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# PERFORMANCE TEST ON DOMESTIC REFRIGERATOR WITH SUCTION LINE HEAT EXCHANGER BY USING R-134a REFRIGERANT WITH $SiO_2$ NANO LUBRICANT

**[1]Rapaka Jagadeesh, [2]Sarthi.Ganesh, [3]Sada.Kishor**

[1]Assistant Professor, Department of Mechanical Engineering, Aditya institute of technology and management tekkali
[2]UG Scholar, Department of Mechanical Engineering, Aditya institute of technology and management tekkali
[3]UG Scholar, Department of Mechanical Engineering, Aditya institute of technology and management tekkali

***Abstract:*** The most commonly used cycle in the refrigeration system is VCRS (Vapour Compression Refrigeration System) system. The suction line heat exchanger is employed in vapour compression refrigeration system for protecting system components. It ensures sub cooled liquid refrigerant supplied to expansion device inlet and superheated vapour refrigerant to the compressor inlet. Nano lubricant was added in the compressor to reduce power consumption and increase COP of the system. In the present work suction line heat exchanger is placed in VCRS cycle and nanoparticle (SiO2) with the 0.5% weight concentration was dispersed into the lubricant oil. With the employing of heat exchanger net refrigeration effect increased. Replacing of POE oil with nano lubricant reduces the power consumption and COP of the system increased.

***IndexTerms*** **- Suction line heat exchanger, R-134a Refrigerant, Nanolubricants, COP.**

## I. INTRODUCTION

Compression refrigeration cycles take an advantage of the fact that highly compressed fluids at certain temperature tend to get colder when they are allowed to expand. If the pressure change is high enough, then the compressed gas will be hotter than our source of cooling (outside air, for instance) and the expanded gas will be cooler than our desired cold temperature. In this case, fluid is used to cool a low temperature environment and reject the heat to a high temperature environment. Vapour compression refrigeration cycles have two advantages. First, a large amount of thermal energy is required to change a liquid to a vapour, and therefore a lot of heat can be removed from the substance to be cooled. Second, the isothermal nature of the vaporization allows extraction of heat without raising the temperature of the working fluid to the temperature of whatever is being cooled. This means that the heat transfer rate remains high, because the closer the working fluid temperature approaches that of the surroundings, the lower the rate of heat transfer. Suction line heat exchanger arranged between the condenser outlet and compressor inlet to increase net refrigeration effect by getting sub-cooling of liquid refrigerant at condenser outlet and superheated vapour refrigerant before entering compressor. Nano fluids or nano-refrigerants are prepared by suspending nano sized particles (1-100nm) in conventional fluids or base oils used in compressor. The heat transfer capacity increased by using nano fluids because of thermal conductivity of nano lubricants was better than the base oils.

## II. LITERATURE REVIEW

Numerous scientists have achieved examines vapour compression refrigeration system (VCRS) and survey the impact of performance parameters on the system with some modifications or by adding some components within the cycle and adding nanoparticles into the compressor lubricant oil.

**P.A Domanski and Didion [1]** In this effect of performance parameters are evaluated by placing suction line/liquid line heat exchanger in the basic Vapour compression refrigeration system with R134a refrigerant. It examines cycle parameters and refrigerant thermodynamic properties that determine whether the installation results in improvement of COP (Coefficient of performance) and volumetric capacity. As a result of employing suction line/liquid line heat exchanger high pressure refrigerant is sub cooled at the expense of superheating of vapour enter into compressor.

**D.M. Nasution and N.A. Pambudi [2]** describes about study of room air conditioning performance using liquid-suction heat exchanger with R290 has been carried out with the aim of determining influence or effect of LSHX and R290 in terms refrigeration effect, power consumption, Coefficient of performance and effectiveness of heat exchanger. The liquid-suction heat exchanger (LSHX) with length of 178mm was designed and fixed in air conditioning pipelines. The experiment was conducted on two system conditions with 6 tests each. Energy savings and COP increased as 27.69% and 38.29% respectively by using LSHX with R290 refrigerant.

**K.T.Pawale, A.H.Dhumal, and G.M.Kerkal [3]** in vapour compression refrigeration cycle alumina (Al2O3) nanoparticles of 50 nm are dispersed in refrigerant R-134a to improve the heat transfer performance to have their improved thermal and physical properties over the conventional refrigerants. Nanoparticles are mixed with two different compositions (0.5% & 1% wt. concentration). R-134a mixed with 0.5%wt. Concentration of Al2O3 nanoparticles increased 30.85% compared with the R-134a system. Increasing the wt. % of nanoparticles decreased the performance of the system.

**K. Saravanana and R. Vijayan [4**] In this work R-134a was used as refrigerant in domestic refrigerator and compressor oil replaced with different concentrations of Al2O3, TiO2 nanoparticles dispersed in POE oil as nanolubricants. Nanoparticles were added to POE oil with the volume concentration of 0.1g/L. The experiments conducted for different compositions are R134a with POE oil, R134a with Nano-lubricant (Al2O3/POE oil and TiO2/POE oil) and R134a with Nano-composite lubricant (75%Al2O3/25% TiO2/POE oil, 50% Al2O3/50% TiO2/POE oil and 25%Al2O3/75% TiO2/POE oil). R-134a with Nano composite lubricant 50% Al2O3/50% TiO2/POE oil results in power consumption 12.29% decreased, COP 11.89% increased, compressor work 8.65% decreased when compared with basic cycle.

**M.S.Bandgar, R. N. Kare [5]** In this evaluated the performance of vapour compression refrigeration system using nanoparticles mixed with Polyolester (POE) oil / Mineral oil (MO) as Nanolubricant and R600a as refrigerant. POE Oil / Mineral Oil are mixed with Silica (SiO2) Nano particles by ultrasonic sonication and stirring process to prepare the Nano lubricants. The investigation done on compatibility of POEMineral oil mixed with Silica (SiO2) nanopowder (concentration of 0.5% by mass fraction) as Nanolubricant. It gives better results at mass fraction of 0.5% for all combination of Nano-oils. It was found that the time required to reducing the temperature of water though 10C is less and the power consumption reduces 12.02% when POE oil is replaced with a mixture of (MO+ 0.5% Silica). It has been observed that coefficient of performance is increased 11.66% when POE oil is replaced by a Nano lubricant (mineral oil (MO) + 0.5% of SiO2).

**A.A.M. Redhwan, W.H. Azmi and M.Z. Sharif [6]** in this work viscosity and thermal conductivity of SiO2 nanoparticles dispersed in polyalkylene glycol (PAG) lubricants for 0.2-1.5% volume concentrations 303-353 K working temperatures was investigated and compared with Al2O3 Nanolubricant. The correlations for viscosity and thermal conductivity of SiO2 nanolubricants at various concentrations temperatures were proposed in this work. Allowable volume concentrations of SiO2 and Al2O3 nanolubricants for automobile air conditioning compressors are up to 1% and 0.3% respectively. Thermal conductivity of SiO2 nanolubricants at 1% concentration is higher than Al2O3 nanolubricants at 0.3% concentration.

## III. EXPERIMENTAL SETUP AND PROCEDURE

The current vapour compression refrigeration system consisting of four components which are compressor, condenser, expansion valve, and evaporator. In this experimental setup consists of a domestic refrigerator with the capacity of 220 litres and the refrigerant which is used R290 also called propane with system main components. The heat exchanger is placed after the condenser outlet and before entering into the compressor. These two lines are joined with the copper tube which acts as the suction line heat exchanger. The name itself suction line heat exchanger is arranged between the suction line of compressor inlet and the condenser outlet. Within the system some portion of condenser outlet tube is connected with the evaporator outlet tube and these two are arranged in the copper tube which acts as a heat exchanger for this experimental setup.

**Fig 1**: Experimental setup

### A) Preparation of nano lubricants:

Lubricants were enhancing the performance of system with their different parameters like when they were added into their components. Also addition of the additives like which are nanoparticles improve and effect on some critical parameters like anti-friction, anti-wear, anti-corrosion, anti-oxidants. The performance of composites, oils, fluids, etc are enhanced with the addition of nanoparticles, due to having their surface area to volume ratio lead to interaction between contact points and lubricants containing nanoparticles. $SiO_2$ and $Al_2O_3$ nanoparticles were added to the compressor lubricant in refrigeration system. In general, the most commonly used lubricant in refrigeration system is POE (Poly olester) oil. Ultrasonic dispersion is the method used in this preparation of Nano lubricant.

The steps which are involved in the preparation of Nano lubricants are as follows as The Al2O3 nanoparticles with the average diameter of 30-50nm and SiO2 nanoparticles with average diameter of 20-30 nm are weighed using digital electronic balance with the measurement ranging from 12mg to 200 g and the error allowed is 0.1 mg. The nanoparticles were mixed into the POE (Poly olester) oil with using magnetic stirrer with hot plate to form POE oil-$SiO_2$(0.5%wt.) and nano lubricants. After the preparation of POE oil-SiO2(0.5%wt.) and nano lubricants in the magnetic stirrer for some time the Nano lubricants were placed in the ultrasonic vibration mission up to 3 – 4 hours for better dispersion of nanoparticles into the POE oil. And after that it may kept for 3 days without deposition or coagulation. The process of using ultrasonic vibrator and Magnetic stirrer repeatedly for getting better homogenization of the Nano lubricant. And there is no surfactant is not added to this mixture of Nano lubricant because it decreasing the thermal conductivity and also the system performance.

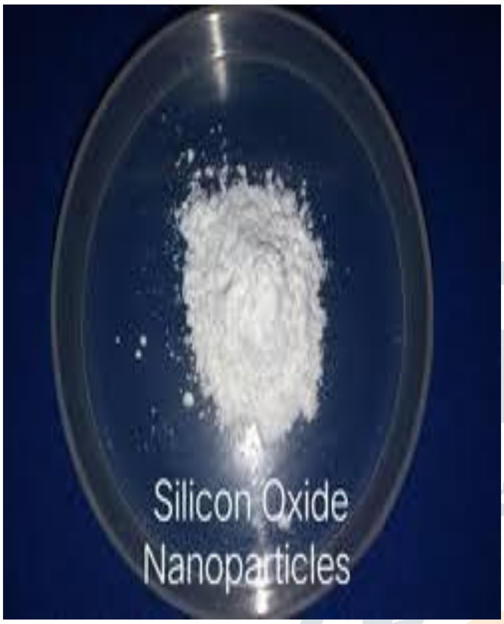


**Fig 2:** $SiO_2$ nanoparticles in powered form


**Fig 3:** Magnetic stirrer

## B) Experimental procedure:

First select a refrigerator which is operated on vapour compression refrigeration system. After that evacuate the system and fix required pressure gauges and thermocouples at the start and end of all components. Then the compressor is filled with the nitrogen gas and then the leak detection test is to be performed and confirming that there are no leakages in the system. Now vacuum is created inside the system by using external device. Now the system is charged with the R-134a refrigerant and POE oil is placed in the compressor then noted down all the readings of pressures and temperatures at the different temperatures of the evaporator. After that once again evacuated that refrigerant from the system and placed the suction line heat exchanger between the condenser outlet and compressor inlet and after closing the cycle again performed the leak detection test. Again charging the system with R-134a and taken all the readings of pressures and temperatures at all the points.

## IV. RESULTS AND DISCUSSIONS

**Comparison of performance parameters for VCRS with SLHE and Nano lubricants:**

### 4.1) Comparison of Net Refrigeration Effect (NRE):

- Net refrigeration effect increased by 12.6% for a VCRS cycle R134a with suction line heat exchanger compared with R134a without suction line heat exchanger.
- Net refrigeration effect increased 31.25% for a VCRS cycle R134a with suction line heat exchanger and SiO2 Nano lubricant compared with R134a with suction line heat exchanger.

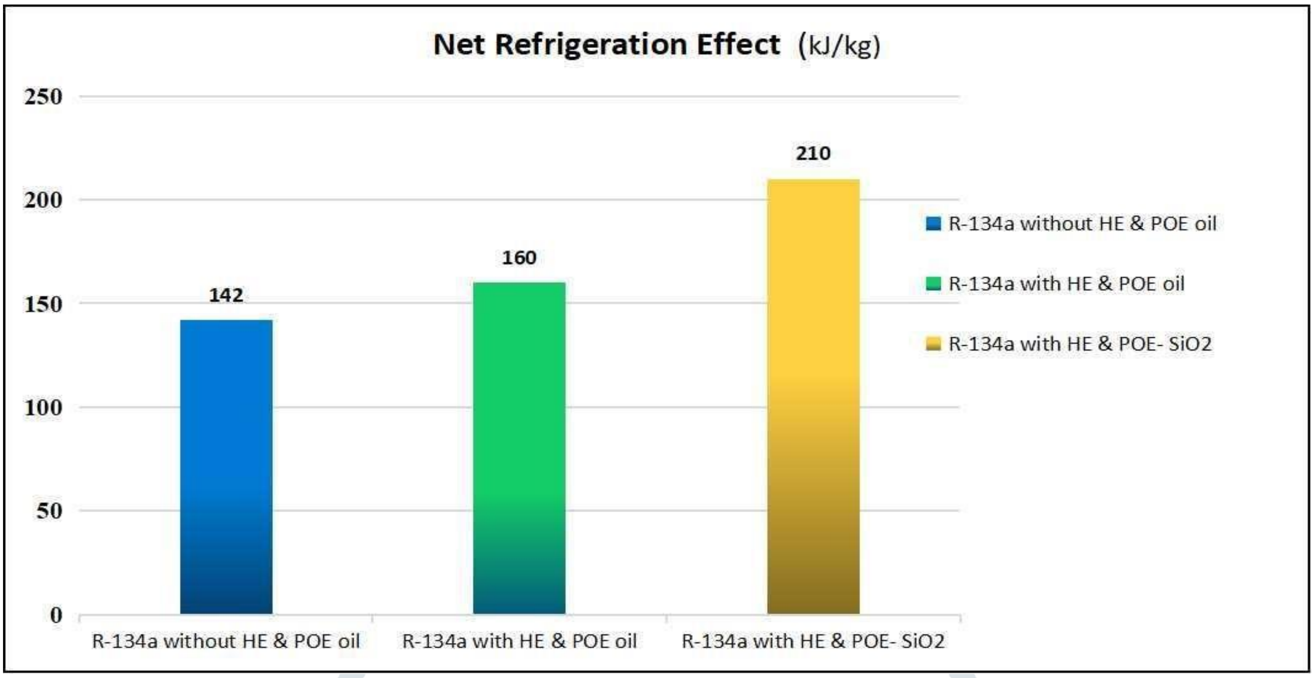


**Fig 4:** Comparison Of Net Refrigeration Effect

**4.2) Comparison of Compression work:**

- Compression work effect increased by 6.97% for a VCRS cycle R134a with suction line heat exchanger compared with R134a without suction line heat exchanger.
- Compression work effect increased 12.5% for a VCRS cycle R134a with suction line heat exchanger and $SiO_2$ Nano lubricant compared with R134a with suction line heat exchanger.

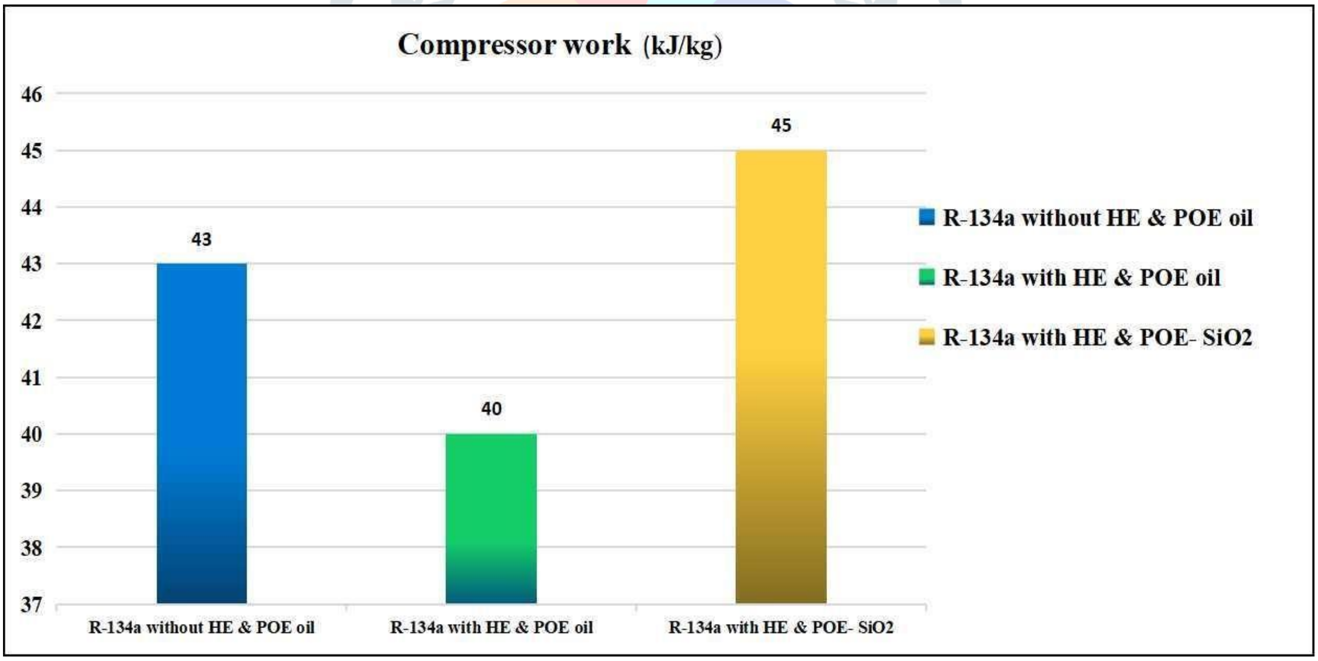


**Fig 5:** Comparison of Net Compression work

**4.3) Comparison of Coefficient of Performance (COP):**

- Coefficient of performance effect increased by 21.21% for a VCRS cycle R134a with suction line heat exchanger compared with R134a without suction line heat exchanger.
- Coefficient of performance effect decreased 16.5% for a VCRS cycle R134a with suction line heat exchanger and SiO2 Nano lubricant compared with R134a with suction line heat exchanger.

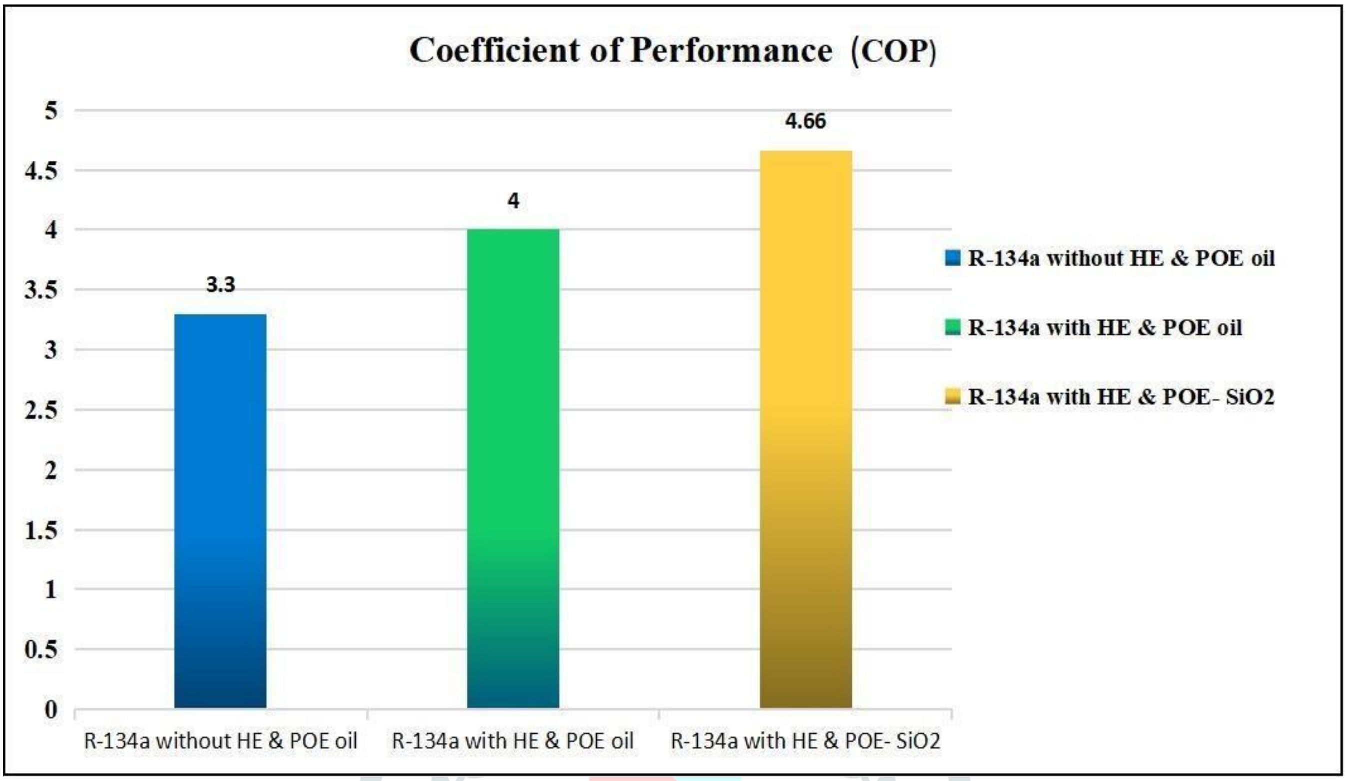


**Fig 6:** Comparison of coefficient of performance

## V. CONCLUSION

In this work, the experiments which are conducted on a existed domestic refrigerator using R-134a refrigerant with existed cycle, R-134a with heat exchanger, R-134a with heat exchanger & (POE oil-0.5%) Nano lubricant, R-134a with heat exchanger & (POE oil-0.5%SiO2) Nano lubricant. The conclusions which are made from the experimental results are as follows.

- Net refrigeration effect increased by 12.6% for a VCRS cycle R134a with suction line heat exchanger compared with R134a without suction line heat exchanger.
- Net refrigeration effect increased 31.25% for a VCRS cycle R134a with suction line heat exchanger and SiO2 Nano lubricant compared with R134a with suction line heat exchanger.
- Compression work effect increased by 6.97% for a VCRS cycle R134a with suction line heat exchanger compared with R134a without suction line heat exchanger.
- Compression work effect increased 12.5% for a VCRS cycle R134a with suction line heat exchanger and SiO2 Nano lubricant compared with R134a with suction line heat exchanger.
- Coefficient of performance effect increased by 21.21% for a VCRS cycle R134a with suction line heat exchanger compared with R134a without suction line heat exchanger.
- Coefficient of performance effect increased 16.5% for a VCRS cycle R134a with suction line heat exchanger and SiO2 Nano lubricant compared with R134a with suction line heat exchanger.

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