

# Experimental Performance Analysis of VCR System Using Nano Additive Lubricant

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**Abstract-** Refrigeration may be define as lowering the temperature of an enclosed space by removing heat from the space and transferring heat elsewhere. It consists of four components, viz. compressor, condenser, expansion device and evaporator. Vapour Compression Refrigeration System is a system where refrigerant under goes phase change to produce cooling effect. This project involves introduction of nanoparticles, in the lubrication oil (As per refrigerant used in system) known as Nano-lubricant. The COP is calculated at the different volume fraction and is compared with that of the old VCR system (only lubricating oil without nanoparticles). The Nano-particles in Nano-lubricant improves the tribological characteristics when introduced in compressor of VCR system which in turn reduces the compressor work. By reduction in compressor work, it is expected that the COP of this VCR system would improve.

**Keywords-** VCR system, Nano additive, Lubricant

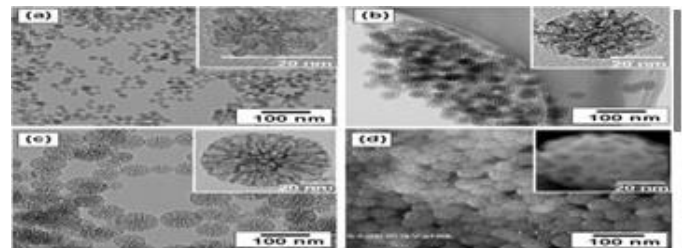
## I. INTRODUCTION

Refrigerant is the mixture of substance. Basically, any time talk about a liquid will be used for par of heat pump and refrigeration cycle. Various working fluids are used in much purpose for many tasks. Fluids sensible for refrigeration purposes can be portrayed into essential and optional refrigerants. Essential refrigerants are those liquids, which are used particularly as working liquids, for example in vapor pressure and vapor retention refrigeration frameworks. These liquids give refrigeration by encountering a phase change process in the evaporator. Auxiliary refrigerants are those fluids, which are used for transport warm vitality from one area to other. Auxiliary refrigerants are moreover known under the name bitter water or fluid impetuses. Air as a refrigerant. Air is so every now and again utilized as a coolant that air cooling is from time to time said in a refrigeration setting. Because to the low boiling point of it constituents and low heat conveying limit, air is rarely utilized as a refrigerant.

Nanoparticle:

Nanoparticles are particles between 1 and 100 nanometers (nm) in size with a surrounding interfacial layer. The interfacial layer is an integral part of Nano scale matter, fundamentally affecting all of its properties. The interfacial layer typically consists of ions, inorganic and organic molecules. Organic molecules coating inorganic nanoparticles are known as stabilizers, capping and surface ligands, or passivation agents. In nanotechnology, a particle is defined as a small object that behaves as a whole unit with respect to its transport and properties. Particles are further classified according to diameter.

Images of prepared mesoporous silica nanoparticles with mean outer diameter: (a) 20nm, (b) 45nm, and (c) 80nm. (d) Image corresponding to (b). The insets are a high magnification of mesoporous silica particle.



(NANOPARTICAL)

## II. LITERATURE REVIEW

Application of SiO<sub>2</sub> Nanoparticles as Lubricant Additive in VCRS: An Experimental Investigation. This report has been written by the author Nilesh S. Desai and P.R.Patil. In this work, the SiO<sub>2</sub> Nano-oil is proposed as a promising lubricant to enhance the performance of vapour compression refrigerator compressor. The stability of SiO<sub>2</sub> nanoparticles in the oil is investigated experimentally. It was confirmed that the nanoparticles steadily suspended in the mineral oil at a stationary condition for long period of time. The application of the Nano-oil with specific concentrations of 1%, 2% and 2.5 % ( by mass fraction) were added in the compressor oil. The VCRS performance with the nanoparticles was then investigated using energy consumption tests. The result shows the COP of system were improved by 7.61%, 14.05% &

11.90%, respectively, when the Nano-oil was used instead of pure oil.

Application of TiO<sub>2</sub> nanoparticles as a lubricant-additive for vapour compression refrigeration systems - An experimental investigation. This report has been written by the author R. Krishna Sabareesh, N. Gobinath, V. Sajith, Sumitesh Das and C.B. Sobhan. The coefficient of performance of a refrigeration system can be improved if a reduction in the work of compression can be achieved by a suitable technique, for a specified heat removal rate. The present study investigates the effect of dispersing a low concentration of TiO<sub>2</sub> nanoparticles in the mineral oil based lubricant, on its viscosity and lubrication characteristics, as well as on the overall performance of a Vapour Compression Refrigeration System using R12 (Dichlorodifluoromethane) as the working fluid. An enhancement in the COP of the refrigeration system has been observed and the existence of an optimum volume fraction noticed, with low concentrations of nanoparticles suspended in the mineral oil. The physics involved in the interaction of nanoparticles with the base fluid has been further elucidated by estimating the Optical Roughness Index using a Speckle Interferometer, by performing measurements on the pin surface following tests with a Pin-On-Disk tester.

Comparison of Performance of a Domestic Refrigerator using Al<sub>2</sub>O<sub>3</sub> Nanoparticles with PAG Oil and Mineral Oil as Lubricant. This report has been written by the author R K Adyanshee Pattanayak, Prasheet Mishra, Amitava Sarkar. Nano fluid has caught the attention of many researchers for its novel properties which makes it unique and different in the field heat transfer, specifically thermal conductivity. So the present study comprises of the use of Nano fluid in enhancement of the performance of a domestic refrigerator. Comparison of performance is analysed between the domestic refrigerator using refrigerant R134a (tetrafluoroethane) and PAG Oil with the same refrigerant and Mineral oil with different mass fraction of Al<sub>2</sub>O<sub>3</sub> nanoparticles. From the experimental observation it was found that for 0.2% mass fraction of nanoparticles, the coefficient of performance of the system increases by 7.75% and 19.38% when we take PAG Oil and Mineral Oil as lubricant respectively. As a result of comparison of COP between PAG Oil with 0.2% mass fraction of nanoparticles and Mineral Oil with the same mass fraction of nanoparticles, Mineral oil mixture gives an increase of 10.79% of COP over PAG Oil mixture. Likewise, for 0.4% mass fraction of nanoparticles the COP of the system increases by 14.48% and 25.3% for PAG Oil and Mineral Oil respectively. Here also Mineral Oil mixture gives an enhanced COP of 9.44% over PAG Oil mixture.

A review on the performance of nanoparticles suspended with refrigerants and lubricating oils in refrigeration systems. This report has been written by the author R. Saidur, S.N. Kazi, M.S. Hossain, M.M. Rahman and H.A. Mohammed. Recently scientists used nanoparticles in refrigeration systems because of their remarkable improvement in thermo-physical, and heat transfer capabilities to enhance the efficiency and reliability of refrigeration and air conditioning system. In this paper thermal- physical properties of nanoparticles suspended in refrigerant and lubricating oil of refrigerating systems were reviewed. Heat transfer performance of different Nano refrigerants with varying concentrations was reviewed and review results are presented as well. Pressure drop and pumping power of a refrigeration system with Nano refrigerants were obtained from different sources and reported in this review. Along with these, pool boiling heat transfer performance of CNT refrigerant was reported. Moreover, challenges and future direction of Nano fluids/Nano refrigerants have been reviewed and presented in this paper. Based on results available in the literatures, it has been found that Nano refrigerants have a much higher and strongly temperature-dependent thermal conductivity at very low particle concentrations than conventional refrigerant. This can be considered as one of the key parameters for enhanced performance for refrigeration and air conditioning systems. Because of its superior thermal performances, latest up to date literatures on this property has been summarized and presented in this paper as well. The results indicate that HFC134a and mineral oil with TiO<sub>2</sub> nanoparticles works normally and safely in the refrigerator with better performance. The energy consumption of the HFC134a refrigerant using mineral oil and Nano particles mixture as lubricant saved 26.1% energy with 0.1% mass fraction TiO<sub>2</sub> nanoparticles compared to the HFC134a and POE oil system. It was identified that fundamental properties (i.e. density, specific heat capacity, and surface tension) of Nano refrigerants were not experimentally determined yet. It may be noted as well that few barriers and challenges those have been identified in this review must be addressed carefully before it can be fully implemented in refrigeration and air conditioning systems.

### III. SUMMARY OF THE LITERATURE REVIEW

Nano lubricant is an advanced lubrication type with increased capabilities in terms of losses and heat transfer enhancement. Nanoparticles (1 to 100 nm in diameter) are added to oil to make nano lubricants, and these can then be used in applications such as the compressors of refrigeration systems. A considerable number of studies on the applications or thermal properties of nano refrigerants have been done. conducted a study on refrigeration using

R134a/TiO<sub>2</sub> nano refrigerant, with results that indicated the COP was better and the energy savings were 26.13% at a 0.1% mass fraction.

$$\begin{aligned} \text{Theoretical COP} &= (h_1 - h_4) / (h_2 - h_1) \\ &= (427.424 - 254.14) / (461.018 - 427.424) \\ &= 5.15 \end{aligned}$$

**IV. READINGS, CALCULATION AND RESULTS**

*A. Readings Of The Test Setup Without Nano Additive Lubrincant*

| Ex. No.                             |                   | 1        | 2        | 3        | 4        |
|-------------------------------------|-------------------|----------|----------|----------|----------|
| Mass flow rate of Evaporator ( lps) |                   | 0.067    | 0.033    | 0.04     | 0.05     |
| Mass flow rate of Condenser ( lps)  |                   | 0.008558 | 0.008558 | 0.008558 | 0.008558 |
| Compressor Work( kWh)               |                   | 0.421    | 0.428    | 0.426    | 0.40     |
| Temperature of Refrigerant ( °C)    | Evaporator inlet  | 0        | 1        | 1        | -1       |
|                                     | Evaporator outlet | 26       | 27       | 29       | 30       |
|                                     | Condenser inlet   | 81       | 81       | 82       | 83       |
|                                     | Condenser outlet  | 40       | 39       | 40       | 38.5     |
| Temperature of water( °C)           | Inlet             | 30       | 30       | 30       | 29       |
|                                     | outlet            | 27       | 27.5     | 28       | 27       |
| Pressure (psi)                      | Condenser         | 200      | 190      | 190      | 190      |
|                                     | Evaporator        | 25.5     | 25       | 25       | 25       |

*B. Sample Calculation*

1) Refrigerating effect is balanced by water circulation.

Heat given by the water=Refrigerating effect

$$\begin{aligned} R.E &= m.C_p.\Delta T \\ &= 1/15 \times 4.186 \times 2 \\ &= 0.5528 \text{ kW} \end{aligned}$$

2) Compressor work

$$\begin{aligned} C_w &= (n \times 60) / 3000 \\ &= (22 \times 60) / 3000 \\ &= 0.44 \text{ kW} \end{aligned}$$

3) Actual COP

$$\begin{aligned} [(COP)]_{act} &= (R.E.) / (C.W.) \\ &= 0.5528 / 0.44 \\ &= 1.268 \end{aligned}$$

4) Theoretical COP

Theoretical COP is calculated from P-H chart and given two pressure.

Condenser pressure = 190 psi

Evaporator pressure = 25 psi

This two pressure value plot in P-H chart and given enthalpy of 4 values  $h_1 = 427.424 \text{ kJ/kg}$   $h_2 = 461.018 \text{ kJ/kg}$   $h_3 = h_4 = 254.14 \text{ kJ/kg}$

*C. Result Table*

| Sec/liter | Mass flow rate of water | COP <sub>Theoretical</sub> | COP <sub>Actual</sub> |
|-----------|-------------------------|----------------------------|-----------------------|
| 15        | 0.067                   | 5.15                       | 1.268                 |
| 20        | 0.05                    | 5.10                       | 1.046                 |
| 25        | 0.04                    | 5.00                       | 0.98                  |
| 30        | 0.033                   | 4.933                      | 0.978                 |
| 35        | 0.02857                 | 4.74                       | 0.8522                |

*D. Readings Of The Test Setup With Nano Additive Lubrincant*

| Ex. No.                             |                   | 1        | 2        | 3        | 4        | 5        |
|-------------------------------------|-------------------|----------|----------|----------|----------|----------|
| Mass flow rate of Evaporator ( lps) |                   | 0.0667   | 0.050    | 0.040    | 0.0333   | 0.0286   |
| Mass flow rate of Condenser ( lps)  |                   | 0.008558 | 0.008558 | 0.008558 | 0.008558 | 0.008558 |
| Compressor Work( kWh)               |                   | 0.3426   | 0.3129   | 0.3200   | 0.3129   | 0.3084   |
| Temperature of Refrigerant ( °C)    | Evaporator inlet  | 2        | 2.5      | 0        | 0        | 0        |
|                                     | Evaporator outlet | 29       | 29       | 29       | 27       | 27       |
|                                     | Condenser inlet   | 77       | 76       | 78       | 79       | 77       |
|                                     | Condenser outlet  | 38       | 39       | 38       | 36       | 38       |
| Temperature of water ( °C)          | Inlet             | 32       | 32       | 30       | 32       | 32       |
|                                     | outlet            | 30       | 30       | 29.5     | 29.5     | 30       |
| Pressure ( psi)                     | Condenser         | 170      | 170      | 170      | 180      | 170      |
|                                     | Evaporator        | 15.5     | 15.5     | 15.5     | 16       | 15.5     |

*E. Result Table*

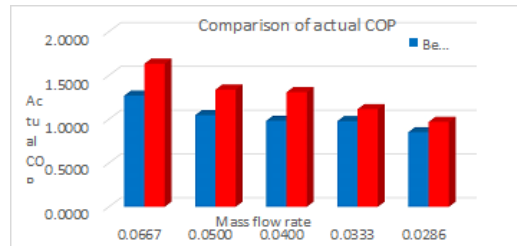
| Without Nanolubricant |                         |                            |                       |
|-----------------------|-------------------------|----------------------------|-----------------------|
| Sec/liter             | Mass flow rate of water | COP <sub>Theoretical</sub> | COP <sub>Actual</sub> |
| 15                    | 0.067                   | 2.402                      | 1.268                 |
| 20                    | 0.05                    | 2.372                      | 1.046                 |
| 25                    | 0.04                    | 2.290                      | 0.98                  |
| 30                    | 0.033                   | 2.253                      | 0.978                 |

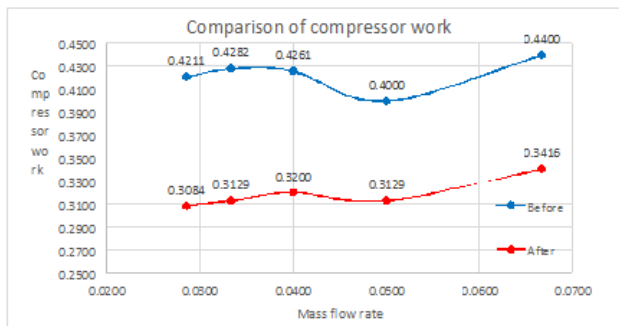
| With Nanolubricant |                         |                            |                       |
|--------------------|-------------------------|----------------------------|-----------------------|
| Sec/liter          | Mass flow rate of water | COP <sub>Theoretical</sub> | COP <sub>Actual</sub> |
| 15                 | 0.067                   | 2.6430                     | 1.6337                |
| 20                 | 0.05                    | 3.4268                     | 1.3378                |
| 25                 | 0.04                    | 3.6470                     | 2.3081                |
| 30                 | 0.033                   | 3.9107                     | 2.1148                |

## V. RESULTS AND CONCLUSIONS

- 1) Experimental analysis with 0.1% volume fraction in Nano-lubricant, one can conclude that, COP of refrigeration system will increase in the range of 15-18%. This increase in COP of refrigerating system is because of reduction in compressor work.



- 2) The COP of refrigerating unit with Nano-particles is higher than that of ordinary refrigerating unit because of improvement in tribological characteristics.
- 3) Less quantity of refrigerant required to produce the same amount of refrigerating effect.



## REFERENCES

- [1] Exergy Analysis of Vapor Compression Refrigeration System Using R12 and R134a as Refrigerants , Mohan Chandra, Department of Engineering, Al Musanna College of Technology sekharan.
- [2] Analysis of Exergy Change during Compression Process of a VCR Cycle using R 134 a as Refrigerant,Shreekant Tare, Nitesh Mishra,International Journal of Engineering Research,Volume No.5, Issue No.4.
- [3] Exergy Analysis of Vapour Compression Refrigeration System, Prateek D. Malwe, Bajirao S. Gawala and Shekhar D. Thakre , Walchand College of Engineering, Maharashtra.
- [4] Vaibhav Jain, S.S. Kachhwaha, R.S. Mishra, (2011), Comparative Performance Study of Vapour Compression Refrigeration System with R22, R134A, R410A,

- International Journal of Energy and Environments, Volume 2 (2), 297-3.
- [5] B. O. Bolaji, "Exergetic Performance of a Domestic refrigerator using R12 and its Alternative Refrigerants," Eng. Sci. Technol., vol. 5, no. 4, pp. 435–446, 2010. 10.