EXPERIMENTAL INVESTIGATIONS ON ISOBUTENE (R600A) REFRIGERANT WITH DIFFUSER AND NOZZLE IN A VCR SYSTEM

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Abstract: Vapour compression system typically utilised expansion valve to lower the pressure of the liquid refrigerant and deliver into the evaporator .The process of throttling is isenthalpic, which means that the kinetic energy produced during the pressure reduction is dissipated and eventually wasted. Through the action of Diffuser and nozzle, the compression section pressure higher than it would be in standard cycle and increases velocity of the refrigerant. In domestic refrigerator the power consumption increases with increase in compression load. The Diffuser provides additional compression to the refrigerant which reduces the mechanical work required for the compressor and nozzle provides increase in velocity.

Key words- Isobutene(R600a), Diffuser, Nozzle.

I INTRODUCTION

In today's world refrigeration systems are important for both domestic and industrial applications. Most of household refrigerators are work on vapour compression system. The leaked refrigerants from refrigerators may cause several problems to environment like ozone depletion, global warming etc. this is one of the big issues in refrigeration field. In order to rectify this problem we have to use environmental safety refrigerants like hydrocarbon**s,** their blends etc. R600a is one of the environmental safety refrigerants with zero ODP and GWP is less than 3. In VCR system process of throttling is isenthalpic, which means that the kinetic energy produced during the pressure reduction is dissipated and eventually wasted. Through the action of Diffuser and nozzle, the compression section pressure higher than it would be in standard cycle and increases velocity of the refrigerant. In domestic refrigerator the power consumption increases with increase in compression load. The Diffuser provides additional compression to the refrigerant which reduces the mechanical work required for the compressor and nozzle provides increase in velocity.

II LITERATURE REVIEW

Mohd.Aasim, NazeerAhmad, et.al [1] investigated an experimental study of isobutene (R-600a), an environment friendly refrigerants with zero ozone depletion potential (ODP) and very low global warming potential (GWP), to replace R-134a in domestic refrigerators. A refrigerator designed to work with R-134a was tested, and its performance using R-600a was evaluated and compared its performance with R-134a. The average COP using R-600a was 27% higher than R-134a respectively. The power consumption was reduced by 3.7% with R-600a refrigerant. The compressor ON time ratio was lowered by 6.98% with R-600a compared with R-134a. The experimental results showed that R-600a can be used as replacement for R-134a in domestic refrigerator. Hence, it can be concluded that R-600a can be used as a replacement to R-134a with better performance lesser energy consumption, pull down time and ON time ratio.

M.A.Sattaret, et.al. [2] Investigated and compared the performance of the refrigerator using R600a, R600 and a ternary mixture of mixture of R290/R600a/R600 as refrigerants with theR134a. The effects of evaporator and condenser temperatures on COP, refrigerating effect, compressor power and heat rejection ratio were investigated. The results show that the compressor consumed 3% and2% less energy than that of R134a at 28°C ambient temperature whenR600a and R600 was used as refrigerants respectively. The compressor power and COP of hydrocarbons and their blends shows that hydrocarbons can be used as refrigerants in the domestic refrigerator. The COP and other results obtained from the experiments show a positive indication of using HC as refrigerants in a domestic refrigerator.

Yari, Selvaraju et.al. [3] Developed a new cycle with Diffuser at compressor outlet in a VCR system using R134a as a refrigerant to enhance the performance of the cycle. Results obtained and showed that there was increase of 8.6% in coefficient of performance of the new compression refrigeration cycle as compared to the normal vapour compression refrigeration cycle with R134a. The experiment shows that the kinetic energy obtained at compressor outlet was converted into pressure energy. And the temperature, pressure at the diffuser outlet was increased when compared with that at compressor outlet. Due to this the reduction in compressor work takes place and COP of the system was increased. The experiment shows that the time required for the freezing in evaporator was also quicker than that of normal cycle.

Mahesh. [4]Conducted an experimental analysis of effect of the nozzle at the outlet of condenser on vapour compression refrigeration system performance. In his investigation he has found that the capillary tube in addition to the nozzle encourages further reduction of pressure before entering into the evaporator. This leads to the improvement of the refrigerating effect and coefficient of performance of the vapour compression refrigeration system. This is the most advantageous to provide a nozzle at the outlet of the condenser and to maintain the condenser pressure. The performance of vapour compression refrigeration system can be enhanced with the help of the nozzle at the outlet of the condenser.

III EXPERIMENTAL SETUP & METHODOLOGY

The layout of the tested refrigeration cycle as shown in figure 1. The main components are R600a compressor, proposed diffuser, condenser, capillary tube (expansion valve), nozzle and evaporator. The details of diffuser and nozzle as shown in fig 3 and fig 4 respectively and dimensions are in fig 5 and fig 6.By use of this diffuser kinetic energy is converted into pressure energy before entering the condenser. Increased pressure in diffuser helps to reduce the compressor work. Diffuser also reduces the condenser tube vibration as it decelerates and nozzle is for converting pressure energy to kinetic energy by this velocity of refrigerant increases before entering the evaporator which increases cooling rate of refrigerator.

Fig 1: experimental refrigerator

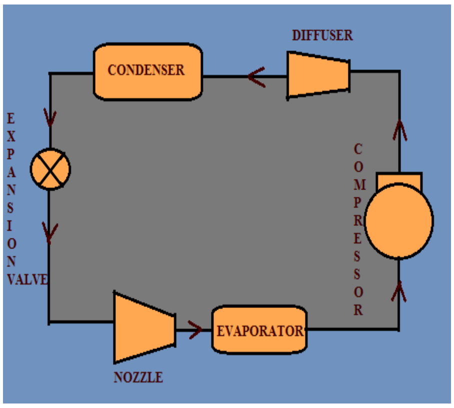

Fig 2: Line Diagram for experimental refrigerator

Fig3: Diffuser

Fig4: Nozzle

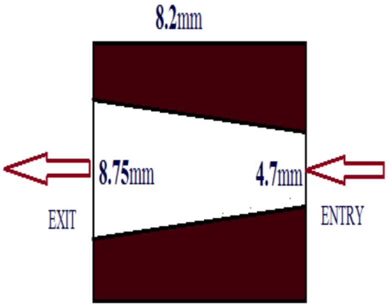

Fig 5: Line Diagram of Diffuser

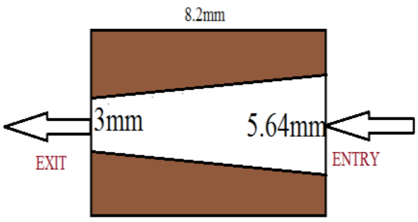

Fig 6: Line Diagram of Nozzle

3.2 *Experimental Procedure:*

Experimental test rig is developed from the 160L Refrigerator .In which first R600a compressor is fixed and then nitrogen gas is filled in the compressor and system and then leak detection test like soap bubble test conducted and conformed that there are no leakages In the system. Then vacuum is created by another compressor and then R600a refrigerant charged into the compressor. Temperature and pressure readings are noted by using thermocouples and pressure gauges respectively at required places for normal cycle. Then diffuser valves are opened and readings are noted and then diffuser valves are closed and nozzle valves are opened and readings are noted for nozzle cycle and finally both diffuser and nozzle valves are opened and combined readings were taken and results are calculated and compared.

IV RESULTS AND DISCUSSION

A) *Time Vs. Evaporator Temperature:*

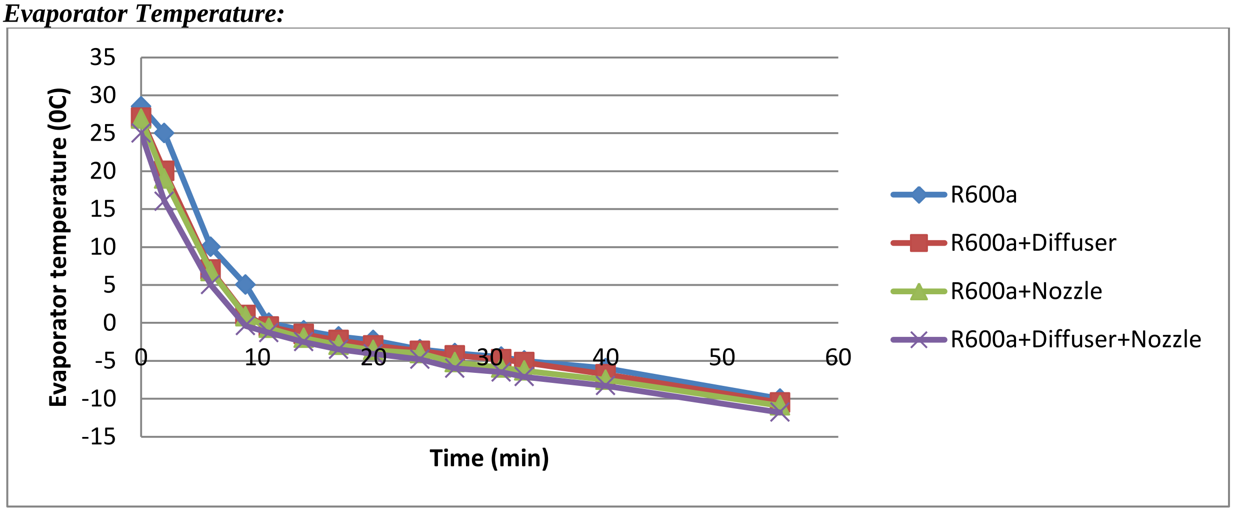

Fig 7: Time Vs. Evaporator Temperature

The above figure 7 indicates relation of time and evaporator temperature and fig clearly states that how the change of temperature changes with respect to the time. The time taken to reach -10^0c is minimum for the cycle which got diffuser and nozzle, then follows by cycle with diffuser, nozzle and normal cycle

B) Comparison of Compressor Work:

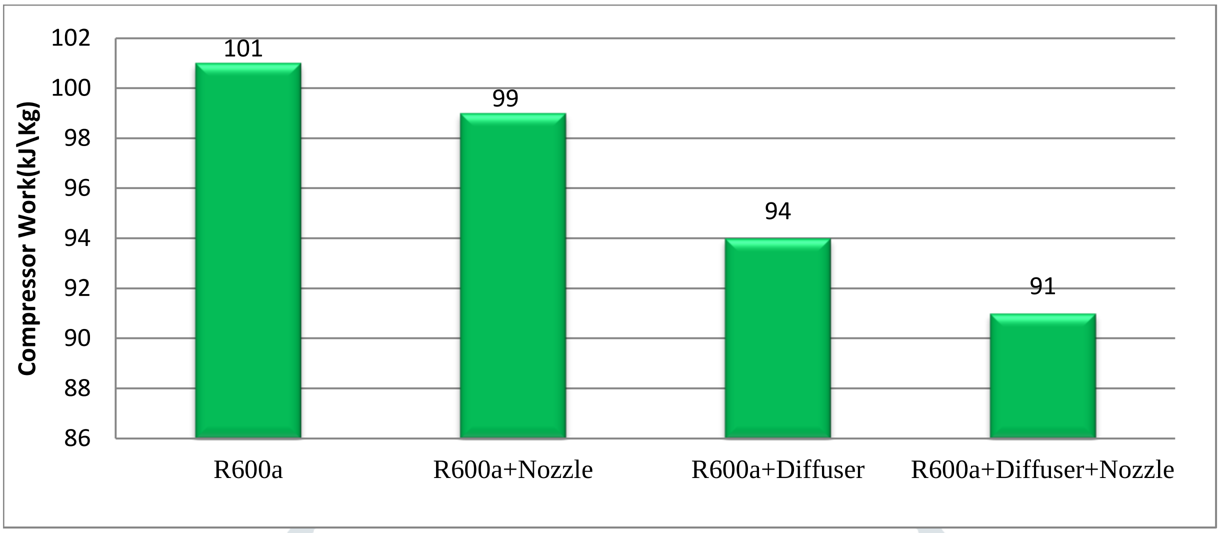

Fig 8: Comparison of Compressor Work

The figure 8 shows that compressor work required for ton of refrigeration is less in the case of R600a with with diffuser at condenser inlet and nozzle at evaporator inlet when compared with R600a normal cycle. The diffuser reduces the compressor work for the same refrigeration effect by converting all the kinetic energy available at compressor outlet to pressure energy and nozzle increases the refrigeration effect by increasing the flow in evaporator. Therefore the compressor work required for ton of refrigeration is less for the diffuser with nozzle when compared with R600a refrigerant in all the remaining cases.

C) Comparison of Refrigeration:

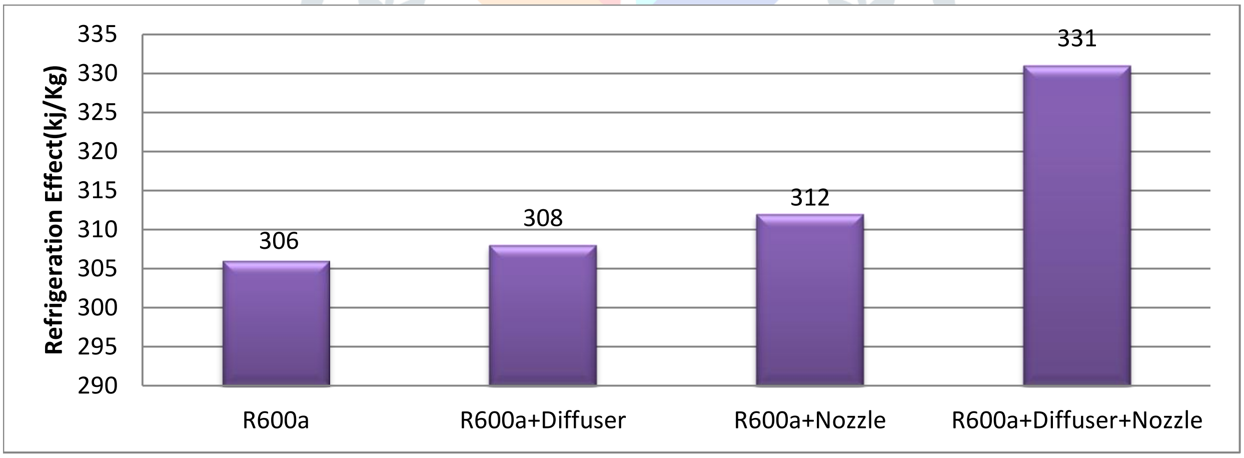

Fig 9: Comparison of Refrigeration

The figure 9 shows that the refrigeration effect for R-600ausing diffuser at condenser inlet and nozzle at out let of capillary is more when compared with normal cycle use of diffuser and nozzle the refrigeration effect is more because of the nozzle at the inlet of evaporator it increases the flow of refrigerant into the evaporator this causes the increasing of the cooling capacity and reduces cooling time of evaporator and cabin of the refrigerator and this increases refrigeration effect when compare to normal cycle

D) Comparison of Coefficient of Performance (COP):

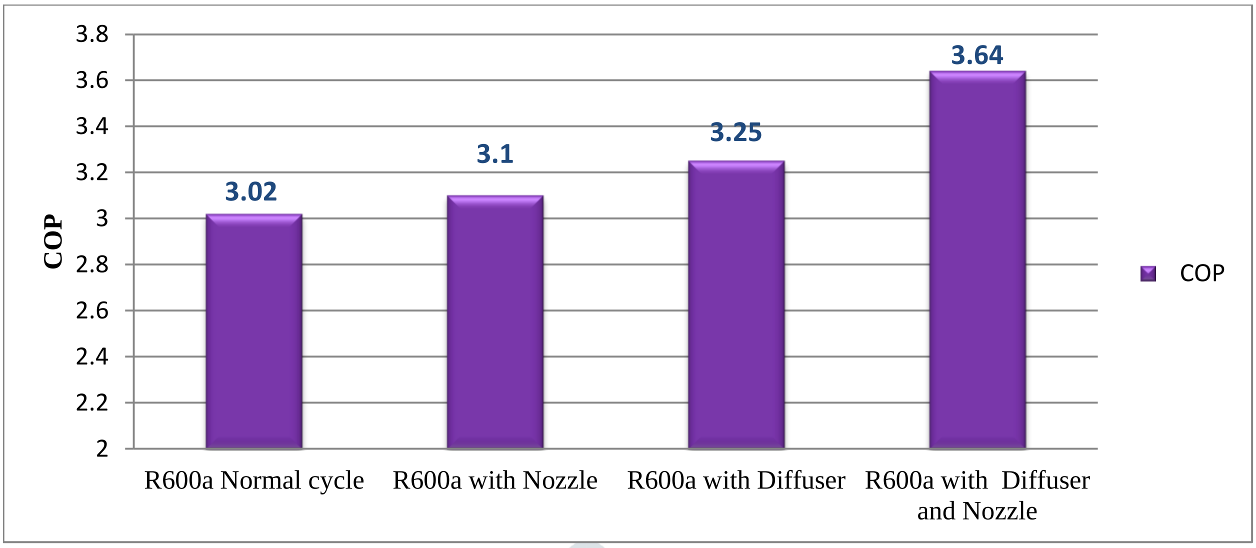

Fig 10: Comparison of Coefficient of Performance

The above graph states that the coefficient of performance for R-600a using both diffuser and nozzle is higher performance of than the all three cycles. Then the order is follows R600a with diffuser at the inlet of condenser, R600a with nozzle at in let of evaporator and R600a normal cycle.

V CONCLUSIONS

An experimental analysis is performed on Vapour Compression Refrigeration System with R600a used as refrigerant and the system is run for four cases. Those are normal cycle, diffuser at condenser inlet cycle, nozzle at evaporator inlet and diffuser with nozzle. In these four cases the performance parameters like Refrigeration effect, Compressor work, COP, Power consumption and heat rejection rate in condenser are investigated and evaluated. Based on the results the following conclusions are drawn:

- The compressor work saved due to nozzle inlet at evaporator inlet to the normal cycle is 2.02%. The compressor work saved due to diffuser cycle when compared with normal cycle is 7.44%. The compressor work saved due to diffuser at condenser inlet and nozzle at inlet of evaporator when compared to the normal cycle is 10.9%
- The refrigeration effect for R-600a using diffuser at condenser inlet and nozzle at evaporator inlet is more than that of all the remaining three cases. The refrigeration effect is 8.16% increased when compare with normal cycle.
- The percentage increase of COP with nozzle to the normal cycle is 4.3%. The percentage increase of COP for diffuser cycle when compared with normal cycle is 8.27%. The percentage increase of COP for diffuser and nozzle when compared to the normal cycle is 20.5%.
- The time taken for R-600a using diffuser at condenser inlet and nozzle at evaporator inlet is less than that of all the remaining three cases. Around 15mins time was saved to get the same freezing temperature (-6^{0}C) when compare with normal cycle.

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