser and evaporator fans.

### **Selection of the Refrigerant**

The new trend is to use zeotrope blend refrigerants in the air conditioning system. In the present experiment, two zeotrope blend refrigerants are selected as alternative refrigerants for R-22 in the window air conditioner test rig. These refrigerants are R-410A comprising of (R32/R125) in a mass fraction composition percentage as (50/50).

### **Refrigerant Charging**

The refrigerant may be charged in a liquid or vapour modes. This is limited by operating factors, such as the amount of refrigerant and time of charging. Charging a refrigeration system, especially the one built-up with capillary tube control, is the

most critical task. Amount of refrigerant to be charged is so selected that it maintains desired suction & discharge pressures. It is customary to charge the system with a charging cylinder on volume basis but the short-coming of this method is that since the density of refrigerant varies appreciably with temperature, one can come across erroneous quantity as the charging cylinder does not have different scales for different ambient temperatures. A better alternative method is to charge the refrigerant by weight. Charging without the aid of any equipment requires a high level of skill and human judgment. Sometimes charging is done without the aid of any equipments, this system uses suction pressure and discharge pressure as indicative of the charge quantity. However, this needs a high level of skill and human judgment.

### **Selection of condenser**

The multi channel and single channel condensers were selected with the conditions to have the same fin area and volume. The criteria on the air side were imposed in order to evaluate the effect of the refrigerant tube size on the heat transfer rate and effectiveness of the condenser. The detail characteristics of both condensers are shown in Table. 1. The condenser was constructed of multi channel aluminum tubes having two rows of horizontally aligned serpentine condensers in series. The single condenser had two parallel circuits and 32 passes per circuit. The photographs of single channel and multi channel condensers, illustrated in Fig. 1 (a) and (b).

The following assumptions were used in the testing single and multi channel condensers: (a) Ambient temperature was 35° & 40°C; (b) Refrigerant system pressure of both systems was equal; (c) Refrigerant charge of multi channel

condenser system was less than that of single channel system.

### **Test Description**

At the incipience of the test, the system was kept running at least 10 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.

The data reduction procedure includes the refrigerating effect, power consumed by compressor, heat rejected in the condenser, energy efficiency ratio calculated for both R-22 and its alternatives R-410A. In addition, (COP) was calculated from the above mentioned parameters. The properties of R-22 and other refrigerants were obtained from the published data by ASHRAE Hand Book.

### **Result and Discussion**

Table (2) and (3) gives the various measured system parameters for different test conditions.

#### **Cooling Capacity**

While testing the alternative refrigerants, the cooling capacity is an important parameter. If the cooling does not match with the base line data, and then the compressor has to be redesigned. Therefore, if an alternative Refrigerant gives closer cooling capacity then only it can be considered for retrofitting. Figure 1 shows the variation of cooling capacity for

both single and multi channel condenser for a range of outdoor conditions. R-22 gave a cooling capacity of 1.70 kw for the single channel and 2.76 kw for the multi channel condenser. Test results Show that R-410A had 4.5% cooling capacity for the single channel condenser and 2.17% higher for the multi channel condenser with respect to R-22.

#### **Coefficient of Performance**

Figure 2 shows the variation of COP for both R-22 and R-410A for range of outdoor conditions. COP for R-22 was 2.57 for the single channel and 1.84 is for the multi channel condenser. For R-410A, for the higher outdoor conditions, the COP is higher than R-22.

#### **Energy Consumption**

Figure 3 shows that the energy consumed by the system with R-410A is higher, for all the outdoor conditions, than R-22. The power consumed by the system with R-22 is in the range 3.05 to 3.36 KW. The power consumed with R-410A is lower by 12.2 to 16%. . There may be potential to improve the performance with some optimization.

#### **Mass flow rate**

Figure 4 shows the mass flow rate of R-410A and R-22 for a range of outdoor conditions. The mass flow rate of R-22 is 0.0259 kg/sec for the single channel and 0.0269 for the multi channel condenser. The mass flow rate of R-22 for multi channel is 9% higher than R-410A and for single channel condenser is 11% higher than R-410A.

#### **Operation at Maximum Operating Conditions**

It was observed that during the entire test, the window A/C was working without any

**Table.1** Detail characteristics of both condensers

Particulars	Single channel condenser	Multi channel condenser
Fin density (fins/cm)	6	7
Tube material	Aluminium	copper
Fin type	Louver fin	Offset strip
Pass	1 row	2 rows
No. of tubes	30	40

**Table.2** Performance Result of Refrigerant R-22

S/ no	Condenser type	Ambient temp (°C)	Cooling capacity (kw)	Refrigerant mass flow rate (kg/s)	Heat rejected in the condenser (kw)	Compressor work (W)	EER	COP
1	Single channel	37°C	1.86	0.0253	3.83	336	2.01	10.39
		39°C	1.70	0.0259	3.81	327	1.83	10.60
		40°C	1.59	0.0265	3.82	328	1.72	10.65
		38°C	2.06	0.0253	3.77	322	3.11	10.86
2	Multi channel	39°C	2.76	0.0269	3.79	326	2.94	11.36
		41°C	2.62	0.0266	3.80	305	2.83	11.42

**Figure.1** The photographs of single channel and multi channel condensers



**Fig. 1(a)**

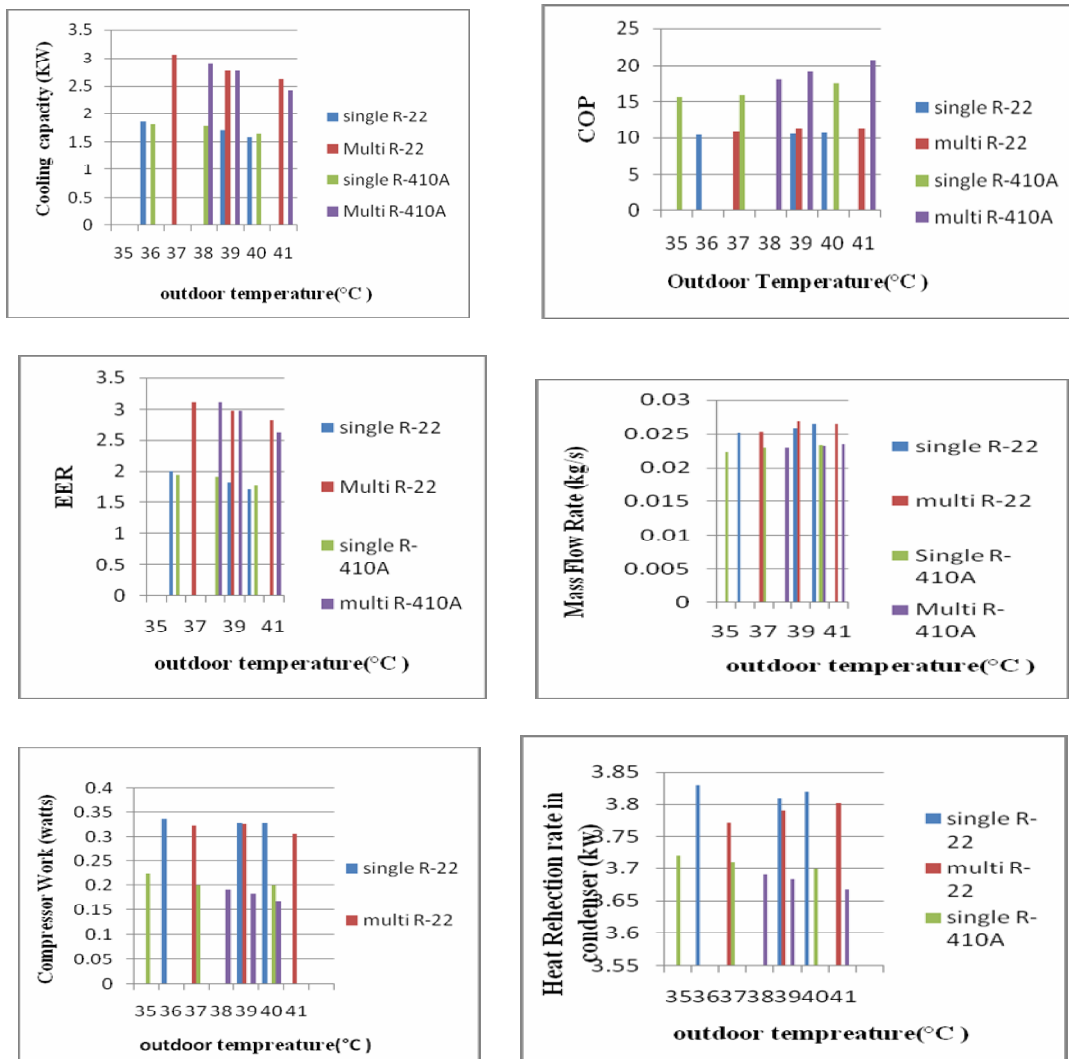


**Fig. 1(b)**

**Table.3** Performance Result of Refrigerant R-410A

S. no	Condenser type	Ambient temp (°C)	Cooling capacity (kw)	Refrigerant mass flow rate (kg/s)	Heat rejected in the condenser (kw)	Compressor work (W)	EER	COP
1	Single channel	36°C	1.81	0.0223	3.72	223	1.95	15.65
		38°C	1.78	0.0230	3.71	220	1.92	15.89
		40°C	1.65	0.0233	3.67	200	1.78	17.45
		38°C	2.88	0.0230	3.69	193	3.11	18.10
2	Multi channel	39°C	2.76	0.0232	3.68	183	2.98	19.08
		41°C	2.43	0.0234	3.66	168	2.62	20.74

**Figure.2** various parameters on Outdoor temperatures



visible and audible damage and without tripping with both R-22 and R-410A. After a shut down period for 3 minutes, the A/C started again and remained in operation for the next one hour without tripping for both R-22 and R-410A.

### **Conclusions**

From the experimental study to evaluate the influences of condenser on 1TR window air conditioner with refrigerant R-22 and R-410A, the following conclusions are drawn:

- a) For single channel condenser, the cooling capacities, condenser heat transfer rates and EERs decrease with increasing outdoor temperatures.
- b) The same trends are for the system with multi channel condenser, the COPs and mass flow rates increase with increasing outdoor temperatures.
- c) The coefficient of performance of multi channel condenser is 7.1% efficient than the single channel condenser.

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