International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 4, Issue 12, December-2018

PERFORMANCE IMPROVEMENT OF VCR SYSTEM USING SIO_2 NANO POWDER WITH POLYOLESTER OIL AND MINERAL OIL AS LUBRICANT

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Abstract: Lubrication Oil is required for smooth running of the compressor in the vapour compression refrigeration systems. In order to reduce friction between the moving parts of the compressor, lubrication is much needed. Nano particles as additives are also considered to improve the lubrication properties of lubricant oil, Nano particles are used as additives for the compressor of vapor compression refrigeration systems. In the present work, SiO_2(silica) Nano powder (0.5% W/w) was mixed with Polyolester(POE) oil and Mineral oil separately. Experiments are done with R134a as refrigerant and it was found that power consumption was decreasing with Polylester oil and Mineral lubrication oils when compared with normal compressor oil. By incorporating nozzle at the inlet of the evaporator section, it converts pressure enrgy into kinetic enery, further expansion takes place after expansion in capillary tube. With nozzle refrigeration effect is increased. With the combined effect of SiO_2 Nano powder with Oils and Nozzle at entry section of the evaporator, more COP is produced when compared with nozzle close condition at the inlet of the evaporator.

Keywords: VCRS, Nano silica(SiO_2) powder, COP, Mineral oil, POE oil, R134a refrigerant, Nozzle at inlet of evaporator section.

INTRODUCTION

In vapor compression refrigeration system(VCRS), the working fluid undergoes phase change from liquid to vapour at the heat absorption section(evaporator) and then from vapour to liquid at the heat rejection section(condenser). The Coefficeint of Performance, which is the ratio of refrigeration effect produced at the heat absorption section to the work input by the compressor. COP can be enhanced either by decreasing the work input of compressor of or by increasing the heat removal rate. The rapid advancement in Nano-technology have lead to emerging of new generation heat transfer fluids called Nano fluids. Nano fluids are new class of fluids which consist of a main fluid solution with Nano sized particles (1–50 nm) suspended in main base fluid. The Nano fliuds are the specific concentration mixtures of the base fluid and the Nano particles. The main base fluid can be lubricating oil, water, refrigerant ,etc. the Nano particles are Al, CuO, Al_2O_3 ,TiO_2, SiO_2 etc. mixed together to form a colloid solution called Nano fluid. Recently scientists used Nano particles in the field of refrigeration systems because of its improvement in heat transfer capabilities to enhance the COP and reliability of vapour compression refrigeration system. It reduced the power consumption required to get the refrigeration effect to some extent. Nozzle is an expansion device which converts pressure energy into kinetic energy. If nozzle is placed at the entry of heat absorption section(evaporator), further expansion takes place and more refrigeration effect will produce.

EXPERIMENTAL SETUP & METHODOLOGY

In the present work, refrigerator with 165 litre capacity is used. The main components of VCRS are compressor, condenser, capillary tube (expansion valve), proposed nozzle and evaporator section. The details of proposed nozzle as shown in fig.2.1 respectively and dimensions of nozzle included in line diagram as shown in fig.2.2. Nozzle converts pressure energy into kinetic energy. Because of this kinetic energy, velocity of refrigerant increases before entering into the evaporator which enhances the cooling rate of the refrigerator.

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Fig.2.1Nozzle Cross Section

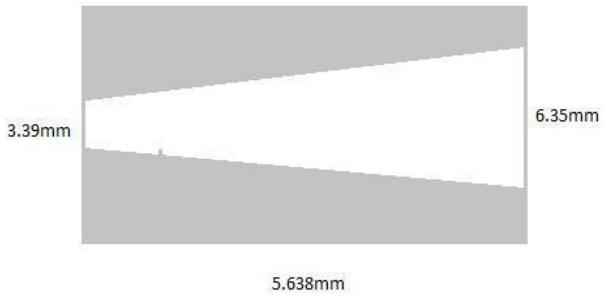


Fig.2.2 Nozzle With Dimensions

A. SiO_2 Nano Powder and its properties:

Properties of SiO_2 Nano particles is as shown in tabular column. Powder form of SiO_2 is shown in figure 2.3

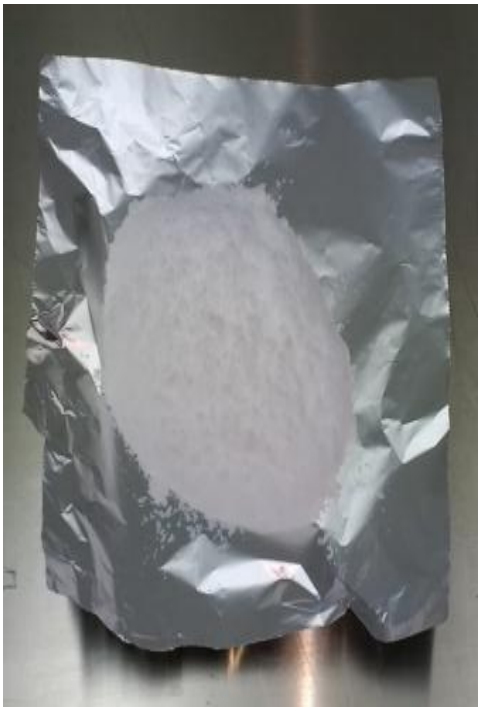


Fig 2.3 SiO_2 in Powder Form

TABLE I. SiO_2 Properties

Melting Point (°C)	1713
Boiling Point (°C)	2950
Density (Kg/m^3)	2220
Specific heat (J/Kg K)	745
Thermal Conductivity (W/m K)	1.4
Molecular Mass (g/mol)	60.08
Specific Surface Area (SSA)(m^2/g)	250
Average Particle Size (APS)(nm)	10-20

B. Preparation of Nano lubricant:

In the preparation of Nano lubricant, lubrication oils are base fluids. Nano particles are mixed with these base fluids to make the Nano lubricant. In the present work, two types of lubrication oils are used.

1. Polyloester Oil.
2. Minearl Oil.

SiO2 Nano fluid is prepared by adding weighted amount of SiO2 particles to the lubricant in the compressor of the domestic refrigerator. The concentration of the SiO2 in the Polyolester oil is 0.5% W/w. To get the uniform mixing of the particles in the Polyolester oil, the mixture is placed on the ultrasonic vibrator. Ultrasonic vibration is used to stabilize the dispersion of the Nano particles in the oils. After preparing SiO_2 Nano lubricant with polyolester oil, same concentration of 0.5% SiO_2 Nano powder mixed with Mineral oil and stirred in the Ultrasonic Vibrator. Fig 2.4 shows lubrication oils before mixing with SiO2. Fig 2.5 shows mixing of lubrication oil with SiO_2 in a beaker. Fig 2.6 shows stirring of SiO_2 with lubricant in Ultrasonic vibrator.



Fig.2.4 Oils before mixing of SiO_2



Fig.2.5 Mixing process



Fig.2.6 Stirring in Ultrasonic Vibrator



Fig.2.7 After mixing SiO_2 with Mineral oil

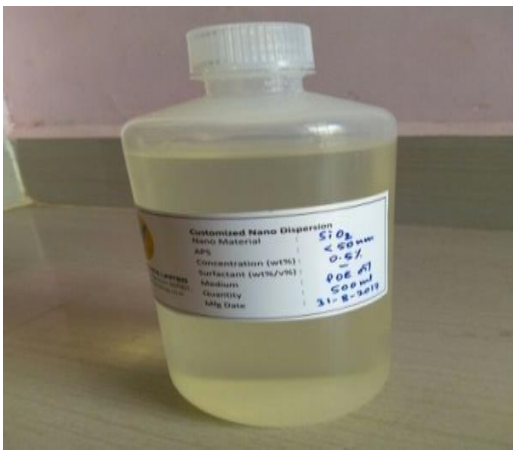


Fig. 2.8 After mixing SiO_2 with Polyolester oil

Fig 2.7 shows after mixing of SiO_2 with Mineral oil and fig 2.8 shows after mixing of SiO_2 with Polyolester oil.

After charging Nano lubricant in the compressor, and charging R134a into the VCR system, Experimental setup is ready to do the experiment. The VCR system with nozzle fixed at entry of evaporator section is shown in fig 2.9.



Fig.2.9 Refrigerator with Nozzle at inlet of Evaporator

C Methodology

The refrigeration system experiment was carried out with

1. Normal compressior oil(with and without nozzle),
2. Mineral oil (with and without nozzle)
3. 0.5% of Silica Nano powder with Mineral oil(with and without nozzle)
4. Polyolester Oil (with and without nozzle)
5. Polyolester Oil with 0.5% of Silica Nano powder(with and without nozzle)

The oils are filled in the compressor and VCR is charged with R134a. Power supply is given by switching on the refrigerator. Readings are noted for every 5^{o}C change in evaporator temperature. Temperature, pressure and time are noted for change in evaporator temperature and charts are drawn. The same procedure is followed in the remaining nine cases.

III. RESULTS AND DISCUSSIONS

Experiments are carried out with all conditions. Energy consumption is calculated and charts are drawn. Refrigeration effect is calculated. Coefficient of Performance is calculated and charts are drawn. The bar charts shows the percentage decrease in energy consumption, increase in refrigeration effect and increase in COP. Time taken for every 5^{0}c change in evaporator temperature and line chart shows Time vs Evaporator temperature.

A. Percentage decrease in energy consumption when compared with normal compressor oil without nozzle

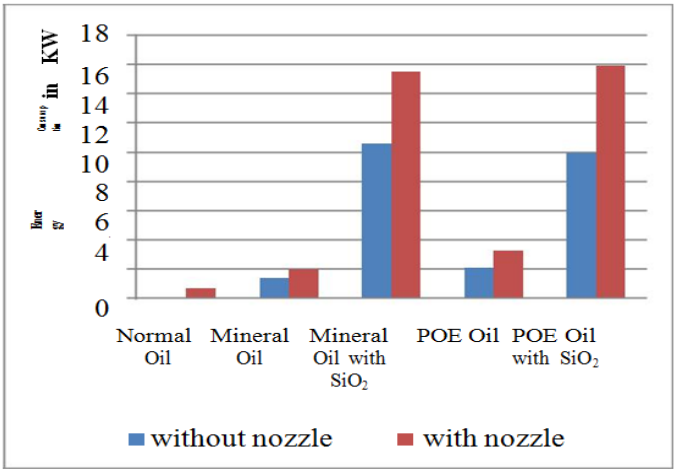


Fig 1. % Decrease in energy consumption

From fig.1, it is clear that decrease in power consumption is more(15.90%) in case of Polyolester Oil+ SiO_2+ Nozzle, and 15.478% in case of Mineral Oil+SiO_2+Nozzle.

B. Percentage increase in refrigeration effect when compared with normal compressor oil without nozzle

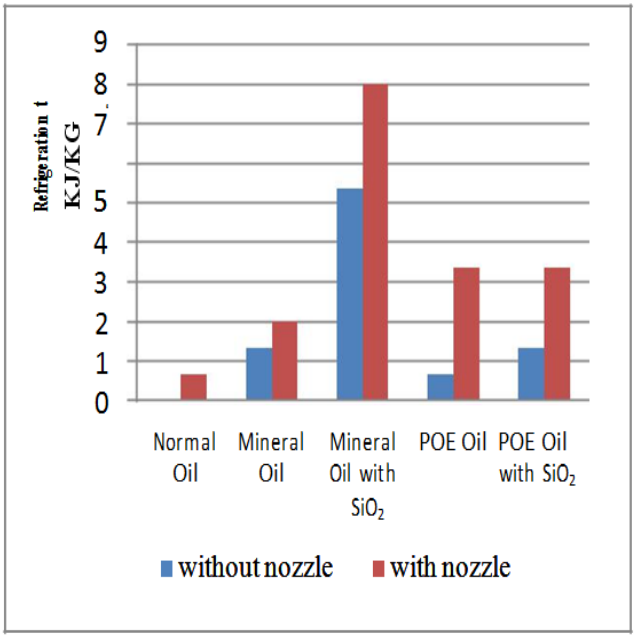


Fig 2. % Increase in Refrigeration effect

From fig.2, it is clear that refrigeration effect is more in case of Mineral Oil +SiO_2+Nozzle.

C. Percentage increase in C.O.P when compared with normal compressor oil without nozzle

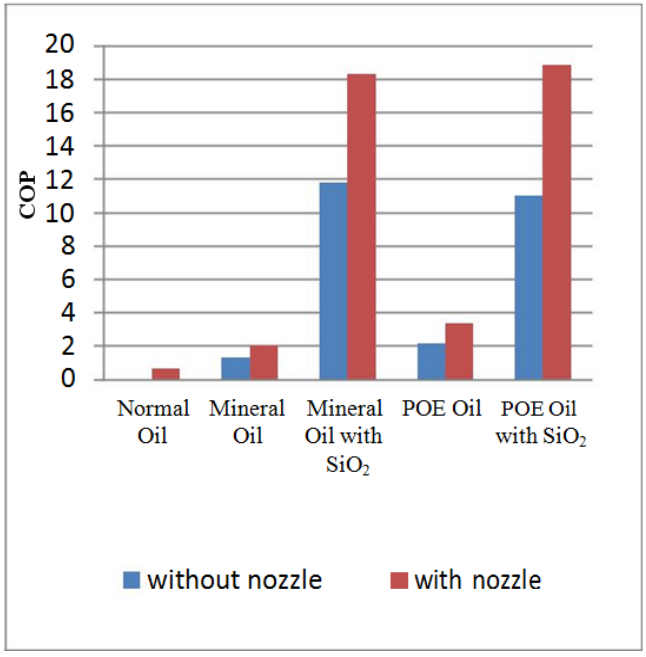


Fig.3. % Increase in COP

Form fig.3, it is clear that % increase in COP is more (18.83%) in case of Polyolester Oil+SiO_2+Nozzle, and 18.285% in case of Mineral Oil+SiO_2+Nozzle open condition .

D. Time vs Evaporator Temperature

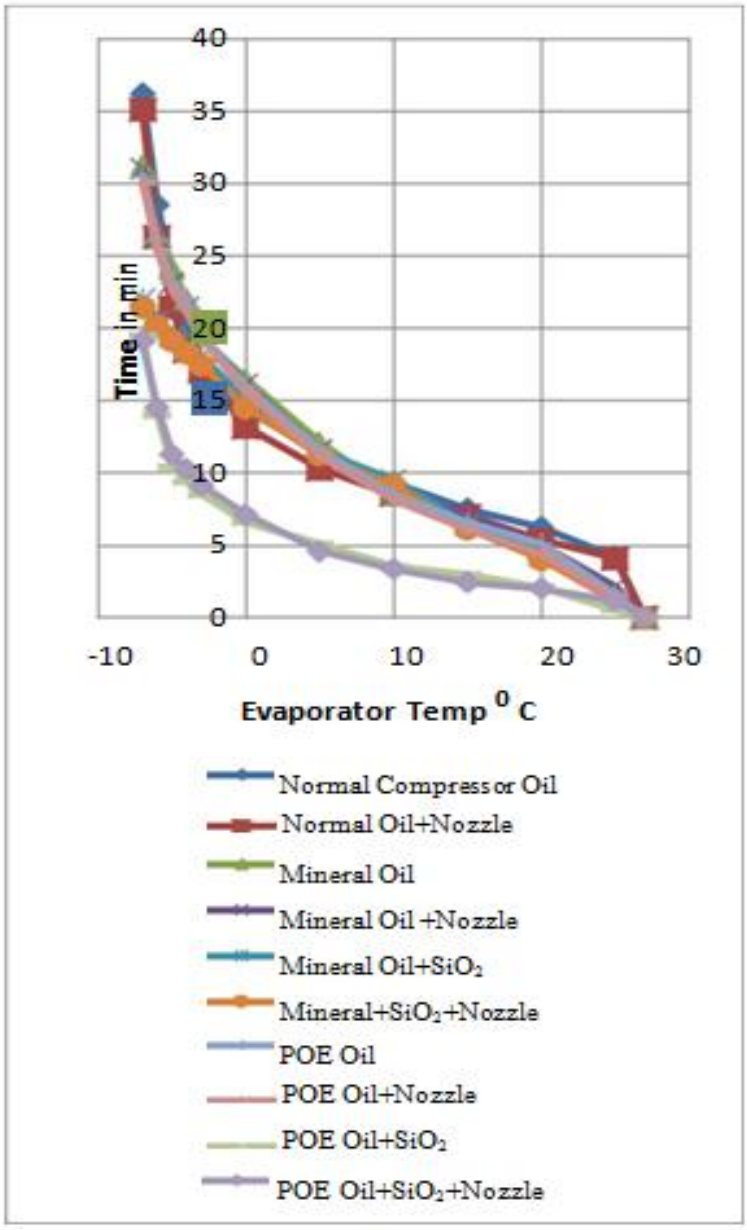


Fig.4 Time vs Evaporator Temperature

Form fig.4, it is clear that time taken to reach -7 ^{0}C is less(19.12 min), when the VCR system is run with POE Oil+SiO_2 +Nozzle open condition. With Mineral Oil mixed with SiO_2, time taken to reach -7^{0}C is 21.49 min

IV CONCLUSIONS

An experimental analysis is performed on Vapour Compression Refrigeration System with R134a used as refrigerant and the system is run for ten cases as shown in charts.

From results and discussions, it was found that mixing of 0.5% SiO_2 with POE oil and mineral oil increases the overall performance of VCR system significantly.

1. Compressor work saved by 15.90% when 0.5% SiO_2 mixed with POE oil with nozzle open condition and it is high in all cases.

2. Increase in refrigeration effect is found more in 0.5% SiO_2 mixed with mineral oil with nozzle open condition.

3. COP is increased with SiO_2 Nano mixed with mineral oil and polyolester oil. Highes percentage increase of 18.83% in case of 0.5% SiO_2 with polyolester oil with nozzle open condition.

4. Time Taken to reach -7^0C is less for POE oil mixed with SiO_2 with nozzle open condition, when compared to other conditions.

5. The results indicated that, R-134a works better with Polyolester Oil than Mineral Oil with nozzle open condition and mixed with SiO_2 Nano powder, When compared to other conditions.

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