Global Journal of Engineering and Technology Advances

eISSN: 2582-5003

Cross Ref DOI: 10.30574/gjeta

Journal homepage: https://gjeta.com/

(RESEARCH ARTICLE)

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Experimental investigation of cop for an air conditioner using zeotropic blend

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Global Journal of Engineering and Technology Advances, 2021, 06(03), 014–023

Publication history: Received on 20 January 2021; revised on 25 February 2021; accepted on 27 February 2021

Article DOI: https://doi.org/10.30574/gjeta.2021.6.3.0028

Abstract

In this project an air conditioner was fabricated using R-410a as refrigerant and its COP is calculated. CFCs have been phased out, except for essential users, and HCFCs are to be eliminated by 2020, because of their ozone depletion potential.This generates a need for the investigation of zero ozone depletion potential (ODP) refrigerants or refrigerant blends.R410A is among newer brand of refrigerant blend, with zero ODP. The biggest difference to R22 is the pressure levels generated which are more than50% higher. The refrigerant R410A operates at higher pressure at the same saturated temperatures than R22, therefore system should be re designed. The overall COP of the system is 5 to 6% more than the R22. We also calculated the relative humidity of room air after it gets cooled, heat removed from the air by considering the input data from weather online which provides us the day to day climatic conditions. Present work provides us regarding performance of an self fabricated zeotropic air conditioner.

Keywords: Air Conditioner; COP; Zeotropic Blend; ODP; R410a; HFC Refrigerant

1. Introduction

The acronym HVAC&R stands for heating, ventilating, air-conditioning, and refrigerating. The combination of these processes is equivalent to the functions performed by air-conditioning. Air-conditioning is a process that simultaneously conditions air; distributes it combined with the outdoor air to the conditioned space; and at the same time controls and maintains the required space's temperature, humidity, air movement, air cleanliness, sound level, and pressure differential within predetermined limits for the health and comfort of the occupants, for product processing, or both. Air- conditioner performs cleaning, circulating, temperature controlling humidity controlling of air functions within a specified area. New thermal conductivity data of the refrigerant mixtures R404A, R407C, R410A, and R507C are presented by V. Z. Geller et al [1]. Axial wall temperature distribution of R410a and water filled thermosyphons at various fill ratios and inclination angles are experimentally determined by Kok-Seng Ong et al [2]. As per, S. S. Jadhav et al [3] work, CFCs have been phased out, except for essential users, and HCFCs are to be eliminated by 2020, because of their ozone depletion potential. This generates a need for the investigation of zero ozone depletion potential (ODP) refrigerants or refrigerant blends.R410A is among newer brand of refrigerant blend, with zero ODP. The environmental impact of high global warming potential (GWP) refrigerants pushed the HVAC&R industry to investigate alternative refrigerants. R410A is a common refrigerant for air conditioning and heat pumping applications, but has a GWP of 2088. Drop-in tests of three R410A low-GWP alternative refrigerants (R32, D2Y60 and L41a) in a 10.55 kW capacity split heat pump unit were performed by Abdullah Alabdulkarem et al [4]. In CHEN Jiu-fa et.al [5] work, R410A and R407C have been considered as two environmentally benign refrigerant candidates in the world for replacing the ODP refrigerant R22.

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Ashish Kumar Paharia et al [6] paper presented performance of three hydro flouro carbon (HFC) refrigerants (R-410A, R-507A, R-407C) to replace R-22 in vapour compression refrigeration system and their results showed that R410A and R407C have thermo dynamic performances similartoR-22.

Mei Kui Li Ming Liang Lujun [7] carried out the comparative analysis and experimental research of the cycle performance of R410A, R32, which are yet used in the world.

2. Psychrometric process

In order to condition air to the conditions of human comfort or of the optimum control of an industrial process required, certain processes are to be carried out on the outside air available. The processes affecting the psychrometric properties of air are called Psychrometric process. These processes involve mixing of air streams, heating, cooling, humidifying, dehumidifying, adiabatic saturation and mostly the combinations of these.

The important pyschrometric processes are:

- Mixing of air streams
- Sensible heating
- Sensible cooling
- Cooling and dehumidification
- Cooling and humidification
- Heating and dehumidification
- Heating and humidification

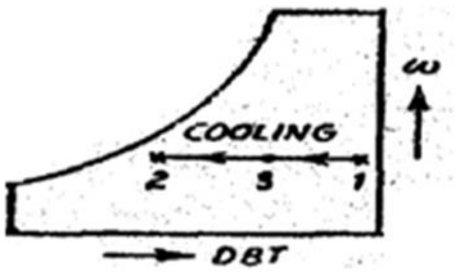

Figure 1 Representation of Sensible Cooling Process on Psychrometric Chart

Table 1 By considering the following data From Weather Online, Vijayawada.

Date	**Relative Humidity**	**DBT**
7th March	72%	36.1°C
9th March	70%	35.4°C
11th March	53%	38.1°C
13th March	70%	36°C
15th March	70.1%	34.3°C
17th March	68%	36.01°C
19th March	74%	36.5°C
21st March	70%	36.3°C

Sensible Cooling: Air undergo sensible heating whenever it passes over a surface that is at a temperature less than the dry bulb temperature of the air but greater than the due point temperature. Thus sensible cooling can be achieved by passing the air over the cooling coil like evaporating coil of the refrigeration cycle or secondary brine coil. During the process, the specific humidity remains constant and dry bulb temperature decreases, approaching the mean effective surface temperature. On a Pyschrometric chart the process will appear as a horizontal line, point 2 represents the effective surface temperature.

We Determined: (a) Relative humidity (RH) of cooled air

(b) Heat Removed from air

Case 1: 7th March

10m3 of air at 36.1°C DBT and 72% RH is cooled to 30°C DBT maintaining its specific humidity constant :

Relative Humidity

$\emptyset$ =0.72

DBT = 36.1°C

$\emptyset$ =pv /pvs ; pvs =0.05947 [at 36°C]

pv = 0.72*0.05947 =0.0428

$\emptyset$ = pv /pvs ; pvs [at 30°C]

=0.0428/0.04246 =1.00 =100%

(b)Heat removed from 10m3 of air

Q =ma(h1-h2)

pv =mRT ;ma =pv/RT

=(pt -pv)v/(Ra *Tdb) =(1.0132-0.0428)105*10/287*(36.1+273)

ma =10.93kg

h1 =cptdb1+W[hg1 + 1.88(tdb1-tdp1)] [W=0.622Pv/(Pt-Pv)=0.0274]

=1.005*36.1+0.0274[2567.1+1.88(36.1-29.81)] =107.02 kj/kg of dry air

h2 = cptdb2+W[hg2 + 1.88(tdb2-tdp2)]

=1.005*30+0.0274[2556.3+1.88(30-29.81)] =100.2 kj/kg of dry air

Q = ma(h1-h2) =10.93(107.02-100.2) =74.516kj

Similar procedure was applied to caluculate the remaining values and the results are presented below as graphs,

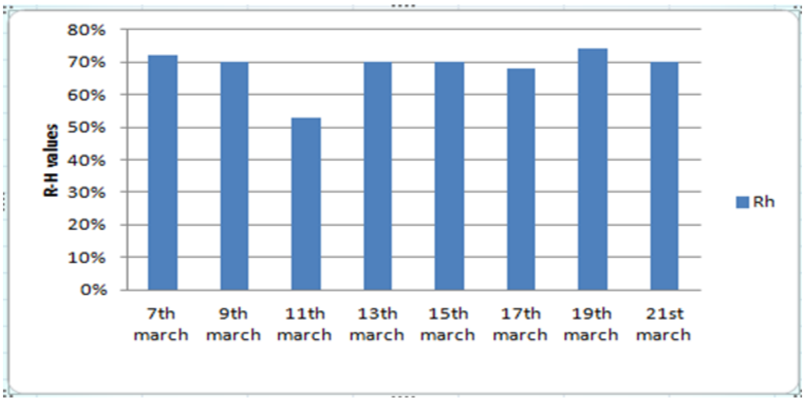

Figure 2 Variation of Relative Humidity Values with respect to Day of the month

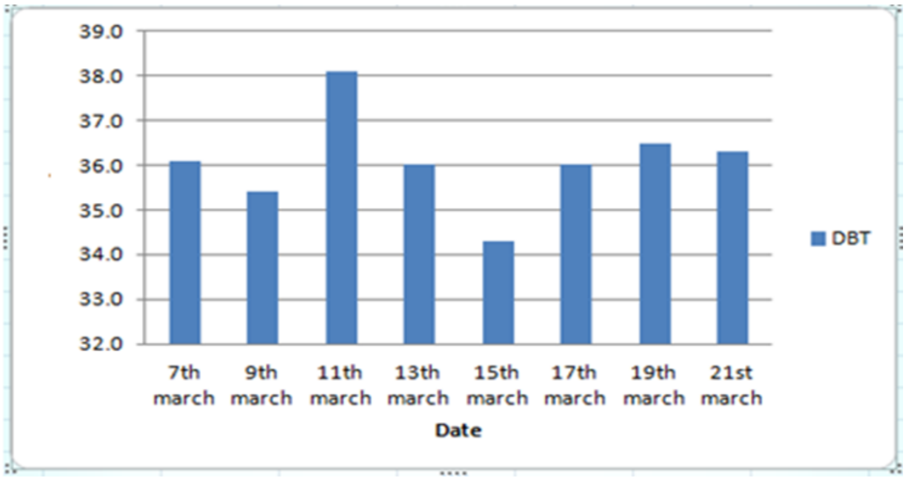

Figure 3 Variation of Dry Bulb Temperature Values with respect to Day of the month**.**

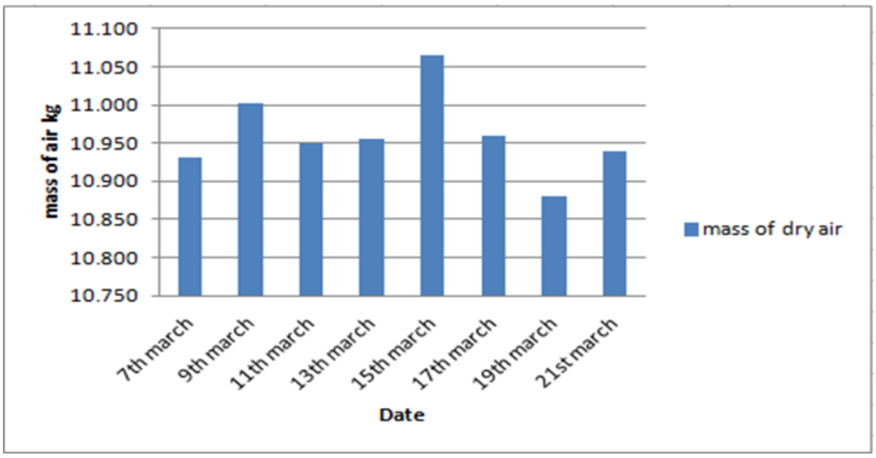

Figure 4 Variation of Mass of Dry air Values with respect to Day of the month**.**

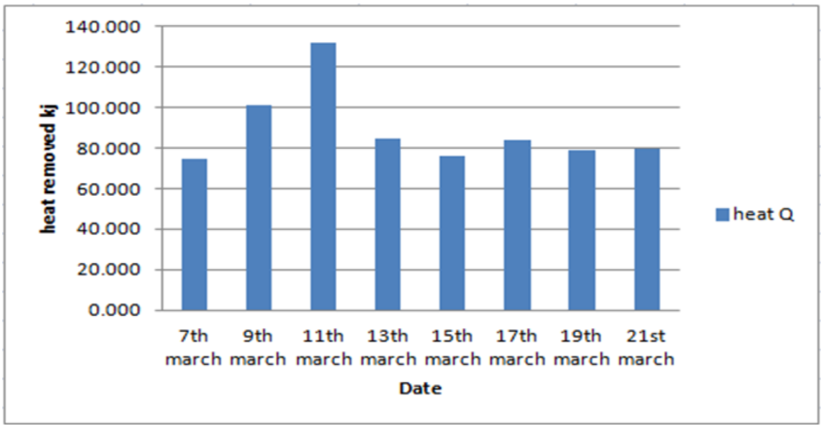

Figure 5 Variation of rate heat removed Values with respect to Day of the month.

3. Experimental setup

An experimental set up was fabricated with the required components like bare tube evaporators,compressor, condensor,

Figure 6 Bare tube Evaporator

The bare tube evaporators are made up of copper tubing or steel pipes. The copper tubing is used for small evaporators where the refrigerant other than ammonia is used, while the steel pipes are used with the large evaporators where ammonia is used as the refrigerant. The bare tube evaporator comprises of several turns of the tubing, though most commonly flat zigzag and oval trombone are the most common shapes. The bare tube evaporators are usually used for liquid chilling. In the blast cooling and the freezing operations the atmospheric air flows over the bare tube evaporator and the chilled air leaving it used for the cooling purposes. The bare tube evaporators are used in very few applications, however the bare tube evaporators fitted with the fins, called as finned evaporators are used very commonly.

Figure 7 Rotary Compressor

We uses a Rotary-screw type compressor.A rotary-screw compressor is a type of gas compressor that uses a rotary-type positive-displacement mechanism. They are commonly used to replace piston compressors where large volumes of high-pressure air are needed, either for large industrial applications or to operate high-power air tools such as jackhammers.The gas compression process of a rotary screw is a continuous sweeping motion, so there is very little pulsation or surging of flow, as occurs with piston compressors.

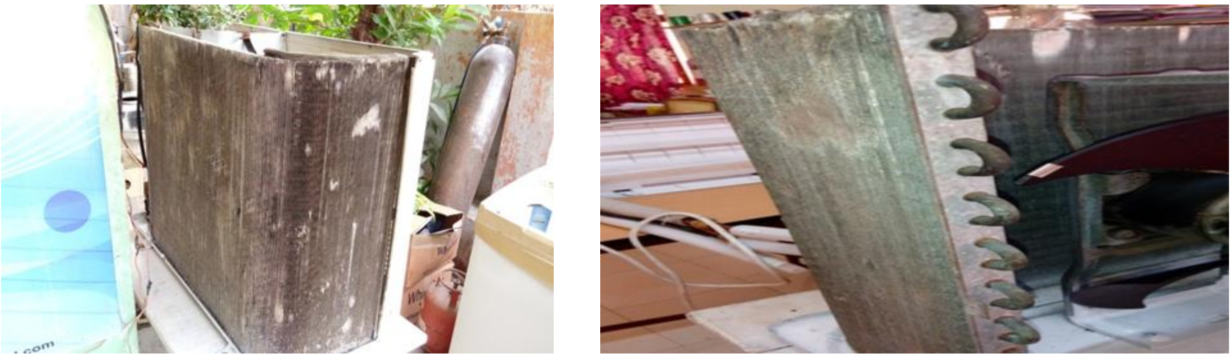

Figure 8 Condenser fins & Condenser coils

3.1. Shell and Coil Condenser

It consists of a copper coil located in a steel shell. Water runs through the coil, and refrigerant vapor is discharged from the compressor, condensing on the outside of the cold tubes. This type of condenser is economical, but its maintenance is difficult. If a leakage occurs in the coil, it is essential to remove the head of the shell, and withdrawal of coil from the shell.

Figure 9 Liquid pipeline and gas pipeline

Liquid pipe line and gas pipe lines are connected to indoor unit and outdoor unit. Liquid pipe lines are ½ inch pipes and gas pipe line is ¼ inch pipes.

Figure 10 Fan Blades & Fan Motor

Fan blades are fabricated with the fabric material and the Motor outer body with the aluminium.Motor can be run by using the capacitor of capacity of 4 microfarads.

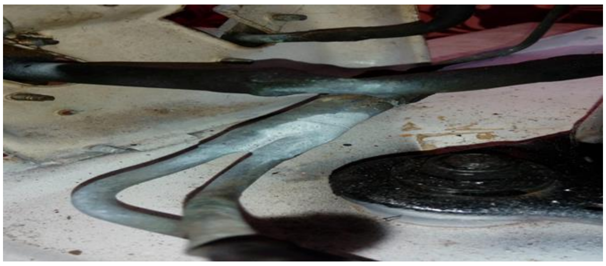

Figure 11 Expansion valve

Expansion valves are devices used to control the refrigerant flow in a refrigeration system. They help to facilitate the change of higher pressure of liquid refrigerant in the condensing unit to lower pressure gas refrigerant in the evaporator.The term "low side" is used to indicate the part of the system that operates under low pressure, in this case the evaporator. The "high side" is used to indicate the part of the system that operates under high pressure, in this case the condenser.

Figure 12 Final Fabricated VCRS System

4. Results and discussion

Table 2 Table of observations**.**

Component	10mins	20mins	30mins	40mins
Evaporator	20	19.6	19.2	18.9
Compressor	50.5	56.7	57	58.2
Condensor	40.5	36.4	37.6	38
½ suction valve	23.5	24.1	24.6	24.9
¼ liquid valve	23.5	23.3	23.2	22.1
Expansion	34	33.7	33.3	32.2

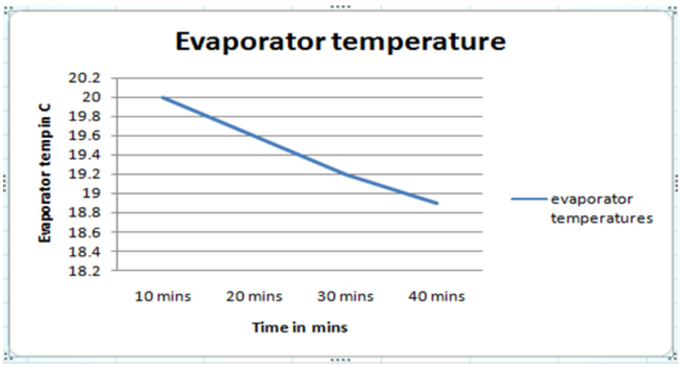

Figure 13 Change in Evaporator temp with Time

By observing the above graph the evaporator temperature is decresasing with increase in time thereby making the room cool.

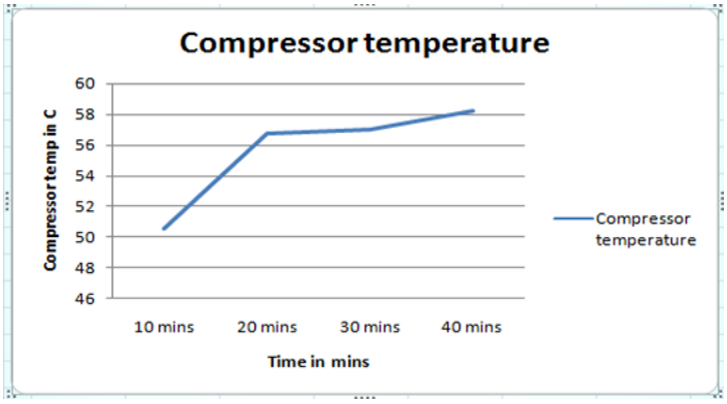

Figure 14 Change in Compressor Temperature with Time

From the above graph the compressor temperature is increasing with increase in time because it is a work absorbing device.

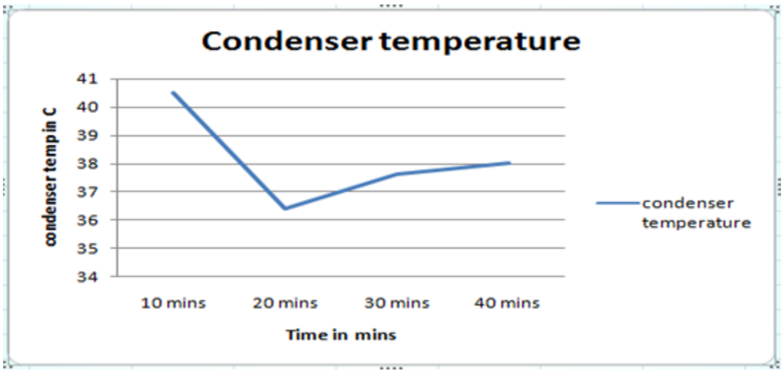

Figure 15 Change in Condenser Temperature with Time

During experimentation the condenser temperature decreased and then increased with respective time because untill the compressor is on the condenser temperature decreased and then it increased rejecting heat to atmosphere.

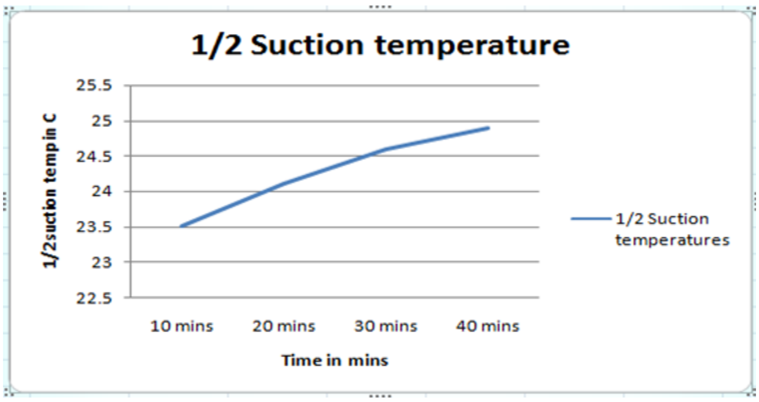

Figure 16 Change in Suction Temperature with Time

½ Suction valve sends vapour refrigerent from Evaporator to Compressor.By Observing the above graph ½ suction valve temperature is increasing with respect to line because the amount of vapour refrigerant is dependent on cooling affect.

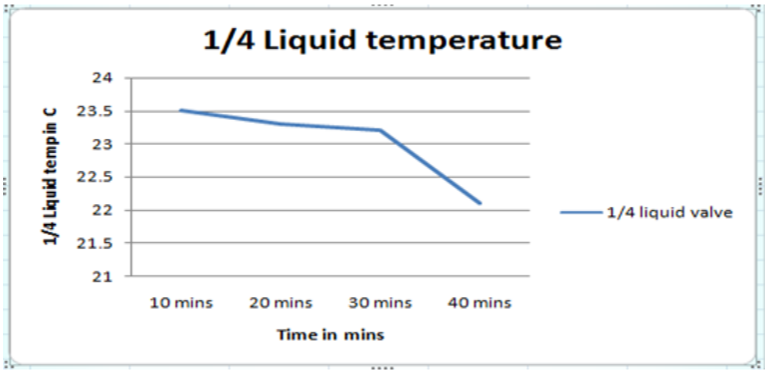

Figure 17 Change in Liquid Line Temperature with Time

¼ delivery valve sends high pressure liquid refrigents from expansion valve to evaporator.From the above graph ¼ delivery valve temperature is decreasing with time.

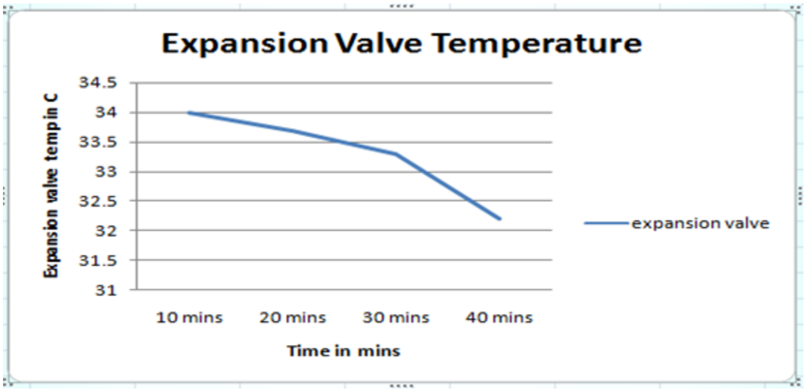

Figure 18 Change in Expansion valve temperature with Time

The capillary tube is used as an expansion device, whose temperature is decreasing with respective time and its purpose is to convert the high pressure liquid refrigerant to low pressure liquid refrigerant and also to monitor, control the flow to refrigerant.

5. Conclusion

As apert of this work, we fabricated an air conditioner of 1.5tonn using a zeotropic blend which comes under HFC refrigerants. Presently we were using R22 which is a HCFC refrigerent, contains Chlorine, Florine.The presence of chlorine is the main factor for ozone depleton. To reduce ozone depletion best prefered refrigernt for the market is HFC refrigerants. After Fabrication of the experimental setup we calculated the COP of the system and also the fina relative humidity of the chilled room air. By observing the values we find out that the COP of the new refrigerant as 0.98. This work is carried out understand the working of a summer air conditioner equiped with an zeotropic mixture of diflouromethane [R32] & penta flouroethane [R125].

Future scope

Present experimentation can be done by employing Hydrocarbon refrigerants, which are flamable in nature. Research need to be continued to reduce the size of the system for the same capacity. R290 could be an alternative refrigerant but still researchers are working on to invent compressors suitable for HC refrigerants.

Compliance with ethical standards

Acknowledgments

Authors would like to thank SAGTE for sponsoring in carrying out this work.

Disclosure of conflict of interest

All authors declare that they have no conflict of interest.

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Author's short biography

	**Dr. P. Anusha** did her Ph.D in Refrigeration & Air Conditioning area with a total of 10 years of Teaching Experience.
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