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Experimental analysis on window air conditioner with R22 and R407c refrigerants

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Abstract:- This project is about the study of two different types of refrigerants in window air conditioning. The air conditioning industry is currently evaluating alternative refrigerants for R-22. A window-type air conditioning system is selected for the tests conducted with two different types of refrigerants. These air conditioning units are spread widely in their applications and are circulating R-22 as a refrigerant. Finding an alternative refrigerant for replacing R-22 is becoming a practical problem because general use of hydro chlorofluorocarbons (HCFCs) including R-22 is promised to be banned by 2020 as per the Montreal Protocol. In this project we use R22 and R407c (mixture of R-32/125/134a) in same system without changing anything like lubricating oil or any other component like compressor, condenser, tubes etc. and compare the performance of both. we also do water cooling of air conditioner using both refrigerants. To their better thermal properties and acceptable pressure and temperature ranges. The alternate refrigerants to be used in the project have very less ozone depletion potential (ODP) and global warming potential (GWP). The performance of each refrigerant has been found individually and the results were used to evaluate and compare the following performance criteria: cooling capacity, Energy Efficiency Ratio and the coefficient of performance (COP).

Keywords:- Window type air conditioner, Refrigerant R-2, Refrigerant R407c, air cooling, water cooling.

I. INTRODUCTION

Refrigeration is the process of achieving and maintaining a temperature below that of the surroundings, the aim being to cool some product or space to the required temperature. Refrigeration systems are extensively used for providing thermal comfort to human beings by means of air conditioning. A great breakthrough occurred in the field of air-conditioning with the development of Freons. Freons are a series of fluorinated hydrocarbons, popularly known as fluorocarbons, derived from methane, ethane etc as bases. Since their development, chlorofluoro carbons (CFCs) were thought to be ideal Refrigerants.. The HVACR industry is facing two major environmental challenges today: stratospheric ozone depletion and global climate change. Stratosphere Ozone Depletion is believed to be caused by the release of certain manmade ozone depleting chemicals into the atmosphere. These are R-115; 500, 502, 505, 506, which are already banned R-161 which is highly toxic R-143a, 152a which are slightly flammable and R-22, 124, 125, 134 and 134a which are nonflammable. Investigation and Comparison of Chlorine Compounds Refrigerants and their Potential Substitutes Operating at high Ambient Temperature for the Replacement of R22.

II. EXPERIMENT ANALYSIS

A LG company window air conditioner of 1 ton refrigeration capacity was selected to be as a test rig. The overall physical dimensions of the window air conditioning system are (60 X 56 X 38) cm and 42 kg weight. Figure 2. shows the schematic diagram of the window air conditioner used in the experiment. The unit is having single electricity phase rotary compressor. The condenser and evaporator coils are made of copper with smooth inner tube surface. The evaporator fins are hydrophilic and Condenser fins are Hydrophobic. 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 compressor and condenser fins were made of alluminium. 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.

2.1 Selection of the Refrigerant

The new trend is to use zeotrope blend refrigerants in the air conditioning system. In the present experiment, one zeotrope blend refrigerant is selected to be tested as alternate refrigerant for R-22 in the window air conditioner test rig. These refrigerant is R-407C comprising of (R32/R125/R134a) in a mass fraction composition percentage as (23/25/52).

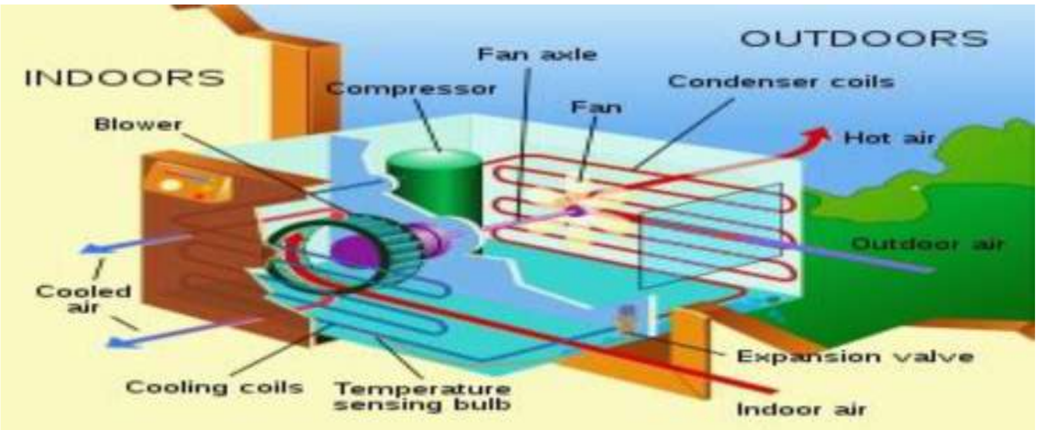


Figure - 1 Construction of a window air conditioner

It is commercially available have been assigned an indentifying number in the 400series. Zeotrope blends shift in composition during condensing process. As the blend changes phases, more of one component will transfer to the other phase faster than the rest. This property is called fractionation. The changing composition of the liquid from one side of the heat exchanger to the other is called the temperature glide. The temperature glide will cause different values for temperature at a given pressure, depending on how much refrigerant is liquid and how much is vapour. The alternate refrigerants used in the present work have very less ODP and GWP as compared to R-22.

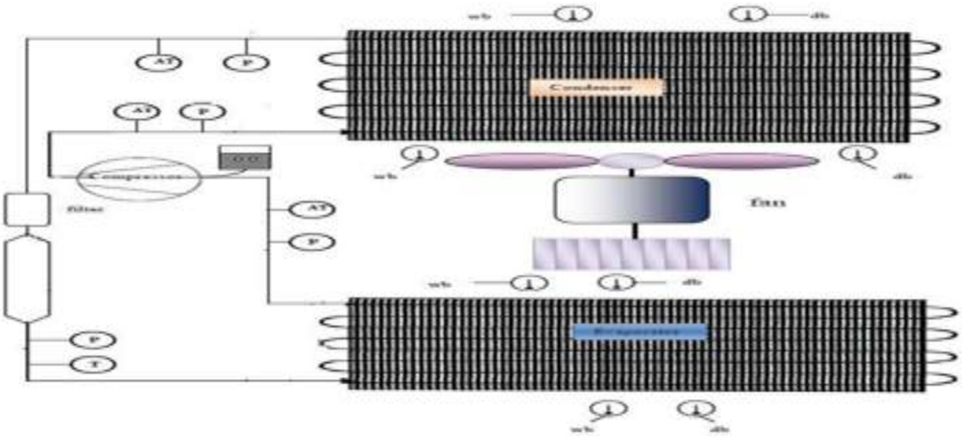


Figure - 2 Schematic diagram of the window air conditioner

2.2 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.

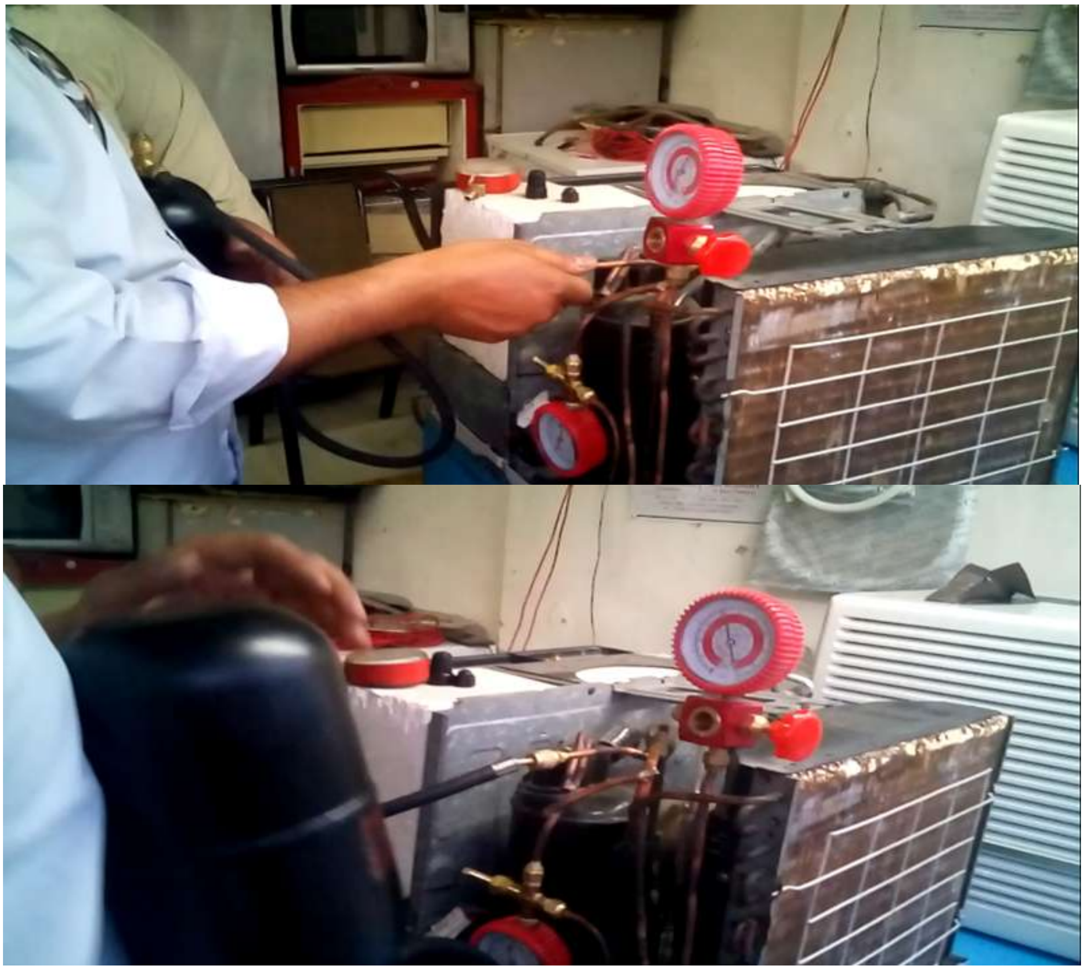


Figure - 3 Refrigerant charging (a) Refrigerant charging (b)

2.2.1 Experiment Analysis

1. First we undertook a window ac for carrying out our experiments. Then we had four temperature sensors for measuring changes in temperature and two pressure gauges measuring pressure changes during working. As shown in fig. At the incipience of the test, the system was kept running at least 10 to 20 minutes to reach the steady state conditions. This was done by monitoring the temperature and pressure gauge for the circulated refrigerant.
2. After getting the steady state condition the readings were taken forone hour on daily basis for 2 to 3 days.
3. After this same data was noted down while water cooling of condenser.
4. This procedure was repeated for the refrigerants R-407C.The tests were usually commenced at highest fan speed where the volumetric air flow rate fixed at (9.33) m3/min. as specified by the unit manufacturer company.

2.2.2 Calculations for COP

Here we calculated COP with two temperatures one is maximum temperature of system and second is lowest temperature of system. From that temperatures we can find the corresponding enthalpies from there saturation tables. From those enthalpies we can calculate the COP of system. Here some formulas which are used to do calculations.

H2, H3 and H4 is taken from table.

For H1,

Figure - 4 Window AC Apparatus (a) Temperature sensor (b) Pressure gauage (c) System in sunlight (d)

H1 = Hf + x (Hg – Hf)
Here Hf and Hg is taken from tables from corresponding temperatures.
x is the dryness fraction, which is calculated by formula as under
Sf1 + (Sg1 –Sf1) x = Sg2
Here Sf1 and Sg1 is entropies of lower temperature of system, which can be taken from table.
Sg2 is entropy of higher temperature of the system.
After calculating all the values of enthalpies we can easily calculate the COP of the system with given formula.
COP = H1 – H4 / H2 – H3
H1 – enthalpy of the refrigerant leaving the evaporator and entering the compressor
H2- Enthalpy of refrigerant leaving the compressor and entering the condenser
H3- Enthalpy of refrigerant leaving the condenser and entering the expansion valve
H4 – Enthalpy of the refrigerant leaving the expansion valve and entering the evaporator

2.2.3 Obsevation Table

	Refrigerant R22 (Air cooling)					
	Temperature				**Pressure**	
S.no	**T1**	**T2**	**T3**	**T4**	**P1**	**P2**
	27.5	89.3	48.2	13.6	270	260
	27.7	89.6	48.5	13.8	270	260
	28.1	89.8	48.6	14	270	260
	27.6	89.4	48.5	13.7	260	250
	27.9	89.7	48.6	13.9	270	260

	28	89.9	48.8	14	280	270
	28.4	90	49.1	14.3	280	270
	28.6	90.3	49.4	14.5	280	270
	28.3	90.1	49.2	14.2	280	270
	28.6	90.5	49.6	14.6	280	270
	27.6	89.4	48.3	13.6	260	250
	27.5	89.2	48.3	13.5	260	250
	27.8	89.6	48.5	13.5	260	250
	28.1	89.8	48.9	13.7	260	250
	28.4	90	49.2	14	270	260
	28.3	90.2	49.4	14.2	270	260
	28.5	90.4	49.5	14.5	280	270
	28.5	90.1	49.3	14.3	280	270
	28.3	90	49.1	14.1	270	260
	27.8	89.7	48.8	13.9	260	250
	28.6	90.2	49.3	14.5	280	270
	27.9	89.8	48.9	14	280	270
	28.2	90	49	14.1	280	270
	28.4	90.3	49.2	14.4	280	270
	28.7	90.5	49.4	14.7	280	270
	28.7	90.6	49.7	14.8	280	270
	28.4	90.4	49.5	14.5	280	270
	28.1	90.2	49.1	14.3	280	270
	28.3	90	48.9	14.1	270	260
	28	89.8	48.7	13.8	260	250
MEAN	**28.4**	**90.1**	**49.2**	**14**	**270**	**260**

Table 5.2.1 Refrigerant R22 (Air cooling)

	Refrigerant R22(Water cooling)					
	Temperature				**Pressure**	
S.No.	**T1**	**T2**	**T3**	**T4**	**P1**	**P2**
	25.5	79.4	44.2	11.6	240	230
	25.7	79.7	45.5	11.8	240	230
	25.7	79.8	45.6	11.8	240	230
	25.9	79.4	45.1	11.6	240	230
	26	79.7	45.3	11.9	245	235
	26.1	79.9	45.5	12	245	235
	26.4	80	45.7	12	245	235
	26.6	80.3	45.9	12.2	250	240
	26.3	80.1	45.7	12	250	240
	26.6	80.5	46	12.4	250	240
	25.6	79.2	45	11.4	240	230
	25.5	79.4	45.3	11.5	240	230
	25.7	79.6	45.5	11.5	240	230
	26	79.9	45.6	11.8	240	230
	26.2	80.1	45.8	12	250	240
	26.3	80.2	45.8	12.2	250	240
	26.5	80.4	45.7	12.5	250	240
	26.4	80.2	45.7	12.3	250	240
	26.5	80.5	45.9	12.6	250	240
	26.1	79.9	45.6	11.8	250	240
	26.4	80.3	46	12.5	250	240
	26.1	79.8	45.9	12	250	240
	26.1	80	45.7	12.1	250	240
	26.4	80.2	45.7	12.4	250	240

	26.5	80.4	45.9	12.3	250	240
	26.7	80.7	46.1	12.6	250	240
	26.4	80.5	46	12.6	250	240
	26.1	80.1	45.8	12.2	250	240
	26.3	79.8	45.5	11.9	250	240
	25.9	80	45.7	12.1	250	240
MEAN	26.1	80	45.6	12.1	250	240

Table 5.2.2 Refrigerant R22(Water cooling)

	Refrigerant 407c (air cooling)					
	Temperature				**Pressure**	
S.No.	**T1**	**T2**	**T3**	**T4**	**P1**	**P2**
	25.5	76.5	42.6	12	370	360
	25.6	76.8	42.3	11.9	370	360
	25.8	77	42.1	11.9	370	360
	26	77.4	41.9	11.7	370	360
	25.9	77.3	41.2	11.8	370	360
	25.7	77	40.9	11.5	370	360
	25.5	76.7	40.5	10.9	360	350
	25.6	77	41.1	11.6	365	355
	26	76.8	40.6	11.2	360	360
	25.7	76.5	40.8	11.4	365	355
	25	75.9	39.5	10.8	360	350
	24.8	75.6	39.1	10.4	360	350
	24.5	75.4	39	10.5	360	350
	24.7	75.8	39.5	10.7	360	350
	24.9	76	40	11.1	360	350
	25.2	76.3	40.1	11.1	360	350
	25.1	76.3	40.2	11	365	355
	25.3	76.5	40.6	11.3	365	355
	25.5	76.8	40.8	11.4	365	355
	25.4	76.6	40.5	11.2	365	355
	24.9	75.1	39	10.4	360	350
	25.2	76.4	40.3	10.8	360	350
	25.6	76.9	41.1	11.3	365	355
	25.4	76.5	40.8	10.9	365	355
	25.8	77	41.2	11.4	365	355
	26	77.3	41.5	11.6	370	360
	26.2	77.5	41.9	11.9	370	360
	25.7	76.8	41.7	11.6	370	360
	25.5	76.6	41.2	11.4	365	355
	25.3	76.4	40.9	11.1	365	355
MEAN	**25.4**	**77**	**40.2**	**11.8**	**365**	**355**

Table 5.2.3 Refrigerant 407c (air cooling)

	Refrigerant 407c (water cooling)					
	Temperature				**Pressure**	
S.No.	**T1**	**T2**	**T3**	**T4**	**P1**	**P2**
	25.8	71.2	35.7	9.8	330	320
	26	71.5	36	9.5	330	320
	26.1	71.7	36.1	9.7	320	310
	25.9	71.4	36	9.6	320	310
	26.2	71.8	36.3	9.8	310	300
	26.4	71.2	36.5	9.9	320	310

	26.2	71.9	36.2	9.6	320	310
	26.6	72.3	36.4	9.9	320	310
	26.5	72	36.2	9.7	330	320
	26.8	72.4	36.5	10	330	320
	26.2	71.4	35.5	10.4	340	330
	26.3	71.2	35.7	10.3	340	330
	26.5	71.5	35.8	10.5	330	320
	26.3	71.6	35.6	10.4	330	320
	26.3	71.3	35.4	10.2	340	330
	26.6	71.5	35.6	10.5	330	320
	26.7	71.8	35.9	10.7	330	320
	26.9	72	36.2	10.4	330	320
	26.8	72.2	36.5	10.1	320	310
	27	72.5	36.7	10.3	320	310
	26.5	72.1	34.3	9.9	330	320
	26.8	71.9	34.5	9.8	330	320
	27	72.3	34.5	9.5	330	320
	26.9	72.1	34.4	9.3	320	310
	26.7	72.4	34.6	9.4	320	310
	26.5	72.2	34.8	9.6	310	300
	26.8	72.6	34.7	9.3	320	310
	26.9	72.5	34.9	9.8	320	310
	27.1	72.8	35	9.9	320	310
	27.3	72.9	35.2	10.1	330	320
MEAN	**26.5**	**72.4**	**35.3**	**10.2**	**330**	**320**

Table 5.2.4 Refrigerant 407c (water cooling)

COP of Systems

S.No.	System	COP
1.	R22 (Air cooling)	1.14
2.	R22 (Water Cooling)	1.98
3.	R407c (Air Cooling)	.48
4.	R407c (Water cooling)	1.89

2.2.4 Graphs

2.2.4.1 Comparison Graph between T1 Vs T2, T3, T4 in air cooling case for R-22

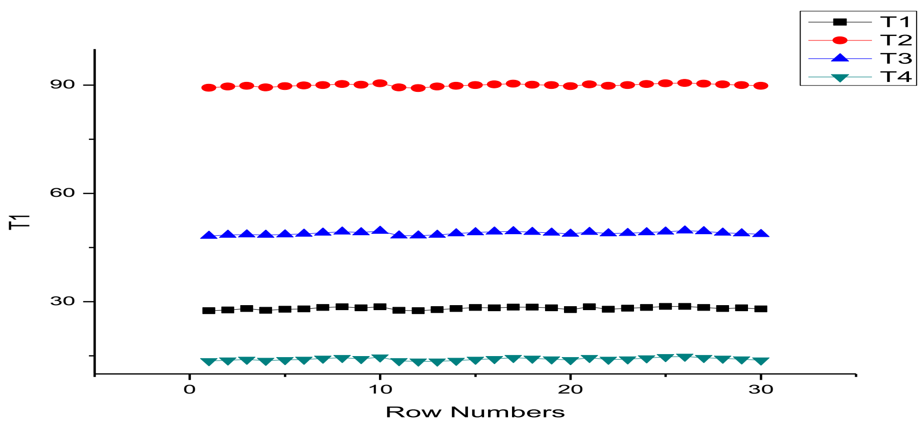


Fig 1. T1 Vs other temperatures for Air Cooling for R-22

2.2.4.1 Comparison Graph between T1 Vs T2, T3, T4 in water cooling case for R-22

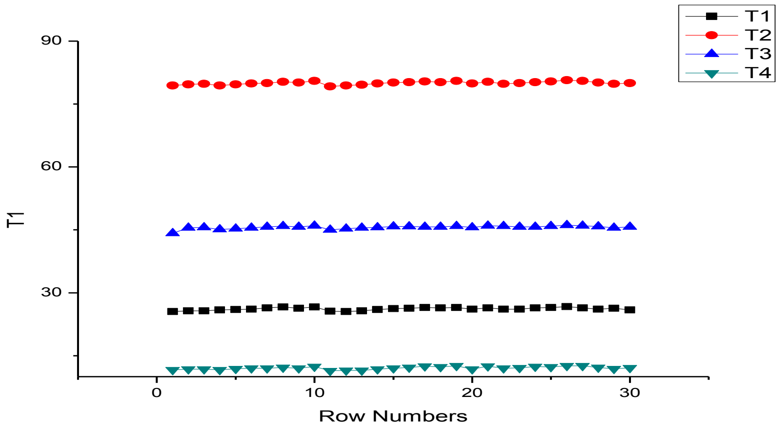


Fig 2. T1 Vs other temperatures for Water Cooling for R-22

2.2.4.2 Comparison Graph between T1 Vs T2, T3, T4 in air cooling case for R-407c

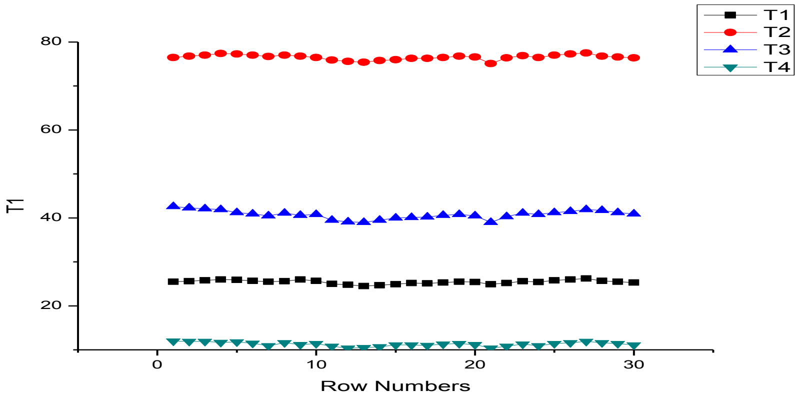
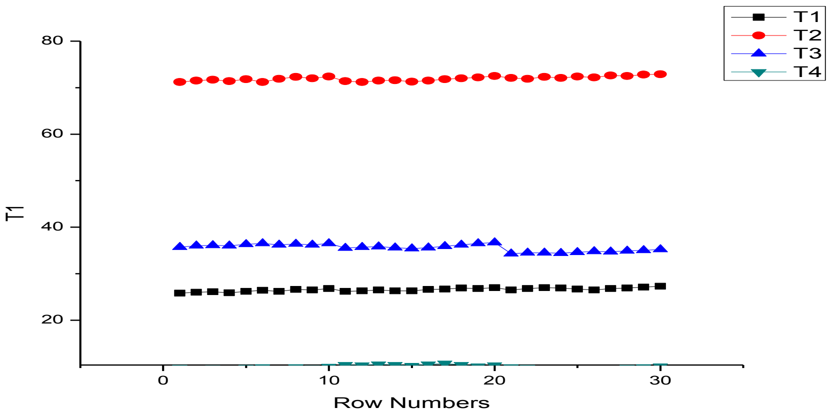


Fig. 3 T1 Vs other temperatures for Air Cooling for R-407c

2.2.4.3 Comparison Graph between T1 Vs T2, T3, T4 in water cooling case for R-407c



III. CONCLUSION

1. The results confirmed that R-407C is promising alternatives as a direct replacement (Air cooling); drop in of R-22 in RAC. Noting that the drop in technique is a feature of the refrigeration unit. Therefore, the performance of a specific alternative varies from one application to another. R-407C showed a significant increase in COP by (29%) for the operating conditions presented here.
2. With the water cooling, we see small increase in COP. As the system kept in outdoor so it was small but when we have a defined area which is to be conditioned when that small difference may be increase. R22

during water cooling of condenser showed increase in COP than Air cooling of condenser i.e. 73% in the Air-conditioner but R407c relatively showed less increase in the COP for the same process i.e. 27%

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