Effect of Sub-Cooling On Performance of Spilt Air Conditioning System Using Hydrocarbon R-290 and R-600a Refrigerants Mixture Comparing With R-134a

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Abstract: *The performance of hydrocarbon R-290 and R-600a refrigerants as alternative to R-134a in vapor compression refrigeration, that is the split air conditioning system, the theoretically investigated the sub-cooling effect on the split air conditioning system. The effects of sub-cooling on the performance of the investigated refrigerants were quantified. The results obtained showed that the saturated vapour pressure and specific volume of R290 and R600a mixture are very close to those of R-134a; therefore, they had been used as substitute for R-134a.The condenser is performed better with these two refrigerant mixtures. The thermodynamic properties of (R-290/R-600a) mixture were obtained by using REPRPOP software. The coefficient of performance of investigated refrigerant mixture was found to be in range 3.08–3.35. The degree of sub-cooling greatly increased the coefficient of performance and it had the positive effects on the refrigerating capacity.*

Keywords: *Sub-cooling, hydrocarbon mixture(R-290/R-600a), R-134a*

I.INTRODUCTION

1.1 Need:

Due to the emission of the greenhouse gases and refrigerant leaks from refrigeration and air conditioning system has effect on the stratosphere ozone layer which leads to increase in the atmospheric temperature. So there is a drastic change in the refrigeration and air-conditioning technology since the beginning of 1990s. There is continued growing awareness at the international level with particular focus on the working fluids of refrigeration and industry There is continued growing awareness at the international level with particular focus on the working fluids of refrigeration and air conditioning systems. Chlorofluorocarbons (CFCs) have a long and successful association with the refrigeration industry due to their pre-eminent properties such as stability, non-toxicity, non-flammability and good thermodynamic properties. However, they even have harmful result on the Earth's protecting layer. Therefore, they have been banned in 1996. In 2010, production and usage of CFCs have been prohibited completely all over the world.

Hydrocarbon refrigerants have each zero ODP and really low GWP. They are compatible with common materials found in refrigeration and air-conditioning systems are soluble in conventional mineral oils. The most important concern regarding the adoption of hydrocarbon as a refrigerant is their flammability. It should be remembered millions of tons of hydrocarbons are used safely every year throughout the world for cooking, heating, powering vehicles and as aerosol propellants. In these industries, procedures and standards have been developed and adopted to ensure the safe use of the product ensure the safe use of the product. The same approach using enhanced compact heat exchangers, optimizing system design, reducing the charge of systems and establishing and establishing rules and regulations for the safety precautions.

1.2 Sub-cooling for optimization and power saving

Sub-cooling procedure outdoor the condenser (as with an internal heat exchanger) is a great manner of using up all of the condensing tool's heat exchanging. A massive portion of refrigeration systems use part of the condenser for sub-cooling which, even though very effective and easy, can be considered as a diminishing issue inside the nominal condensing potential. A similar state of affairs can be found with superheating taking area in the evaporator, as a result, an internal heat exchanger is a great and relatively reasonably easy solution for the maximization of heat exchanger capability (Klein et al., 2000).

1.3 Sub- cooling for enhancing refrigeration Capability

Every other large application of sub-cooling is for enhancing refrigeration ability. Inversely to superheating, sub-cooling, or the quantity of heat withdrawn from the liquid refrigerant on the sub-cooling technique, manifests itself as an increase inside the refrigeration capacity of the device. This means that any extra heat removal After the condensation (sub-cooling) allows a better ratio of heat absorption on in addition ranges of the cycle. it is to be stated that superheating has precisely the inverse effect, and that an internal heat exchanger alone, is not capable of boom the ability of the device due to the fact the boosting effect of sub-cooling is dimmed by using the superheating, making the internet ability advantage identical to zero(Bolaji and Huan, 2013).

1.3 Natural and synthetic sub-cooling

The sub-cooling procedure can happen in many unique approaches; therefore, it's far feasible to differentiate among the specific parts in which the system takes region. Commonly, sub-cooling refers back to the significance of the temperature drop that's without problems measurable, however it's miles feasible to talk of sub-cooling in terms of the full heat being removed. The most normally illustrious is that the condenser condenser sub-cooling, that is sometimes referred to as the full temperature drop that takes place within the condenser, now when the fluid has totally condensed, until it leaves the condensing unit (Selbas et al., 2006).

Condenser sub-cooling differs from total sub-cooling generally due to the fact after the condenser, during the piping, the refrigerant may naturally have a tendency to cool even more, before it arrives to the enlargement valve, but also due to artificial sub-cooling. The entire sub-cooling is the whole temperature drop the refrigerant undergoes from its actual condensing temperature, to the concrete temperature it has while attaining the enlargement valve: this is the effective sub-cooling (Del-Colet al., 2010).

Natural sub-cooling is the call typically given to the temperature drop produced inside the condenser (condenser
Sub-cooling), mixed with the temperature drop happening thru the pipeline alone, with the exception of any heat exchangers of any kind. Whilst there may be no mechanical sub-cooling (i.e. an internal heat exchanger), natural sub-cooling must same total sub-cooling. However, mechanical sub-cooling is the temperature decreased by using any synthetic technique that is intentionally located to create sub-cooling. This concept refers mainly to devices such as internal heat exchangers, independent sub-cooling cascades, economizers or boosters (Bolaji., 2010).

II.METHODS USED

The schematic diagram of spilt air-conditioning diagram is as shown in fig below. There are some assumption are made for the easy of calculations. The reading is taken at the time of experiment and verified by COOLPACK software. Some calculations are calculated by this software.

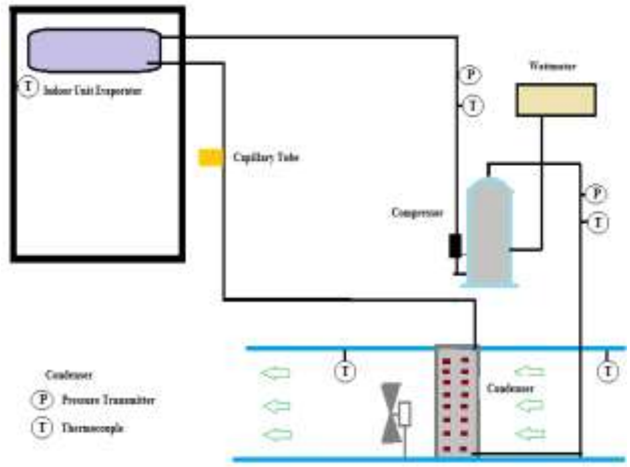

Fig.1 Schematic diagram of split air-conditioner.

Assumptions:
1) Efficiency of compressor is not considered.
2) Compression is isentropic.
3) No pressures drop in the condenser as well as evaporator.
4) Isenthalpic expansion in the expansion valve.
5) Heat losses from all the parts are neglected

The heat absorbed by the refrigerant within the evaporator or refrigerating effect. The refrigerating effect (RE) is calculated as:

$$RE = h_1 - h_4 \text{ in Kw} \quad (1)$$

Where, h_1 is the specific enthalpy of refrigerant at the outlet of the evaporator (KJ/kg) and h_4 the specific enthalpy at the inlet of the evaporator (KJ/kg) and isentropic work input to compressor (Wcomp, Kw) is given by:

$$Wcomp = h_2 - h_1 \text{ in Kw} \quad (2)$$

Where, h_2 is the specific enthalpy of refrigerant at the outlet of compressor(KJ/kg)

Coefficient of performance is given by:

$$COP = RE/Wcomp \quad (3)$$

The flow of refrigerant in the expansion device points 3 to 4 is assumed to be at constant enthalpy (isenthalpy). Therefore

$$h_3 = h_4 \quad (4)$$

Where, h_3 is the specific enthalpy of refrigerant at the outlet of condenser (KJ/kg)

III. SAFETY CONSIDERATIONS FOR R-290 AND R-600A IN A SPLIT AIR CONDITIONER

1. All tubing joints were brazed.

2. The charge of R-290 was about 500g and R-600a Even if the total R-290 leaked in the test chamber, the

concentration (11.6 g/m3) would have been well below the explosive density of R-290 (43.6–175 g/m3).

3.The electrical components like a capacitor, thermostat switch, on/off switch, etc. were sealed using some means.

4. Special precautions were taken to protect the tubes from damage.

5. Every time before starting the system, the room was ventilated well. 6. Electronic HC detectors were placed in the room.

IV.RESULT AND DISCUSSION

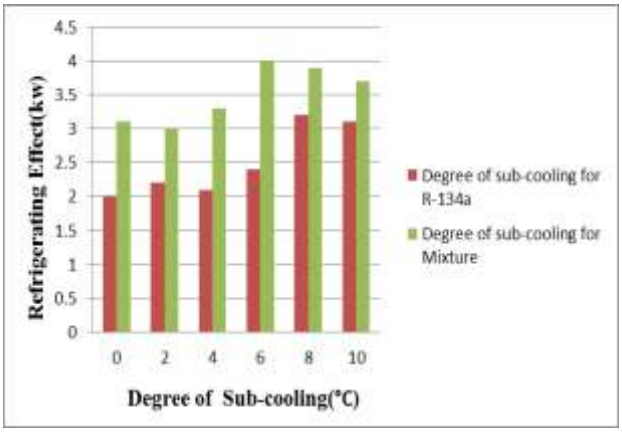

Fig.2 Variation of refrigerating effect with degree of Sub-cooling at 35°C condensing temperature at -29°C evaporating temperature.

Figure 2 shows graphical representation of the variation of refrigerating effect as a function of degree of sub-cooling for R-290/R-600a mixture and R-134a.The refrigeration effect at Sub-cooling temperature of 7°C for mixture was 4.1 Kw and for 9°C, 10°C were 3.5 and 3.7 resp.

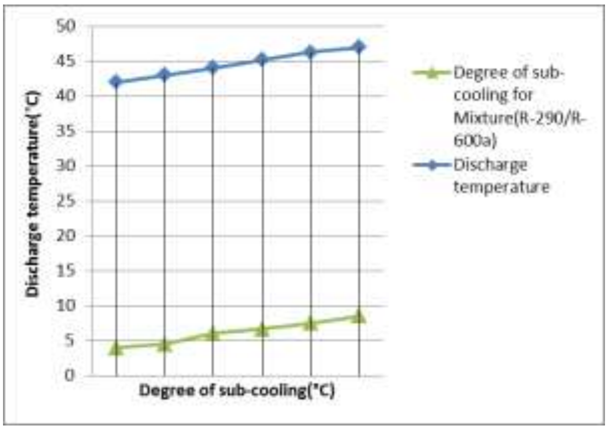

Fig.3 Variation of discharge temperature with degree of Sub-cooling at 35°C condensing temperature at -29°C evaporating temperature.

Figure 3 shows graphical representation of the variation of discharge temperature with sub-cooling. As the discharge temperature increases the sub-cooling temperature increases. At 6°C sub-cooling temperature the discharge temperature is 44°C and 42, 43 and 47 discharges temperatures were obtained at sub-cooling temperature 4, 4.5 and 8.5 respectively.

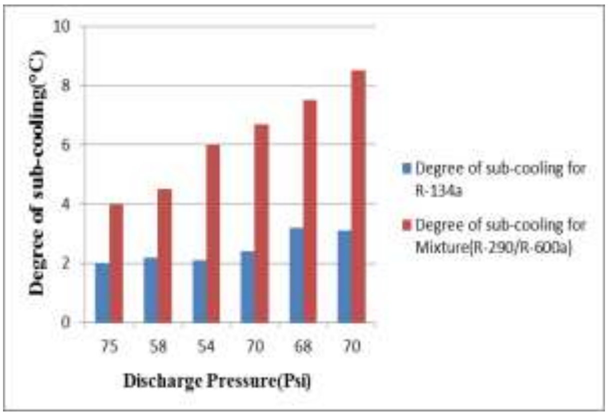

Fig.4 Discharge pressure with degree of Sub-cooling at 35°C condensing temperature at -29°C evaporating temperature.

The comparisons of both refrigerant that is the R-134a and mixture refrigerant R-290/R-600a shown in figure above with the discharge temperatures range from 50 to 75 Psi and sub-cooling variation from 2 to 10°C.

V.CONCLUSION

Ozone depletion and global warming are major environmental concerns with serious implications for the future development of the refrigeration based industries. For this reason, environmentally benign natural refrigerants have attracted a considerable attention. Therefore, in this study, the performance of some hydrocarbon refrigerants (R-290, R-600a, R-1270) and their mixture (R-290/R-600a) with proper proportion are alternative to R-134a in vapor compression system i.e. Split air-conditioner. Based on the experiments and theoretical investigation results, the following conclusions are drawn.

1) The degree of sub-cooling has positive effects on the refrigerating capacity. It has more effect of the refrigerant mixture on cooling capacity.

2) R-290/R600a refrigerant with 50% mixture exhibited higher refrigerating effect than R-134a. Therefore, terribly low mass of refrigerant needed for an equivalent capacity.

3) The average discharge temperature is required obtained for the mixture was 25% lower than R-134a.

4) Though there is difference between discharge temperature of R-134a and Mixture R-290/R600a. The low discharge pressure of the mixture means low

compressor work. The sub-cooling has major role on discharge pressure.

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