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Performance Improvement of an Air Conditioning System Using Matrix Heat Exchanger

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***Abstract*—The objective of this work is to study the performance of a split air conditioning system with and without a Matrix Heat Exchanger (MHE) .The experiment was done using HFC134a as the refrigerant and Polyol-ester oil (POE) as the conventional lubricant in the air conditioning system. The performance of the split air conditioning system with HFC134a/POE oil system was compared with HFC134a/POE oil/MHE for different load conditions. The result indicates that the system performance has improved when HFC134a/POE oil/MHE system was used instead of HFC134a/POE oil system and there was also a reduction in power consumption at all load conditions. The HFC134a/POE oil/MHE works normally and safely in the air conditioning system. HFC134a/POE mineral oil/MHE system reduced the energy consumption by 33.84% when compared with the HFC134a/POE oil system. There was also an enhancement in coefficient of performance (COP) when MHE was introduced in the normal system.**

***Keywords*—Split air conditioner, HFC134a, POE oil, Matrix Heat Exchanger, COP, Vapour Compression System**

I. INTRODUCTION

Most of the refrigeration system uses conventional Vapour Compression Refrigeration (VCR) cycle which has a low Co-efficient of Performance (COP).But installing a heat exchanger to the VCR makes it more efficient. The refrigerating effect of a refrigeration cycle mainly depends on the temperature of refrigerant that is entering the expansion valve. When it is compared with standard vapour compression cycle, the system using the heat exchanger will have increasing refrigerating effect as refrigerating temperature entering the expansion valve is low due to the presence of heat exchanger. Hence both the capacity and coefficient of performance will be increased. This study aims to investigate experimentally the effect of Matrix Heat Exchanger (MHE) in a split air conditioner system and compare the results.

Shengshan Bi et.al [1] conducted a performance study of a domestic refrigerator using R134a/mineral oil/nano-Ti02 as working fluid. A reduction in 21.2% energy consumption for a mass proportion of 0.06% of nano particle was obtained with R134a/POE oil system.

R saidur et.al [2] conducted an experiment in a domestic refrigerator with R134a/mineral oil with TiO2 nanoparticle to determine the thermal physical properties of these particles suspended in the refrigerant and lubricating oil refrigerating systems. The energy consumption was saved by 26.1% with 0.1% mass fraction Ti02 nanoparticle compared to the R134a and POE oil system

Shengshan Bi et.al [3] conducted a performance study of a domestic refrigerator using R600a/mineral oil/nano-Ti02 as working fluid. They got a reduction of 9.6% energy consumption for 0.5g/L of Tio2-R600a nanoparticle. This system rejected less heat to the environment so it is safer in environmental aspects.

II. EXPERIMENTAL SETUP

A. Experimental System

The experimental setup is a modification of conventional vapour compression refrigeration cycle. The basic components are all same as that of VCR namely compressor, condenser, expansion valve and evaporator. Fig.1 shows the photograph of experimental set up. The fabricated compact heat exchanger is installed between the condenser and the expansion valve. The flow here is counter flow type as the effectiveness is more when compared with the parallel flow type heat exchangers. The hot fluid flows through the inner tube of the compact heat exchanger and the cold stream passes through the outer tube. The hot fluid from condenser is given as input and the cold fluid coming out of the heat exchanger is passed to the expansion valve. The cold fluid from the evaporator is given as cold in and the cold out is passed to the compressor to repeat the cycle. Copper tubes are used to connect the components and observations are made under different loading conditions. A split air conditioner was used as an experimental setup and the system was modified by adding a matrix heat exchanger by making a bypass line. The matrix heat exchanger is a tube in tube heat exchanger. The temperature at various points was noted using thermocouples. The power consumption of the split air conditioner was measured using a digital energy meter.

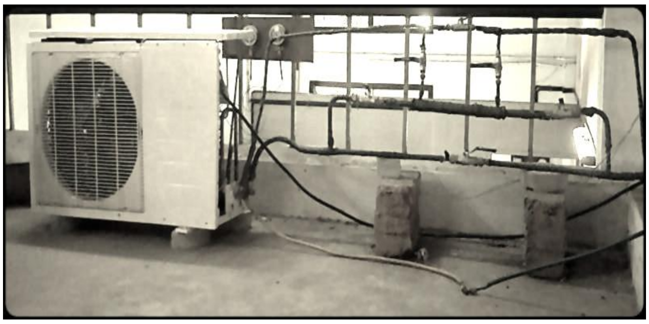

Fig. 1 Photograph of experimental set up of an air conditioner with MHE

B. Experimental Procedure

After the integration of the components the heat exchanger is isolated so that the system is working normally without the heat exchanger. The tests were conducted at 1000W, 1500W and 2000W using R134a/POE oil. At each load conditions temperature and pressure at salient points were noted down at regular intervals. The experiment was done until steady state condition was attained. After taking the readings, the heat exchanger valves are opened and the system starts working with heat exchanger. The loading procedures are repeated until steady state conditions achieved.

III. RESULTS AND DISCUSSIONS

Figure 2 shows comparison of the work done by the compressor with HFC134a/POE oil and HFC134a/MHE mineral oil system. The work done by the compressor was greater for the HFC134a/POE oil system than the HFC134a/POE/MHE mineral oil system. This was because the condenser-evaporator pressure difference was high for the system when operating with HFC134a/POE oil than the HFC134a/POE/MHE mineral oil system. As the work done by the compressor increases the power consumption also increases

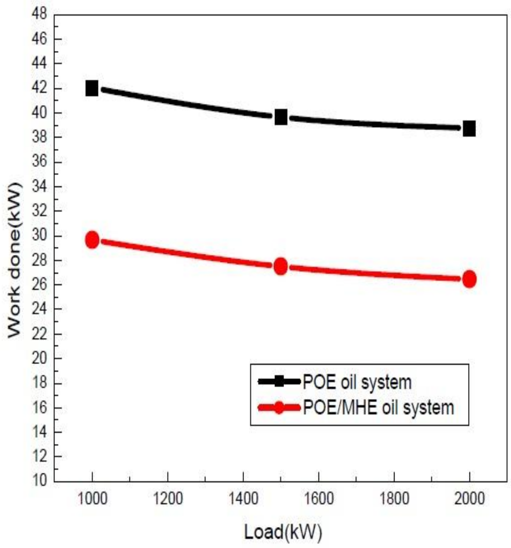

Fig.2 variation of work done vs cooling load

Figure 3 shows the COP variation of HFC134a/POE oil and HFC134a / POE/MHE mineral oil system. The COP was greater for the HFC134a/POE/MHE mineral oil system. This may be due to reduction in compressor work done at different load conditions.

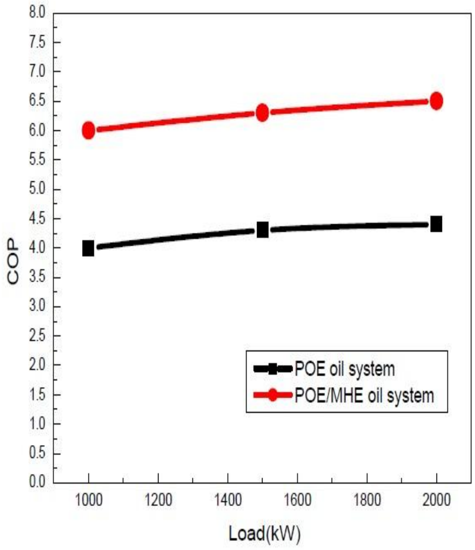

Fig.3 variation of cop vs cooling load

Figure 4 shows the comparison of power consumption of the air conditioning system. As the work done increases the power consumed by the system also increases. Power consumed by the compressor is less when the system is operating with MHE. The power consumption of HFC134a/POE/MHE mineral oil system is lower than the HFC134a/POE oil. These results show that the performance of the air conditioner with HFC134a/POE/MHE mineral oil system is better than that of the HFC134a/POE oil system and there was an improvement in the operation when the air conditioner works with MHE.

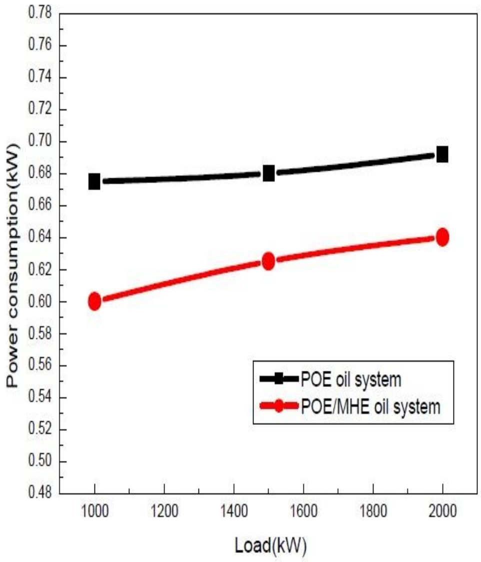

Fig.4 variation of power consumption vs load

Figure 5 shows the variation of cooling capacity of the air conditioner with load. The increase in the cooling capacity of R134a/POE/MHE oil system may be due to much lower temperature attained compared to the conventional system.

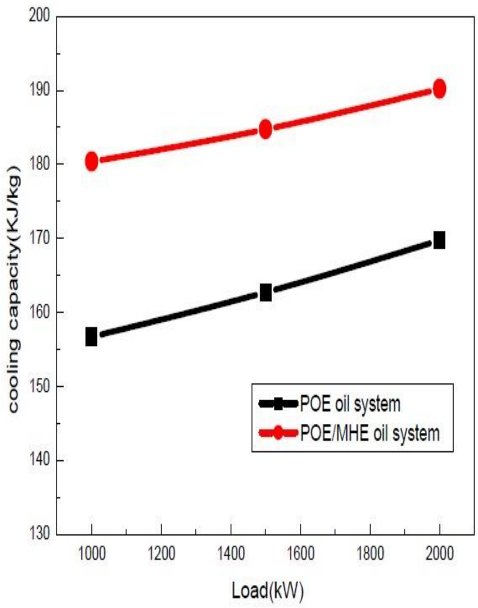

Fig.5 variation of cooling capacity vs cooling load

Table 1 gives a performance comparison of the conventional system and the modified one. Various parameters such as COP, work done, refrigerating effect, and power consumption are analysed.

Table 1: PERFORMANCE COMPARISON of an AIR CONDITIONER with R134A/POE OIL SYSTEM and R134A/POE/MHE OIL SYSTEM

parameters	R134a/POE Oil system Various Loading conditions			R134a/POE Oil/MHE system Various Loading conditions		
	1000W	1500W	2000W	1000W	1500W	2000W
Work done W (KJ/kg))	42.04	39.65	38.76	29.65	27.5	26.45
Power P (kW)	0.675	0.68	0.695	0.6	0.625	0.65
Refrigerating Effect (KJ/kg)	156.65	162.4	168.47	180.56	187.86	190.44
COP	4	4.3	4.3	6.3	6.5	6.8
Evaporative Outlet temperature (T^0c)	15.7	16.2	16.5	17	18.5	20

IV. CONCLUSIONS

The matrix heat exchanger worked normally and efficiently with the air conditioner. The power consumption of the HFC134a/POE/MHE mineral oil system was reduced by 33.84% when compared with the conventional one. The results show that the COP of HFC134a/POE/MHE mineral oil system was higher than that of the conventional system. Most of the refrigeration system uses conventional vapour compression refrigeration cycle which has a low co-efficient of performance, but installing a matrix heat exchanger to the VCR makes it more efficient. The refrigerating effect of a refrigeration cycle mainly depends on the temperature of the refrigerant entering the expansion valve. The refrigerating temperature entering the expansion valve was low due to the presence of heat exchanger So when it was compared with conventional vapour compression cycle, the system using the heat exchanger had more refrigerating effect.. So both capacity and coefficient of performance increased.

ACKNOWLEDGEMENT

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