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An experimental investigation of VCRS using Aluminium oxide nanoparticles as lubricant

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Abstract **The performance of the refrigeration system depends upon the heat transfer capacity of the refrigerant. Normally R12, R22, R600, R600a and 134a are used as a refrigerant. This refrigerant heat transfer capacity is not so good and increase power consumption. Due to these limitation nanofluids are enhanced with the normal lubricant and increases the heat transfer capacity and reduces the power consumption. Aluminium oxide nanofluid is used for enhancing the heat transfer capacity of the refrigerant in the refrigeration System. In this experiment heat transfer enhancement was investigated numerically by using Al_2O_3 nano-lubricant. The addition of nanoparticles to the lubricant results in improvements in the thermophysical properties and heat transfer characteristics of the refrigerant, thereby improving the performance of the refrigeration system. Stable nanolubricant has been prepared for the study. The experimental studies indicate that the refrigeration system with nanolubricant works normally. It is found that the freezing capacity increases by 86.26% and the COP increases up to 31% when PAG oil is replaced by a mixture PAG oil and aluminium oxide nanoparticles. Thus, using Aluminium oxide nanolubricant in refrigeration system is feasible**

Index terms- **VCRS, R134a, R600a, COP, Refrigeration Effect, Compressor Work, Nanoparticle**

1. INTRODUCTION

Vapour Compression Refrigeration Cycle is improved refrigeration cycle which utilizes fluid rather than air as working substance. These frameworks have a place with general class of vapour cycles, wherein the working refrigerant experiences phase change in any event during one procedure. The working substance is circulated in the framework in which it alternatively evaporates and condenses; in this manner it experiences a phase change.

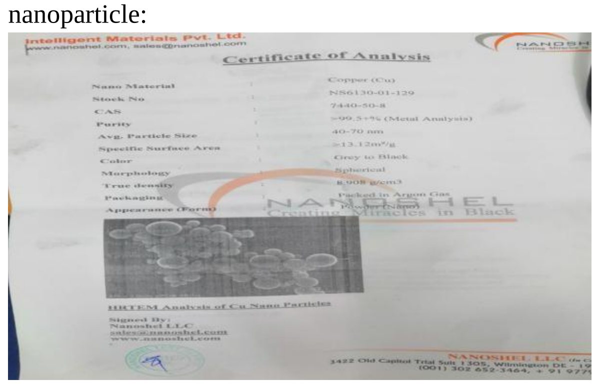
These systems are also called as mechanical refrigeration system because input to the system is in the form of mechanical energy required to run the compressor. Refrigeration is achieved as the refrigerant evaporates at low temperature in the refrigeration system.

Refrigeration might be characterized as bringing down the temperature of an enclosed space by extracting heat from that space and moving it somewhere else. A gadget that performs this type of function may likewise be called a climate control system, fridge, air source heat siphon, geothermal warmth siphon or chiller (heat siphon).

Nano fluid is an advanced type of fluid, that contain nanometer sized (10m^-9m) solid particles known as nanoparticles. Nanoparticles improve the property of simple fluid. In past some years, Nano-refrigerant has become very popular for large number of practical vapor compression systems because of deficiency in availability of energy and environmental issues.

When we add the nanoparticles in the base refrigerantthen the thermo physical properties and heat transfer characteristics of the base refrigerant improves,thereby improving the performance of the refrigeration system.

Following figure describe the specification of copper nanoparticle: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Certificate of Analysis

Nano Material	Copper (Cu)
Stock No	NS6130-01-129
CAS	7440-50-8
Purity	>99.5+% (Metal Analysis)
Avg. Particle Size	40-70 nm
Specific Surface Area	>13.12m²/g
Color	Grey to Black
Morphology	Spherical
True density	8.908 g/cm3
Packaging	Packed in Argon Gas
Appearance (Form)	Powder (Nano)

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Fig.1:Specification certificate of copper nanoparticles

Several experiments have been carried out for enhancing performance of the vapour compression refrigeration system, as mentioned in literature.

Nilesh Desai et al. has done a trial examination of a vapour compression refrigeration system utilizing R134a/SiO2/polyester Nano refrigerant as working liquid. In the examination the Nano-oil with explicit centralizations of 1%, 2% and 2.5 % (by mass part) were included the compressor oil. They found that as the nanoparticles fixation in POE oil increases, there is decline in input work and it is ideal at 2%. It has been seen that vitality sparing can be accomplished from a base estimation of 7.03% to a most extreme estimation of 12.30% utilizing Nano ointment contrasted with conventional refrigerants. The outcome shows the COP of framework were improved by 7.61%, 14.05% and 11.90%, individually, when the Nano-oil was utilized rather than unadulterated oil.

Bi et al. discovered that there is noteworthy decrease in the power utilization and huge improvement in refrigeration effect. It has been seen that the compressor utilizing mineral oil expends 16.67% less energy than POE oil. It has been discovered that power saving can be accomplished to a most extreme estimation of 21.2 % utilizing Nano oil contrasted with traditional refrigerants. The oil return proportion of mineral oil was just 84% contrasted with 92% for the Nano lubricant.

Subramani et al. has done a test examination of a vapour compression refrigeration system. In exploratory investigation, three cases have been considered. The hermetic compressor loaded up with I) unadulterated POE oil ii) SUNISO 3GS oil (mineral oil) and iii) SUNISO 3GS+ Al2O3 Nano- particles as grease. The mass portion of the Nano- particles in the Nano-ointment is 0.06%. The decrease in control utilization is 18% if the SUSISO 3GS is utilized rather than POE Oil and a decrease of 25% is seen when SUNISO 3GS is blended Nano- particles and SUNISO 3GS + Al2O3 Nano-molecule blend has the most noteworthy COP when contrasted and different cases. The upsides of adding Nano- molecule to the grease is that it lessens the power utilization of the compressor and there is sub cooling of the Nano-refrigerant in the condenser which thereby improves the COP.

This examination paper centers around the power utilization decrease by utilizing SiO2 as a Nano-grease. Nonetheless, there is extremely less research take a shot at the SiO2 as Nano-particles as added substances with oils utilized in refrigeration framework. It is uncovered that this exploration work will be valuable to beat the difficulties of Nano-lubricant.

2.EXPERIMENTAL SETUP AND RESEARCH METHODOLOGY

2.1EXPERIMENTAL SETUP

In this chapter we discuss the breif explanation on the facilities provided for conducting the experimental work on vapour compression refrigeration system testrig. The technique used for charging of the refrigerant and evacuation of the system is also discussed here. The vapour compression refrigeration system test consist of a hermitically sealed compressor for HFCs and retrofitted to HCs, a forced type air cooled condenser, a capillary tube as an expansion valve, evaporator, cooling chamber , controlling devices andmeasuring instruments which are fitted with the test rig. Manufactured by NEELAM ENGG. AGRA. In the test rig. Two Pressure gauge for pressure measurement, Five thermocouple temperature indicator (digital led) for measuring the temperature, rotameter for measurement of flow of refrigerant and a energy meter for calculating the power consumption is used. For electrical power input to the compressor a electrical switch is used. The refrigeration system performance test includes energy consumption tests, COP and refrigeration effect tests.For lubrication oil in our experiment we use PAG oil.For mixing of aluminium nanoparticle in the refrigerant by weight of refrigerant we use the sonicator for 3hrs. Sonicator is a machine which applies sound energy toblend the particles.

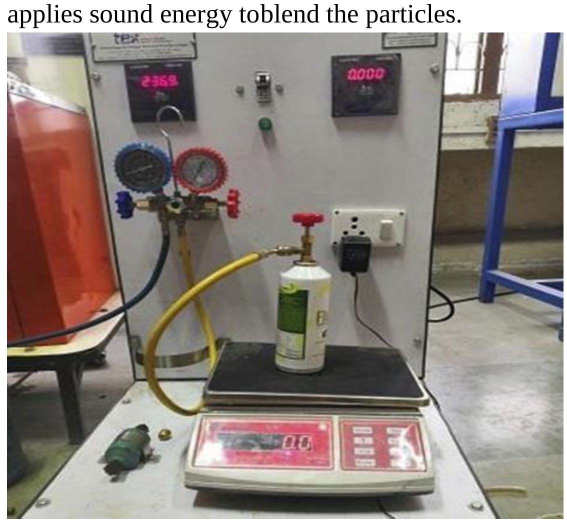


Fig.2: Charging Kit

Fig.3: PAG oil


Fig.4: Shows the actual setup for vapour compression refrigeration test rig in which R438a Refrigerant is used as working fluid along with the Al nanoparticle by weight of refrigerant

2.2EXPERIMENTAL PROCEDURE

The refrigeration system experiment was carried out at various stages for different concentration of Al nanoparticles by weight of refrigerant with R438a refrigerant and PAG oil. First performance test was carried by using R438a and pure PAG oil for base data and then after R438a by mixing of different amount of aluminium oxide nanoparticle and PAG oil. In this operation, Evaporator tank is filled with 33 kg of water and initial and final temperature was measured. Now the system was run for 30 min. and for every 5 min. all the pressure and temperature are noted down. The energy meter reading is taken down in terms of second for 5 revolutions. After the completion of test with PAG oil, lubricant oil was completely drained out from compressor and system was completely evacuated by connecting the vacuum pump to the charging line of compressor (service port) for 10 minutes. Again, the compressor was charged with R438a and pure PAG oil and then after R438a and aluminium oxide nanoparticle by weight of refrigerant in different amount and PAG oil.

It should be noted that the charging amount for R438a is taken 350g.

The following precautions are taken before the set-up is started:

1. Ensured that all joints, nuts and bolts are fitted tight and leakage free.
2. Naked flames and smoking strictly forbidden while charging of R438a.
3. Isobutane-containers must not be exposed to heat in excess of 50°C by sunlight or other heat sources.
4. Checked whether all electrical equipment’s are tight or not and protected.
5. Made sure that the room is well ventilated.

2.3Calculation of Experimental data

The calculation method and formulas used to determine the performance parameters are explained in detail below:

1.Compressor Work

Compressor work measure by the energy meter,Electrical Input power,

Ip= (5/Tc)*(3600/EMC), in KW

Where, EMC= Energy meter constant in rev./kw/hr.EMC= 1200 in our system compressor

Tc= Time revolution for indication to complete 5 revolutions

As per manual motor efficiency is 75% we have inputshaft power

SHAFT POWER= ELECTRICAL INPUT POWER *0.75

2.Refrigeration effect:

Refrigeration effect is balanced by water circulation,Heat given by the water = Refrigeration effect

R.E. = mCpΔt/Time, IN KW

3.Coefficient of Performance

Coefficient of Performance = (R.E.)/Compressor Work

3.RESULT AND DISCUSSION

3.1 : Comparison of Refrigeration Effect:

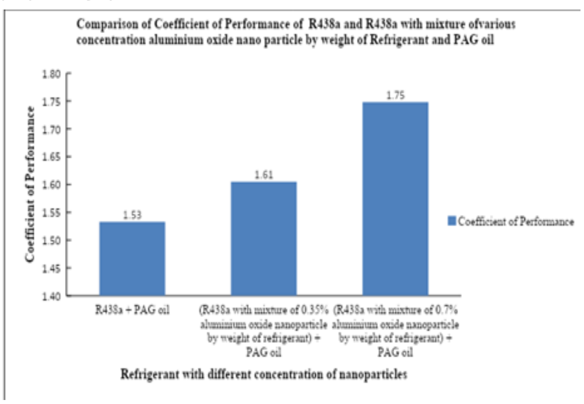
Refrigerant	Refrigeration Effect (in KW)
R134a+PAG oil	0.276
R600a+PAG oil	0.345
(R600a with mixture of 0.5% copper nanoparticle by weight of refrigerant)+PAG oil	0.360
(R600a with mixture of 1.0% copper nanoparticle by weight of refrigerant)+PAG oil	0.398
(R600a with mixture of 1.5% copper nanoparticle by weight of refrigerant)+PAG oil	0.452

Table 3.1: Comparison of Refrigeration effect among R134a, R600a and R600 with various concentration of copper nanoparticle by weight of refrigerant and PAG oil

3.2Comparison of Coefficient of Performance

Refrigerant	Coefficient of Performance
R438a + PAG oil	1.53
(R438a with mixture of 0.35% aluminium oxide nanoparticle by weight of refrigerant) + PAG oil	1.61
(R438a with mixture of 0.7% aluminium oxide nanoparticle by weight of refrigerant) + PAG oil	1.75

Table 8:Comparison of Coefficient of Performance R438a and R438a with various concentration of aluminium oxide nanoparticle by weight of refrigerant and PAG oil



4.CONCLUSION

The result of the experiment is evaluated by comparing the refrigeration effect, compressor work and coefficient of performance R438a with PAG oil and R438a with the mixture of aluminium oxide nanoparticle by weight of refrigerant and PAG oil in the VCRS system. The following are conclusions:

Refrigeration effect of R438a with aluminium oxide nanoparticle for 0.35% and 0.7% by weight of refrigerant was 5.45% and 18.91% respectively higher in compare to pure R438a.

COP of R438a with aluminium oxide nanoparticle for 0.35% and 0.7% by weight of refrigerant was 5.23% and 14.38% respectively higher in compare to pure R438a.

Increase in compressor work in the range of 26% and 8.7% with 0.35% and 0.7% aluminium oxide nanoparticle with R438a respectively.

The suction pressure and discharge pressure increase with time and attains a maximum value.

The maximum suction & discharge pressure is obtained for charge of R438a with aluminium oxide nanoparticle for 0.35% by weight of refrigerant.

Suction pressure is found to be less for charge of R438a with aluminium oxide nanoparticle for 0.35% by weight of refrigerant.

The thermal conductivities of nano refrigerants are higher than traditional refrigerants. It was also observed that increased thermal conductivity of nano refrigerants is comparable with the increased thermal conductivities of other nanofluids.

Nanofluids stability and its production cost are major factors that hinder the commercialization of nanofluids. By solving these challenges, it is expected that nanofluids can make substantial impact as coolant in heat exchanging devices.

According to data provided by economic times on an average per day 20.52 kwh unit electricity is consumed for refrigeration and air conditioning purpose which becomes 615.6 unit in a month. The cost of 615.6 units in Delhi is 4001.4 rupees so if we use R438a refrigerant with 0.7% aluminium oxide nanoparticle by weight of refrigerant, we can save 240 rupees per month in compare to pure R438a.

5.FUTURE RECOMMENDATION

We should start use R600a in VCRS system instead of R134a and blending of copper nanoparticle with R600a will give better result in comparison to pure R600a for VCRS system.

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