iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 7 **Issue:** I **Month of publication:** January 2019

DOI: http://doi.org/10.22214/ijraset.2019.1147

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 7 Issue I, Jan 2019- Available at www.ijraset.com

Experimental Performance Analysis of VCR System using Nano Additive (Al_2O_3) Lubricant

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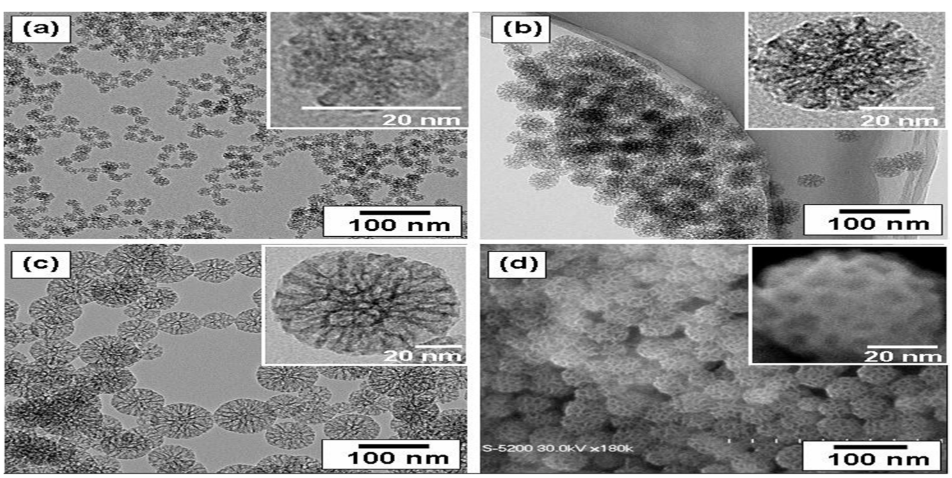
Abstract: Refrigeration may be define as lowering the temperature of an enclosed space by removing heat from the space and transferring heat elsewhere. It consists of four components, viz. compressor, condenser, expansion device and evaporator. Vapour Compression Refrigeration System is a system where refrigerant under goes phase change to produce cooling effect. This project involves introduction of nanoparticles (Al2O3, APS 20 nm, purity 99%), 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 many purpose for many task. 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.

Nanoparticles are particles between 1 and 100 nanometers (nm) in size with a surrounding interfacial layer. The interfacial layer is an integral part of nanoscale 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 passivating 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.



II. LITERATURE REVIEW

1) Application of SiO2 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 SiO2 Nano-oil is proposed as a promising lubricant to enhance the performance of vapour compression refrigerator compressor. The stability of SiO2 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.
2) Application of TiO2 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 TiO2 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.
3) Comparison of Performance of a Domestic Refrigerator using Al2O3 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 (tetrafluroethane) and PAG Oil with the same refrigerant and Mineral oil with different mass fraction ofAl2O3 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.
4) 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 theirs 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_2 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_2 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.

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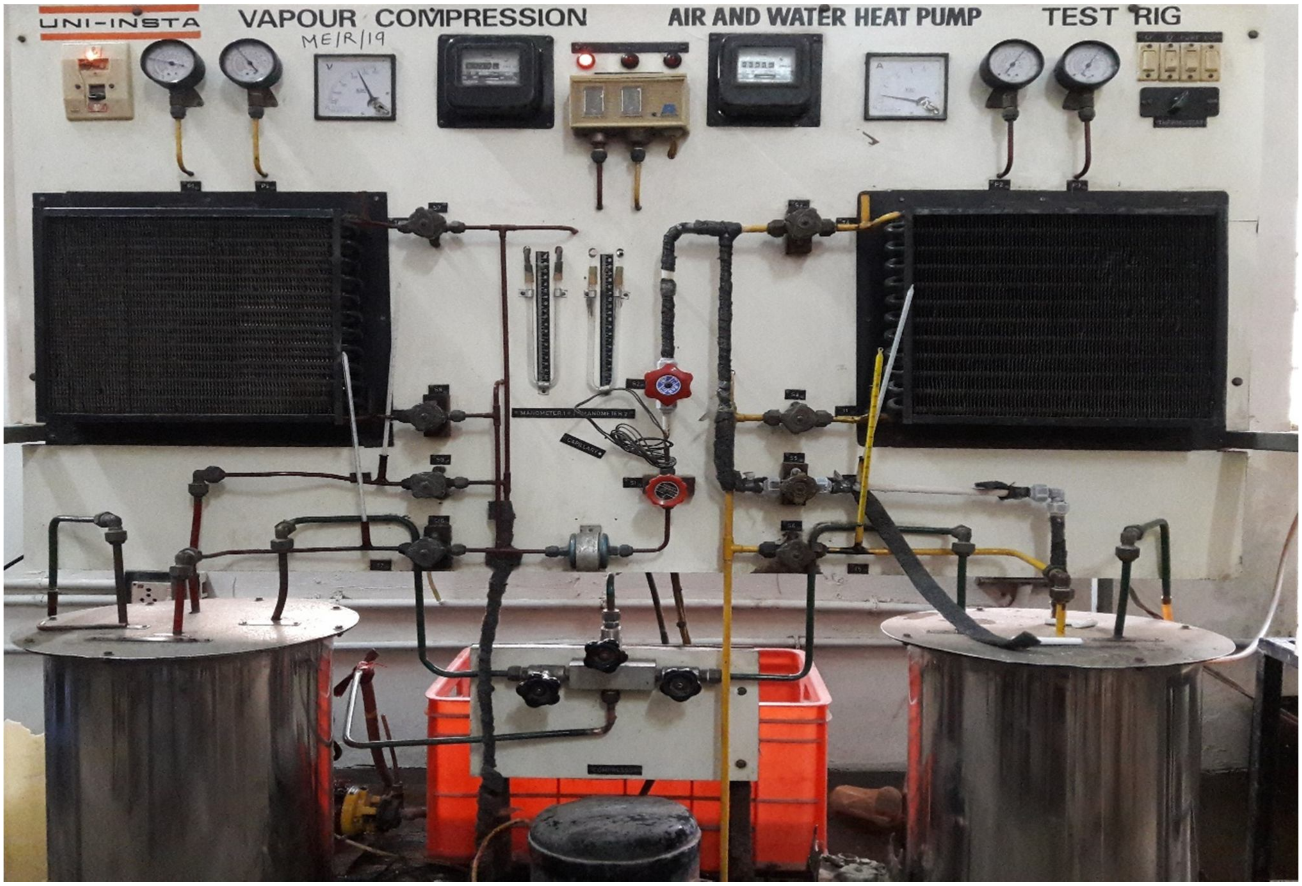
III. EXPERIMENTAL SETUP OF VCR SYSTEM



IV. READINGS, CALCULATION AND RESULTS

A. Readings Of The Test Setup Without Nano Addtive Lubrincant

Ex. No.		1	2	3	4	5
Mass flow rate of Evaporator (lps)		0.067	0.033	0.04	0.05	0.067
Mass flow rate of Condenser (lps)		0.008558	0.008558	0.008558	0.008558	0.008558
Compressor Work(kWh)		0.421	0.428	0.426	0.40	0.44
Temperature of Refrigerant (ºC)	Evaporator inlet	0	1	1	-1	-1
	Evaporator outlet	26	27	29	30	26
	Condenser inlet	81	81	82	83	83
	Condenser outlet	40	39	40	38.5	39
Temperature of water(ºC)	Inlet	30	30	30	29	28
	outlet	27	27.5	28	27	25
Pressure (psi)	Condenser	200	190	190	190	195
	Evaporator	25.5	25	25	25	25.5

B. Sample Calculation

1) Refrigerating effect is balanced by water circulation.

Heat given by the water=Refrigerating effect

R.E = m.C_p.ΔT

= 1⁄15×4.186×2

= 0.5528 kW

2) Compressor work

C_w = (n ×60)/3000

= (22×60)/3000

= 0.44 kW

3) Actual COP

〖COP〗 act = (R.E.)/(C.W.)

=0.5582/0.44

=1.268

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 kJ/kg

h_2= 461.018 kJ/kg

h_3= h_4= 254.14 kJ/kg

Theoretical COP = (h_1 - h_4) / (h_2 - h_1)

= (427.424 - 254.14) / (461.018 - 427.424)

= 5.15

C. Result Table

Sec/liter	Mass flow rate of water	$COP_{Theoretical}$	COP_{Actual}
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

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D. Readings Of The Test Setup With Nano Addtive Lubrincant

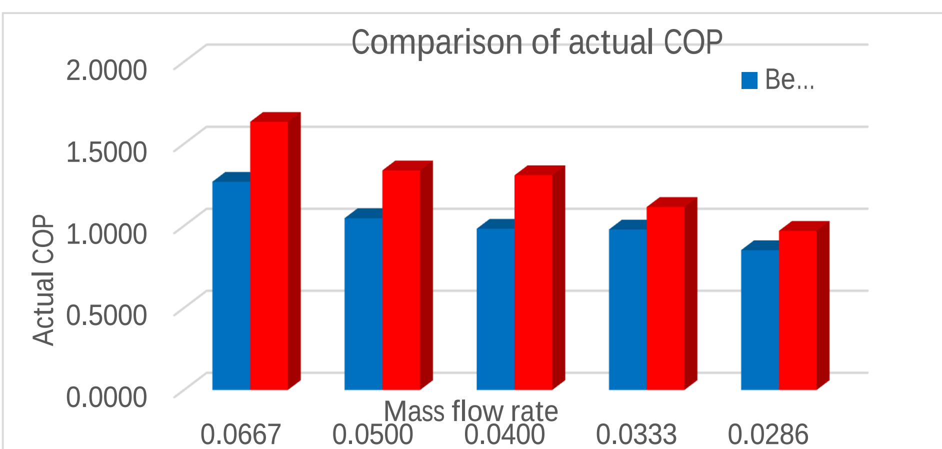
Ex. No.		1	2	3	4	5
Mass flow rate of Evaporator (lps)		0.0667	0.050	0.040	0.0333	0.0286
Mass flow rate of Condenser (lps)		0.008558	0.008558	0.008558	0.008558	0.008558
Compressor Work (kWh)		0.3426	0.3129	0.3200	0.3129	0.3084
Temperature of Refrigerant (ºC)	Evaporator inlet	2	2.5	0	0	0
	Evaporator outlet	29	29	29	27	27
	Condenser inlet	77	76	78	79	77
	Condenser outlet	38	39	38	36	38
Temperature of water (ºC)	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

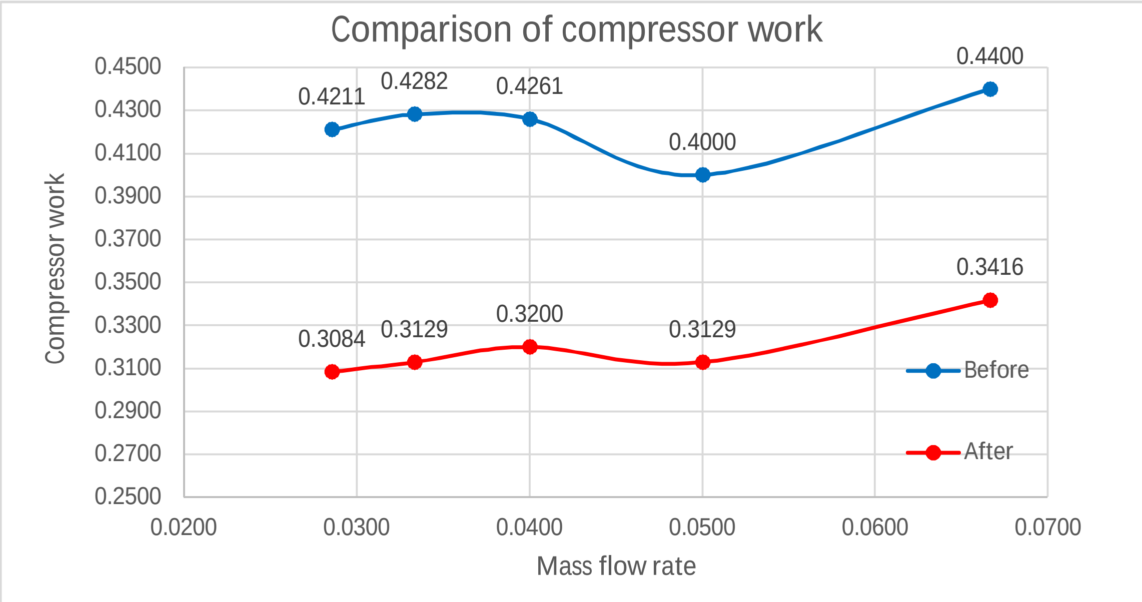
Sec/liter	Mass flow rate of water	$COP_{Theoretical}$	COP_{Actual}
15	0.067	6.0622	1.6337
20	0.05	6.0288	1.3378
25	0.04	5.8432	1.3081
30	0.033	5.6982	1.1148
35	0.02857	5.5477	0.9694

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.



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