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Experimental Analysis of Cooldown Characteristics of an Automobile Air Conditioner Using Alternative Refrigerant

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ABSTRACT: Air conditioning and refrigerator requirement is increasing day by day. To meet the requirements one of the important factors needs to be consider is environment. The refrigerant used for HVAC systems should not harm the environment in any way. As Ozone depletion and therefore the region atmospheric phenomenon thanks to refrigerant emissions have junction rectifier to forceful changes within the refrigeration and air-conditioning technology. For this reason, environmentally benign, 'natural' refrigerants have attracted considerable attention. In the segment of natural refrigerants, hydrocarbons are the foremost closely associated with the HFCs with similar thermodynamic and transport properties, which make them suitable as substitute refrigerants in the existing greenhouse gas systems with none major changes within the style. R134 refrigerant is most commonly used in Automobile Air Conditioning. Which is having GWP of 1410. Hence an alternative for this refrigerant is to be identified. R152a is known as an alternate to R12 and R134a refrigerants. To minimize the usage of HFC 134a with the Hydrocarbon Refrigerant mixtures (HCM) of R134a and R152a refrigerants in the proportion of 50:50 by mass which will help to partly minimize the usage of R134a.

KEYWORDS:R134a; Mixture; Performance; R152.

I. INTRODUCTION

This research work explores the feasibility of the R134a/R152 blend in an existing R134a system. In this mixture both the refrigerants are mixed in proportion 50 percent by mass. Earlier mixture of R134 is done with R290 and R600a which has proved to be a better retrofit refrigerant. This new mixture is free from chlorine atoms and is ozone friendly. Although GWP of R152 is zero as compared to existing refrigerant in use which will result in release of decrease in global warming causing agents.

The working principles of automotive A/C is vapor compression refrigeration cycle which is driven by car engine. Therefore the cooling capacity and input power of the automotive A/C depends on the engine rotation. The higher the car engine speed, maximum the cooling capacity and higher the input power required to the compressor.

II. METHODOLOGY

The working principles of automotive A/C is vapor compression refrigeration cycle that's driven by car engine. To select the refrigerant one of the important factors, need to be considered is boiling temperature of refrigerant. Accounting Boiling Point, Critical state properties, thermodynamic properties, compatibility, operating pressures refrigerants for mixture needs to be selected.

Abbreviations Used:

ASHRAE	-	American Society of Heating Refrigeration and Air Conditioning Engineers
CFC	-	Chlorofluorocarbon
COP	-	Coefficient of Performance
DBT	-	Dry Bulb Temperature
HC	-	Hydrocarbons
HCB	-	Hydrocarbon Blend
HCFC	-	Hydro Chlorofluorocarbons
HFC	-	Hydrofluorocarbons
HVAC	-	Heating Ventilation Air Conditioning
ISHRAE	-	Indian Society of Heating Refrigeration and Air Conditioning Engineers
ODP	-	Ozone Depletion Period
PAG	-	Poly Alkaline Glycol
POE	-	Polyol Ester
RTD	-	Resistance Temperature Detector
DT	-	Temperature Difference
TXV/TEV	-	Thermostatic Expansion Valve
VCR	-	Vapor Compression Refrigeration
VFD	-	Variable Frequency Drive
WBT	-	Wet Bulb Temperature

III. EXPERIMENTAL SETUP

As shown in figure experimental setup is used for the experimentation. To sense the temperature, RTD's are used which are connected to Data Acquisition System to get Realtime data with accuracy after fixed interval.

Fig. System Controls

IV. EXPERIMENTATION

Initially system heater is switched on and system is heated up to 52^0C and then it let to settle to 50^0C. When system reached to 50^0 air conditioning system is turned on with first gas R134. While Air Conditioner system is turned on heater is kept on load of 2500W. While taking reading for first reading of R134 compressor RPM is set to 1000 RPM by using Variable Frequency Drive. System kept running for 1 hour. After 1 hour again system is heated to 52^0C and kept it to reach 50^0C again system is tested for 1500RPM & 2000RPM. After reading for R134 is over gas mixture is charged into the system.

Gas Mixing Procedure:

Refrigerant is mixed in cylinder for charging into the system. First an empty cylinder is evacuated with the help of vacuum pump which eliminates the atmospheric air present in the cylinder and also removes previous gas present if any present in the system. After evacuating the cylinder R152 gas is charged into cylinder with the quantity calculated. After, R152 is charged hose connected to the cylinder having R152 is removed and connected to cylinder having R134a. Gas is purged so that R152 present in the hose is removed and R134a occupies the hose. Gas is charged into the cylinder by quantity calculated. To charge the gas pressure is needs to be created which can be created by applying ice on the cylinder in which refrigerant needs to be mixed. After mixing the refrigerant in the cylinder while charging this gas into the system charge the gas by keeping the cylinder into a water bucket so that pressure difference can be maintained to keep gas charging.

Fig. Gas Mixing Process

Charging Procedure:

Before charging new gas by using gas recovery system gas is recovered. As system gets empty it is connected to the Gauge Manifold Set which is connected to the vacuum pump which evacuates all the left over refrigerant and all the atmospheric air entered in the system while connecting it to Gauge Manifold Set. Once system is reached to -30 psi on blue side of manifold then cylinder containing mixture is connected to the GMS. Valve of the red side which is connected to vacuum pump is turned off. After valve of gas cylinder is opened. Valve of GMS is opened and gas is purged through the opening at GMS. Then system is allowed to suck the refrigerant due to pressure difference once system stops sucking gas. System is turned on to charge the gas and allowed to charge the entire gas of the cylinder as only required quantity mixture is charged into the cylinder. While charging the gas into system cylinder is immersed into water bucket as due to gas charging ice gets accumulated on cylinder surface.

After system is charged with new gas. Again, system is heated to 50^0C and allowed to soak the temperature to 50^0C. Now VFD is set to 31 Hz RPM which gives compressor RPM of 1000 and system is allowed to run for 1 hour. When the system is turned on Data Acquisition system is turned on. While system is running pressures are recorded manually for the interval of 10 Min, 30 Min & 60 Min. Process is again repeated for the 1500RPM & 2000RPM.

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V. RESULTS & DISCUSSION

In experiment conducted by using both the refrigerants at various compressor speeds. The system was exposed to the heat load of 2500W. Compressor speed used are 1000RPM, 1500RPM, 2000RPM. The graph of the Variation in Average Cabin Temperature is shown. Based on the data COP is calculated which is coming out to be 2-3% less effective than actual COP of R134a. Which can be considered for charging into the Automotive Air Conditioning system instead of complete charging of R152 as future of Automotive is Electric mobility to meet the need of environment factors & to compromise for the environment we can us this mixture in Automotive Air Conditioners. Also, at the point where condenser temperature is above 50^0C COP of mixture improves as compared to R134a.

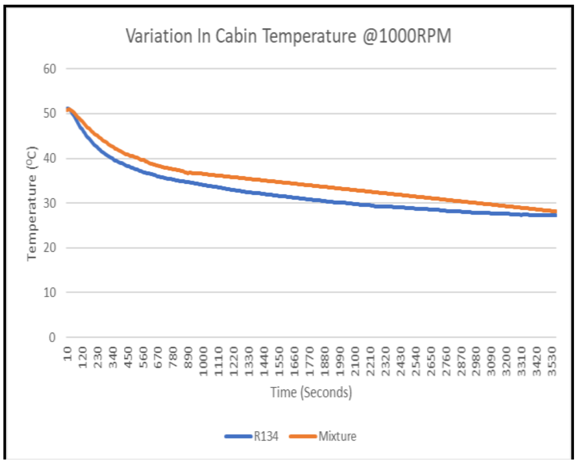

Fig.1: Variation In Cabin Temperature @1000RPM on 2.5KW Load

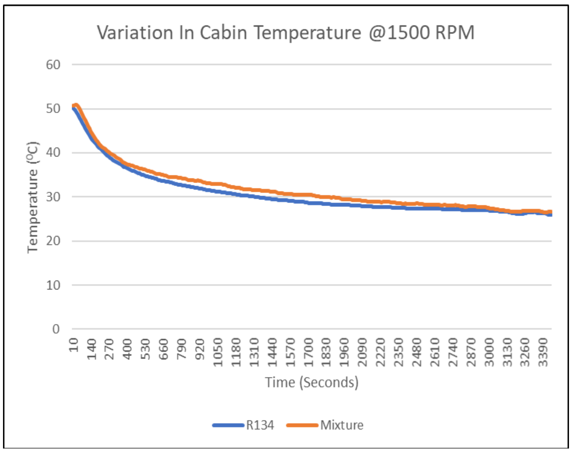

Fig.2: Variation In Cabin Temperature @1500RPM on 2.5KW Load

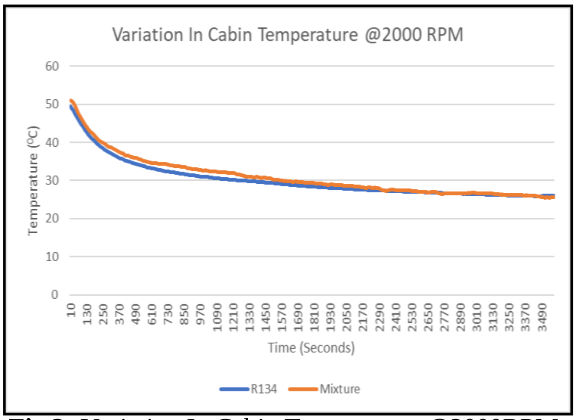

Fig.3: Variation In Cabin Temperature @2000RPM on 2.5KW Load

VI. CONCLUSION

In experiment conducted with alternative refrigerant it is concluded that use of alternative refrigerant mixture is less efficient than R134a. But against the cost of environment it's good to use the new refrigerant to minimize global warming as mixture used is containing 50% of R152 which is environment friendly. When COP is compared it is found that COP of mixture is less by 3.5% to 4% at various speeds. Hence, it is concluded that it is good to go with mixture instead of only R134. Because when we use the mixture due to proportion 50-50, we are reducing the use of R134 by 50% which will help environment a lot to minimize global warming effect.

VII. FUTURE DIRECTIONS

Need of alternate refrigerant needs to be fulfilled as if to use R152a. But future of Automotive industry is Electric Vehicles where to have a good range of vehicle efficiency of Air Conditioning system needs to be accounted for economy drive i.e. long range of vehicle. An invention of refrigerant with COP equivalent or greater than the performance of R134a and GWP equivalent or less than R152a is needed which will help to meet the need of environment friendly nature and also to maintain the economy of the vehicle.

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