CHAPTER 1

INTRODUCTION

Refrigeration is a wonderful technology, and is an integral part of our lives today refrigeration technology acts as the heart of many processes, systems and applications. Refrigeration and Air Conditioning (RAC) applications in the current era, touch our lives in far reaching areas with a wide range of fields. They have become essential not only for food security post-harvest vegetable, fruit and grain storage, food processing and freezing), health security (healthcare, vaccine and pharmaceutical storage and cryosurgery), financial security industrial development including IT. Pharmaceuticals, chemicals. Petrochemicals and many others) but also for human comfort (air conditioning). It is well known that with comfort air conditioning the human productivity has increased. Refrigeration and air conditioning is now a backbone of our lifestyle and plays an important role in future sustainable development.

The vapor compression type of refrigeration systems has been the leading technology for refrigeration applications for nearly 100 years now. It has replaced most vapor absorption devices and other types of cooling systems because of its comparatively compacter size, higher reliability, scalability and other good qualities. Vapor compression refrigeration systems utilize working fluids (refrigerants) that circulate through a closed-loop cycle changing phases when passing through the heat exchangers. They also condense or expand in other components along the cycle to raise or reduce the pressure respectively.

One of the main common and high-energy consuming household appliances is domestic refrigerator. The worldwide number of domestic refrigerators in use is about 1×10^9 with estimation of one refrigerator for six people. Domestic refrigerator operates mostly on the principles of vapor compression refrigeration cycle and the area of applications varies in temperature level and size. Currently, R134a is the conventional refrigerant in the domestic refrigerators; it was developed as alternative to ozone depleting CFC refrigerants and it has been widely used in the systems since 1990 when CFC refrigerants were totally phased-out. However, R134a belongs to the class of HFC refrigerants which are strong green- house gases.

The GWP of R134a is 1430 times that of CO 2 (GWP = 1), therefore, energy efficient and very low GWP refrigerants are needed as substitutes in domestic refrigerator in order to cut-down HFC emissions. The growing awareness of climate change in recent years has led to the numerous studies conducted in search for eco- friendly working fluids in domestic refrigeration system.

Imminent deadline globally for both developing and developed nations to phase out and restrict application of harmful conventional working fluids (refrigerant) like chlorofluorocarbons (CFCs), hydro-chlorofluorocarbons (HCFCs) and hydro fluorocarbon (HFCs) having either or both Ozone depleting characteristic and high global warming potential in refrigeration systems are justifying natural refrigerant (especially hydrocarbons-based types) retrofit researches refrigeration recently. Restrictions across all refrigeration system manufacturing industries are in line with United Nation Montreal and Kyoto protocols and emission gap reports stated aims for achieving safe emission targets by year 2100 and ameliorating present devastating effects of climate change.

Hydrocarbons have been reported in several literatures as excellent replacement option to conventional refrigerants based on its close thermodynamic properties and system compatibility without or with slight modifications in conventional refrigeration systems, their non-Ozone depleting characteristics and almost neutral global warming potential advantages and are justifying its increasing utilization in spite of their flammability concerns. Hydrocarbon utilization flammability fears for small scale domestic refrigerators charges (below 150 g) is negligible due to their lower operating temperatures and pressures conditions and can be placed in any location within households. Numerous nanoparticles additions in domestic refrigerators (that is compressor lubricant or refrigerant called Nanolubricant or nanorefrigerant) has shown their application can remove all stated shortfalls and produced more sustainable domestic refrigerators.

1.1 Vapor Compression Refrigeration Cycle system

A Vapor Refrigeration System Is an Improved Type of Air Refrigeration System in Which A Suitable Working Substance, Termed As Refrigerant Is Used. It Condenses and Evaporates at Temperatures and pressures Close to The Atmospheric Conditions. The Refrigerant Used Does Not Leave The System But Is Circulated Throughout The System Alternately Condensing And Evaporating. The Vapor Compression Refrigeration System Is Now Days Used For All Purpose Refrigeration. It Is Used For All Industrial Purpose From A Small Domestic Refrigerator To A Big Air Conditioning Plant

The System Equipment's/ Components Proposed To Be Used In The System. The Vapour Compression Refrigeration Cycle Is Based On A Circulating Fluid Media, Viz. A Refrigerant Having Special Properties Of Vaporizing At Temperatures Lower Than The Ambient And Condensing Back To The Liquid Form. At Slightly Higher Than Conditions By The Saturation Temperature And Pressure. Thus, When The Refrigerant Evaporates Or Boils At Temperatures Lower Than Ambient. It Extracts Or Removes Heat From The Load And Lower The Temperature Consequently Providing Cooling

The Super-Heated Vapour Pressure Is Increased To A Level By The Compressor To Reach A Saturation Pressure So That Heat Added To Vapour Is Dissipated/ Rejected Into The Atmosphere, Using Operational Ambient Conditions, With Cooling Medias The Liquid From And Recycled Again To Form The Refrigeration Cycle.

Cooling Media, The Liquid from And Recycled Again To Form The Refrigeration Cycle.

The Components Used Are:

1. Evaporator
2. Reciprocating Device
3. Condenser
4. Throttling Device

1.2 Refrigerant

1.2.1 The Refrigerant Scenario

The refrigeration industry has faced several challenges due to environmental issues like ozone depletion and global warming, and the selection of an appropriate refrigerant for any particular application has been a vital factor for ensuring environment safety. Refrigerants have come and gone, e.g.: Chloro-fluoro-carbons (CFCs) used in the past have already moved out because of ozone depletion problem. The next were hydro-chloro-fluoro-carbons (HCFCs), which also have now been phased out in stages in most countries and are in the phase-out mode even in India. Hydro-fluoro- carbons (HFCs) like R134a, R404a and R407c are currently in use but have global warming issues and eventually have to move out. Hydro-fluoro-olefins (HFOs) have been developed with zero ODP and very low GWP; but their commercial production is very low and cost is high.

Refrigerants that are here to stay are the natural refrigerants. Hydrocarbons (HCs): R-290 (propane) is already being used in Europe, India and elsewhere for smaller plants and appliances. R- 600 (isobutene) is being used for refrigerators, etc. Hydrocarbons are effective refrigerants, but the major challenge to their application is high flammability. HCs are now being extensively used in European countries due to their zero ODP and negligible GWP. They have excellent thermodynamic properties. Hydrocarbons are being used as refrigerants in ice cream freezers also.

Ammonia: R-717 (ammonia) is a trusted refrigerant and has been used for industrial refrigeration for more than a century. It is the refrigerant used in nearly 90% of the plants in the Indian cold chain industry. Ammonia has been in continuous use for longer than any other refrigerant and is perhaps the most effective refrigerant available today. Despite the high toxicity of ammonia, the safety record of ammonia refrigeration systems is good, much better than the safety record of ammonia installations used for production of fertilizers. Solutions to the challenge of ammonia toxicity include technically sound design, manufacturing, testing, installation, operation and maintenance of the system in accordance with current safety standards. Today, apart from industrial refrigeration, ammonia has also made inroads into air conditioning, and some of the large installations like airports and food processing halls have been implemented with ammonia chillers. Carbon dioxide: R-744 (CO_2) has been used in the past, but is now becoming popular as a primary as well as secondary refrigerant. The challenges presented by CO_2 include high operating pressures, toxicity and low critical pressure.

1.2.2 Montreal Protocol

To control the damage to the stratospheric ozone layer depletion, the Montreal Protocol on substances that deplete the ozone layer was agreed upon in September 1987 and became effective in 1989. The Montreal Protocol specifies some control measures for the reduction and ultimately the phase-out of Ozone Depleting Substances (ODS), including HCFC The Montreal Protocol embodied "the polluter pays principle with committed but differentiated responsibility and created the Multilateral Fund (MLF) in 1991 for the implementation of the Montreal Protocol based on the contributions made by non-Article 5 countries (developed). The Montreal Protocol also provided a 10-year grace period for Article 5.

1.2.3 Kyoto Protocol

Global warming due to greenhouse effect has become another major environmental issue it is well established that global mean temperatures have increased by more than 0.8 Cover the past100years. The Intergovernmental Panel on Climate Change (IPCC) agrees that global warming is primarily due to human activity, which has occurred since the industrial revolutions. To slow down the global warming, the United Nations: Framework Convention on Climate Change (UNFCCC) was established in 1994 The Kyoto. Protocol, under UNFCCC, which came into effect in 1997.set out more specific and binding commitments to abate the use and emissions of Greenhouse Gases (GHGs), including HFC Currently available HFC options for HCFC have a very high GWP, typically in the range of 600 to 4000. Obviously, there is a linkage between the Montreal Protocol and UNFCCC (Kyoto Protocol and this was studied by IPCC (Andersen et al, 2005, and devote. and Sicars, 2005). CFCs and HCFCs are also GHGs. However, as CFCs were phased out and HCFCs are under phase out under the Montreal Protocol, these are not included in the Kyoto Protocol.

1.3 Nano fluid

More than a century ago, Maxwell initiated the efforts to enhance inherently poor thermal conductivity of liquids by adding solid particles in base fluids. Earlier studies used millimeter or micrometer solid particles, which led to problems such as rapid settling of solid particles, clogging, surface abrasion & high-pressure drop, limiting their practical applications. Nanofluids have good potential to overcome these problems. Choi (1995) conceived the novel concept of Nano fluids by making use of particles sizes in the order of 1 to 100 nm. Research on heat transfer enhancement by adding nanoparticles has had mixed results since then. Main factors, which influence the results, are nanoparticles material, nanoparticles concentration, Nano fluid preparation methods & testing consistency. In last decade, the number of published articles. Mentioning nanoparticles has increased significantly in refrigeration field.

Nanofluids are engineered colloidal suspensions of nanoparticles in base fluids at modest concentrations showing significant enhancement of their properties. Suspensions of solid submicron- and nanometer-sized particles in various fluids (also called Nano fluids) have been considered for applications as advanced heat transfer fluids for almost two decades. However, due to the wide variety and the complexity of the nanofluids systems, no agreement has been achieved on the magnitude of potential benefits of using nanofluids for heat transfer applications. Large volume of studies devoted to characterization of individual thermo-physical properties of nanofluids, such as thermal conductivity, viscosity, and agglomeration of nanoparticles, has been summarized in a number of review articles Compared to normal solid liquid suspensions nanofluids have 1) higher heat transfer between particles & fluids due to high nanoparticles surface area 2) better dispersion stability with predominant Brownian motion 3) reduced particle clogging & 4) reduced pumping power compared to base fluid. Nanoparticles can be added to the lubricant (compressor oil) and the lubricant nanoparticles mixture is known as Nanolubricant. Similarly nanoparticles can be added to the refrigerant and the refrigerant nanoparticles mixture is known as nanorefrigerant. Nanolubricant- refrigerant can be prepared by mixing pure refrigerant with Nanolubricant.

1.3.1 Preparation of Nano fluid

Nanofluids can be produced by one-step and two-step techniques. One-step technique, combines production &dispersion of nanoparticles in the base fluid into a single step & in two-step technique, these two steps are separate. Nanofluids preparation is a key step in experimentation requiring four guidelines 1) Dispensability of nanoparticles 2) Stability of nanoparticles 3) Chemical compatibility of nanoparticles 4) Thermal stability of nanofluids. In refrigeration systems, preparation of Nanolubricant is comparatively easier than direct preparation of nanorefrigerant, as only few refrigerants are available in liquid state at atmospheric pressure. Nanoparticles of required type & size are dispersed in base fluid after precise weighing on electronic balance. Stirring is done in a mechanical stirrer for some period followed by ultra-sonic vibration technique to form a stable nanofluids. Surface-active agents and/or dispersants are generally not used. Nanoparticles increase the surface area; improve mixing, turbulence & temperature distribution in nanofluids. Suspension of highly thermally conductive materials is not always effective to improve the thermal transport properties of nanofluids. Refer Table 1 below. CNT has highest thermal conductivity. Aligned CNTs are easier to disperse. However it is most expensive option. Natural Diamond has second highest thermal conductivity with no significant health risks but is second most expensive option. CuO & ZnO can be dangerous for health. Al2O3 reacts with water & heat is generated. Oil has low thermal conductivity whereas refrigerant has very low thermal conductivity. For other nanoparticles study is limited.

Table 1.3.1 Thermal Conductivity of Different Materials:

Material	CNT	Diamond	Cu	Al	Ni	Ni	Si	CuO	ZuO	Al 2O3	Ti O2	Oil	Oil Refrigerants
Thermal Conductivity (W/mK)	1800 to 6600	2200 to 2300	350 to 400	200 to 250	90 to 240	100 to 150	100 to 150	20 to 40	10 to 50	30 to 40	0.4 to 11.8	0.1 to 0.2	0.01 to 0.09

1.3.2 Single Step Method of Nano fluid preparation

The one-step process is simultaneously making and dispersing the particles in the base fluids which could be reduced to the agglomeration of nanoparticles. This method makes the nanofluids more stable with a limitation of the high cost of the process.

1.3.3 Two Step Method of Nano fluid preparation

The two-step method is the common method to produce nanofluids. Nanoparticles of different materials including nanofibers, nanotubes, or other Nano material are first produced as nanosized from 10 to 100 nm by chemical or physical methods. Then, the nanosized powder will be dispersed in base fluids with the help of intensive magnetic force agitation, ultrasonic agitation, high- shear mixing, homogenizing, and ball milling. As resulting from high surface area and surface activity, nanoparticles tend to aggregate reflecting adversely on the stability of Nano fluid [4–8]. To avoid that effect, the surfactant is added to the nanofluids. The two-method preparation has been done by many researchers. Figure 2 shows a block diagram of preparation of two-step method.

1.3.4 Preparation of Using Nano fluid

The use of Nano fluids seems attractive but its application is hindered by many factors like poor long-term stability, high pressure drops, high pumping power, low specific heat, particle settling, fouling and high production cost.

Table 1.3.5 Thermo- Physical Properties of TiO_2

SR. NO.	PARAMETER	VALUE
01	Molecular formula	TiO_2
02	Melting Point	1,843 °C (3,349 °F; 2,116 K)
03	Boiling Point	2,972 °C (5,382 °F; 3,245 K)
04	Flash Point	Non-flammable
05	Color	white
06	Density	4.23 g/cm^3
07	Specific heat	683 J/kg.K
08	Thermal conductivity	4.8 W/m.K
09	Molecular mass	79.866 g/mol
10	Specific Surface Area	174.5 and 33.3 m2/g
11	Average Primary Particle size	43.3 nm.
12	Appearance	White solid
13	PH	6.8

Table 1.3.6 Properties of R600a Refrigerant

Thermo physical properties of base refrigerant. Its numerical designation is R600a or Isobutene.

SR. NO.	PARAMETER	VALUE
01	Chemical formula	C4H10
02	Normal boiling point	260-264 °K at atm pressure
03	Critical Temperature	135°C
04	Critical pressurer	3.65 MPa
05	Vapour pressure	204.8 KPa AT 21°C
06	Specific heat of liquid	2.38 KJ/Kg°C
07	Molar mass	58.12 g mol−1
08	Density	2.51 kg/m3, gas (15 °C, 1atm) 593.4 kg/m3, liquid
09	Melting point	-159.6 °C, 114 K, -255 °F
10	Boiling point	-11.7 °C, 261 K, 11 °F
11	Solubility in water	Insoluble
12	Ozone Depletion Potential (ODP)	0
13	Global Warming Potential (GWP)	3
14	Flash point	Flammable gas
15	Latent heat of evaporation	362.6 KJ/Kg at atm pressure
16	Specific Heat Ratio Cp/Cv	1.091(atm, 25°C).
17	Assigned colour code	Colorless gas

CHAPTER 2

LITRATURE REVIEW

1. **D. S. Adelkhanet. al.** investigated the effect of varying test conditions varying mass charges of R600a refrigerant 40, 50, 60, and 70 g, and concentrations of TiO2 Nanolubricant (0, 0.2 and 0.4g/L) on the performance of R134a domestic refrigeration system. The results showed that the performance of the refrigeration system at 0.2 and 0.4 g/L concentrations of TiO2 Nanolubricant, improved at optimum ambient temperature and R600a mass charge conditions. At optimum conditions, the evaporator air temperature and energy consumption reduced within the range 5.26 to 26.32 %, and 0.13 to 14.09 % respectively, while the coefficient of performance and second law efficiency increased within the range 0.05 to 16.32 %, and 2.8 to 16 %, respectively.
2. **MdImteaz Ahmed, Jamal Uddin Ahamed**done experimental work byTiO2 Nanolubricant in this study. Three alternate refrigerant blends-Blend 1 (B1) of R32 and R22 (75:25 wt%), Blend 2 (B2) of R32 and R600a (75:25 wt %) and R32 refrigerant have been used in this experimental work to compare the thermo-physical performance with R22.0.01% and 0.02% volume concentration TiO2 Nanolubricant have been used. Results showed that the selected blends with Nanolubricant have higher COP compared to R22. Energy consumption has also been reduced for the blends withNanolubricant.
3. **Senthilkumar, A. Anderson, ManigandanSekar**in their research work the evaluation of performance of performance up to 27% from 1.17 to 1.6 and increase in cooling capacity up to 20% from 160 to 200 W and reduction in power utilized by the compressor up to 24% from 158 to120W in comparison with the R600a system without Nanolubricants. CuO/Al2O3 hybrid Nanolubricant refrigerator can be employed as better substitute for R134a refrigerator.of R600a VCR system was investigated using CuO/Al2O3 hybrid Nanolubricants. Three different hybrid Nanolubricants concentrations of 0.2, 0.4 and 0.6 g/L was considered for this study with 70 g of R600a refrigerant. Addition of CuO/Al2O3 hybrid nanoparticles in to a compressor lubricating oil resulted in enhanced.

4. **Yogesh Joshi, Dinesh Zanwar, et. al.** performed experimental work of Al_2O_3 nanoparticle based nanofluid in a vapor compression refrigeration system. The lubricant oil of compressors has taken as the base fluid for the synthesis of Al_2O_3 nanofluid. The nanofluid has synthesized in the experiment of mass fractions of 0.02 wt%, 0.04 wt%, 0.07 wt%, and 0.1 wt% of Al_2O_3 nanoparticles. Two different types of refrigerant which are synthetic refrigerant (R134a) and hydrocarbon refrigerant (R600a) have used separately for the investigation. The polyester oil (POE) for R134a refrigerant and mineral oil for R600a refrigerant is incorporated in the experimental test rig. The experimental results showed that by using 0.1 wt% of R600a-MO-Al_2O_3 mixture improves the C.O.P. by 37.2%, reduction in power consumption by 28.7%, increment in compressor discharge pressure by 8.9%, lowered evaporator pressure by 24.7%, and lowered the pull-down time by 17.6% compared to the conventional refrigeration system. Nanolubricant in R600a refrigeration system. After conducting experiments the performance of the Nanolubricant system is compared with system without nanoparticles. By addition it will lead to 30% increase in performance, Cooling capacity by 25% and reduced compressor power consumption of 80 W.
5. **Mihail-Dan & N. Staicovici** Are investigates A method of improving the effectiveness of a mechanical vapors compression process and of its applications in refrigeration. It was shown that method can be improved of a polytrophic or an adiabatic mechanical vapors compression system.
6. **Bilal Ahmed Qureshi & Syed M. Zubair**, asked about all Performance decrease of a vapors compression refrigeration system under fouling conditions. In contrast to the current, from a second law, Viewpoint, the second law Efficiency. Indicates that R717 performs the best in all cases. The paper is shows that the volumetric efficiency of R410A R717 remained the highest under their respective operating condition. Performance degradation due to fouling in a simple vapour compression cycle is investigated for low, medium and high temperature applications.
7. **K. Mani, V. Selladurai**, Are Experimental analysis of a new refrigerant mixture as drop-in replacement for CFC12 and HFC134a are Investigate that The refrigerants chlorofluorocarbon (CFCs) and hydro chlorofluorocarbon (HCFCs) both have high ozone depleting potential (ODP) and global warming potential (GWP) and con-tributes to ozone layer depletion and global warming
8. **Akintunde, M.A.et** all Experimental study of R134a, R406 and R600a blends as alternative to Freon 12. The results show that R134a/R600a mixture in the ratio 50:50 can be used as alternative

to R-12 in domestic refrigerators, without the necessity of changing the compressor lubricating oil. At of Te=-50 C and Tc=400 C , R-12 gives a COP of 2.08 while 50:50 blend of R134a/R600a gives a COP of 2.30 under the same operating conditions. 5) According to manual of company danfoss Practical Application of Refrigerant R600a Isobutene in Domestic Refrigerator Systems is observed by Refrigerant R 600a, or isobutene, is a possible replacement for other refrigerants, which have high impact on the environment, in domestic refrigerators. It has zero ozone depletion potential ODP and a negligible global warming potential GWP

9. **Bartelt et al.** also studied the flow boiling process of R134a/POE/CuO nano-refrigerant in a horizontal tube, and showed that when the mass fraction is 2%, the heat transfer coefficient increases by about 50~101%. These results indicate that nano-refrigerant or nano-lubricating oil helps to improve the boiling heat transfer process.
10. **Sharif et al.** also studied the relationship between thermal conductivity, viscosity and volume concentration of Al2O3/PAG nano-lubricating oil for automotive air conditioning (AAC) systems. The results show that when the volume concentration is 1%, the thermal conductivity can be increased to 4%. However, at a volume concentration of 0.4%, the viscosity is 7.58 times higher than that of PAG

CHAPTER 3

OBJECTIVES

1) To measure COP of VCR System by addition of TiO2nanolubricant in lubricating oil.
2) To measure COP of VCR System by variations in mass concentration of TiO2 nanoparticles additions in lubricating oil.
3) To measure effect of TiO2 Nanolubricant addition in lubricating oil on performance of VCR System by changing mass charge of R600.

CHAPTER 4

METHODOLOGY

4.1 Ultrasonication

Sonication is the act of applying sound energy to agitate particles in a sample, for various purposes such as the extraction of multiple compounds from plants, microalgae and seaweeds. Ultrasonic frequencies (> 20 kHz) are usually used, leading to the process also being known as Ultrasonication or ultra-sonication.

In the laboratory, it is usually applied using an ultrasonic bath or an ultrasonic probe, colloquially known as a sonication. In a paper machine, an ultrasonic foil can distribute cellulose fibres more uniformly and strengthen the paper

Applications

Sonication can be used for the production of nanoparticles, such as nano emulsions, nanocrystals, liposome's and wax emulsions, as well as for wastewater purification, degassing, extraction of seaweed polysaccharides[1] and plant oil, extraction of anthocyanins and antioxidants,[6] production of biofuels, crude oil desulphurization, cell disruption, polymer and epoxy processing, adhesive thinning, and many other processes. It is applied in pharmaceutical, cosmetic, water, food, ink, paint, coating, wood treatment, metalworking, Nano composite, pesticide, fuel, wood product and many other industries.

Fig.4.2 Ultrasonication

4.2 Magnetic Stirring

Magnetic stirrers are often used in chemistry and biology, where they can be used to stir hermetically closed vessels or systems without the need for complicated rotary seals. They are preferred over gear-driven motorized stirrers because they are quieter, more efficient, and have no moving external parts to break or wear out (other than the simple bar magnet itself). Magnetic stir bars work well in glass vessels commonly used for chemical reactions, as glass does not appreciably affect a magnetic field. The limited size of the bar means that magnetic stirrers can only be used for relatively small experiments, of 4 litres or less. Stir bars also have difficulty in dealing with viscous liquids or thick suspensions. For larger volumes or more viscous liquids, some sort of mechanical stirring (e.g., an overhead stirrer) is typically needed. In synthetic chemistry, a combined magnetic stirrer/heater, equipped with a built-in temperature control mechanism and temperature probe, is commonly used with a heating bath (commonly oil, sand, or low-melting metal) or cooling bath (commonly water, ice, or an organic liquid mixed with liquid nitrogen or dry ice as coolant), allowing reactions vessels placed in the bath to be maintained at temperatures between approximately −120 and 250 °C (−184 and 482 °F).

Fig.4.3.1 Magnetic stirring

4.3 Experimentation

In this work, the test rig was a modified R134a domestic refrigerator having provision on compressor suction and discharge lines. These modifications enabled fitting of pressure gauges and charging and discharging of spent refrigerant from the system. Digital type K thermocouples and a wattmeter were attached to the system, pressure gauges were used to measure the refrigerant suction (P1) and discharge (P2) pressures respectively, while the installed thermocouples monitored the Evaporated inlet (T1), Evaporated outlet (T2), conde (T3) and cabinet air (Tair) temperatures of the refrigerant. Watt meter was connected to capture the instantaneous energy consumption of the system. The modified test rig consists of built-in evaporator, R134a compressor, air-cooled condenser, a non-adiabatic dryer, and a capillary tube. The compressor of the test rig receives the refrigerant at low pressure and temperature saturated vapor state from the evaporator, and delivers it as compressed superheated high pressure and temperature vapor state to the condenser. Heat rejection to the environment occurs as the superheated vapor state refrigerant moves through the condenser.

Nanolubricant Flow Chart

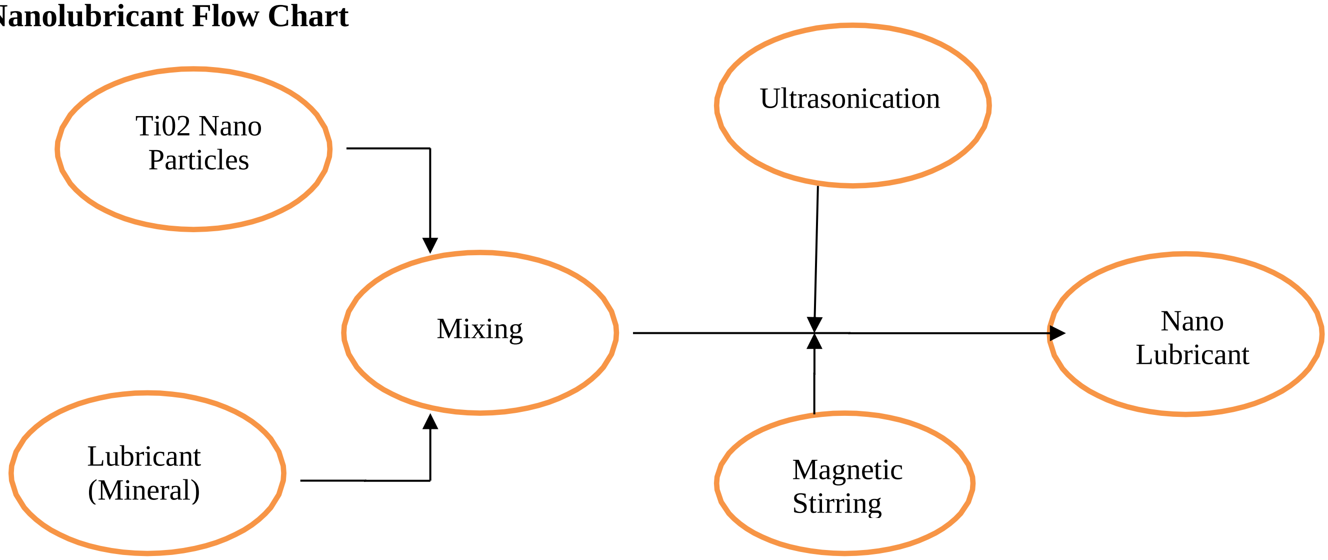


Chart no.4.4 Nano lubricant flow chart

4.4 System Evacuation

Moisture combines in varying degree with most of the commonly used refrigerants and reacts with the lubricating oil and with other materials in the system, producing highly corrosive compound. The resulting chemical reaction often produces pitting and other damage on the valves seals, cylinder wall and other polished surface of the system. It may cause the deterioration of the lubricating oil and the formation of sludge that can gum up valves, clog oil passages, score bearing surface and produce other effect that reduce the life of the system. Moisture in the system may exist in solution or as free water. Free water can freeze into the ice crystals inside the metering device and in the evaporator tubes of system that operate below the freezing point of the water. This reaction is called freeze up. When freeze up occurs, the formation of ice within the orifice of the metering device temporarily stops the flow of the liquid refrigerant. To get rid of the detrimental effect of moisture yellow jacket 12 cfm vacuum pump was used to evacuate the system. This system evacuates fast and better which is deep enough to get rid of contaminant that could cause system failure. The evacuation system consists of a vacuum pump, a pressure gauge and hoses. The hoses were connected with the service port to remove the moisture from the system. When the pump is turned on the internal the pressure gauge shows the pressure inside the refrigerator system.

4.5 Test Procedure

1. In this test procedure first we have taken reading of refrigerant R134a with 40 gm, 60 gm and 80 gm.
2. Next we have vacuumed the system and changes refrigerant from R134a oil to R600a refrigerant.
3. Also we have charged R600a refrigerant and taken reading of 40 gm, 60 gm and 80 gm
4. For next reading we have changed the oil with mixture of TiO_2.
5. For this preparation of mixture we have done magnetic stirring and ultra sonification to get better mixture of Nano particle and R600a compressor oil.
6. The purpose of doing magnetic stirring and Ultrasonication of oil to do the smooth working of compressor.
7. And taken the 3 reading of R600a refrigerant with 0.1g of Tio_2 40g, 60g, and 80g.
8. For every step of changing oil we have done the brazing operation, for this operation we need to remove compressor from its foundation.
9. After the project reading we have done setup in original condition.

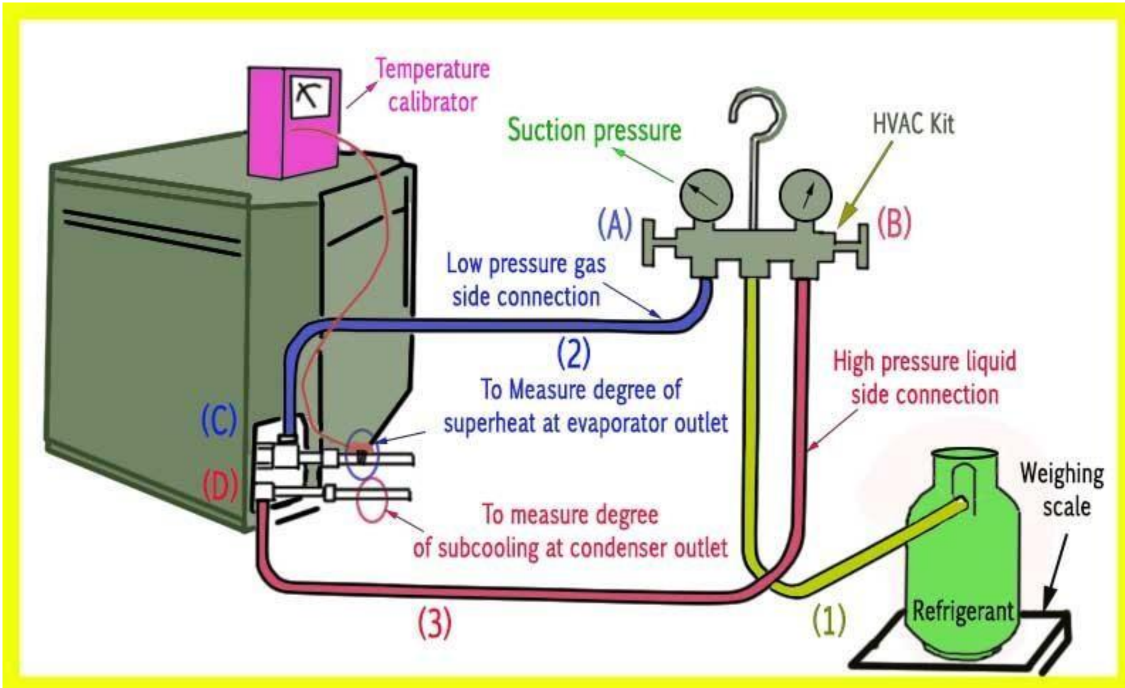


Fig.4.4.2 Air conditioning system refrigerant charge

Fig.4.4.3 Actual system charging

4.6 List of Material and Equipment’s Used for Project

a. R134a Refrigerant
b. R600a refrigerant.
c. Nano lubricant.
d. Synthetic oil
e. Digital weighing machine.
f. Magnetic stirrer.
g. Sonification Machine
h. Vacuum Pump
i. Gauges And hose pipes

Fig.4.6.1. R600a refrigerant Nano lubricant and synthetic.

Fig.4.6.2 Digital weighing machine.

Table 4.7 Experimental Conditions

Sr. No.	Parameter	Range
01	Refrigerant mass charge R134a	30g, 60g, 90g
02	Refrigerant mass charge R600a	30g, 60g, 90g
03	Refrigerant	R600a
04	Compressor lubricant	TiO_2 Nano Lubricant
05	TiO2	20 nm
06	Nano-lubricant concentration	0.1 g/ L
07	Condenser	Air-cooled

4.8 Setup information

Fig.4.8.1 VCR System

Fig.4.8.2 VCR System Compressor

CHAPTER 5

COSTING

Table 5.1. Costing Table

Sr. No.	Description	Quantity	Cost (Rs.)	Total (Rs.)
1	R134a Refrigerant	1	700.00	700.00
2	R600a Refrigerant	2	300.00	600.00
3	R600a Oil	4	130	520.00
4	Nano-Lubricant	1	4000.00	4000.00
5	NRV Valve	1	250.00	250.00
6	Technician Charges	-	3000.00	3000.00
7	Oil filler bottle	1	30.00	30.00
8	Polish Paper	1	20.00	20.00
			TOTAL:	**9120.00**

CHAPTER 6

OBSERVATIONS AND CALCULATION

5.1 Observation and Calculation of finding COP of system with the use of R134arefrigerant

Table 5.1: Symbols and meaning-

Sr. no.	Description	Symbol	Reading
1	Condenser pressure	P_cP_1	Bar
2	Evaporator pressure	P_eP_2	Bar
3	Condenser inlet temp.	$T_{ci}(T_1)$	^0C
4	Condenser outlet temp.	$T_{co}(T_2)$	^0C
5	Evaporator inlet temp.	$T_{ei}(T_3)$	^0C
6	Evaporator outlet temp.	T_{eo} (T^4)	^0C
7	Temp. of water	T_5	^0C

Table 5.1.1: Reading of R134a

Sr.no.	Mass charged (Gram)	Evaporator Pressure (Pe) (PSi)	Condenser pressure (Pc) (PSi)	T_{ei} (^oC)	t_{eo} (^oC)	t_{ci} (^oC)	t_{co} (^oC)	T_c	T_h	CW	RE	COP
1	30g	35	230	9	19	86	34	22.37	29.15	0.3859	0.5029	1.30
2	60g	35	180	16	20	85	41	23.20	20.18	0.3433	0.5574	1.15
3	90g	25	140	18	23	81	40	23.24	16.72	0.484	0.672	1.38

Sample calculation of finding COP of R134a of 30g gas mass charge.

- Time of 10 revolution of energy meter of compressor- 22.37 sec = $CW = \frac{3600\times10}{3200\times22.37}$= 0.3859 KW
- Time of 10 revolution of energy meter of heater- 29.15 sec= $RE = \frac{3600\times10}{3200\times29.15}$= 0.5029 KW

✓ COP= $\frac{\text{RE}}{\text{CW}} = \frac{0.5029}{0.3859} = \mathbf{1.30}$

5.2 Calculation of finding COP of system with the use of R600a refrigerant.

Table 5.2: Reading of R600a

Sr.no.	**Mass charged (Gram)**	**Evaporator Pressure (Pe) (PSI)**	**Condenser pressure (Pc) (PSI)**	**T_{ei} (^oC)**	**t_{eo} (^oC)**	**t_{ci} (^oC)**	**t_{co} (^oC)**	**T_c**	**T_h**	**CW**	**RE**	**COP**
1	40	15	120	7	22	68	35	36.46	34.15	0.3085	0.3611	1.17
2	60	24	180	13	20	78	36	28.24	23.58	0.3983	0.4770	1.19
3	80	13	120	5	24	66	34	38.23	25.3	0.2942	0.4446	1.51

Sample calculation of finding COP of R600a of 40g gas mass charge.

- Time of 10 revolution of energy meter of compressor- 36.46 sec = $CW = \frac{3600\times10}{3200\times36.46}$= 0.3085 KW

- Time of 10 revolution of energy meter of heater- 31.15 sec= $RE = \frac{3600\times10}{3200\times34.15}$= 0.3611 KW

✓ COP= $\frac{\mathrm{RE}}{\mathrm{CW}} = \frac{0.3611}{0.3085} = \mathbf{1.17}$

5.3 Calculation of finding COP of system with the use of R600arefrigerant and Nano-lubricant 0.1 g

Table 5.3: Reading of R600a with 0.1 Tio2

Sr. no.	Mass charged (gm)	Nano-Lubricant (gm)	Evaporator Pressure (Pe) (psi)	Condenser pressure (Pc) (psi)	T_{ei} (^oC)	t_{eo} (^oC)	t_{ci} (^oC)	t_{co} (^oC)	T_c	T_h	CW	RE	COP
1	40	0.1	20	192	10	24	71	36	35.5	31.99	0.3036	0.351	1.16
2	60	0.1	20	190	8	22	76	34	29.98	24.02	0.3036	0.351	1.24
3	80	0.1	15	120	5	21	64	33	43.1	27	0.261	0.416	1.59

Finding COP of R600a of 40g gas mass charge.

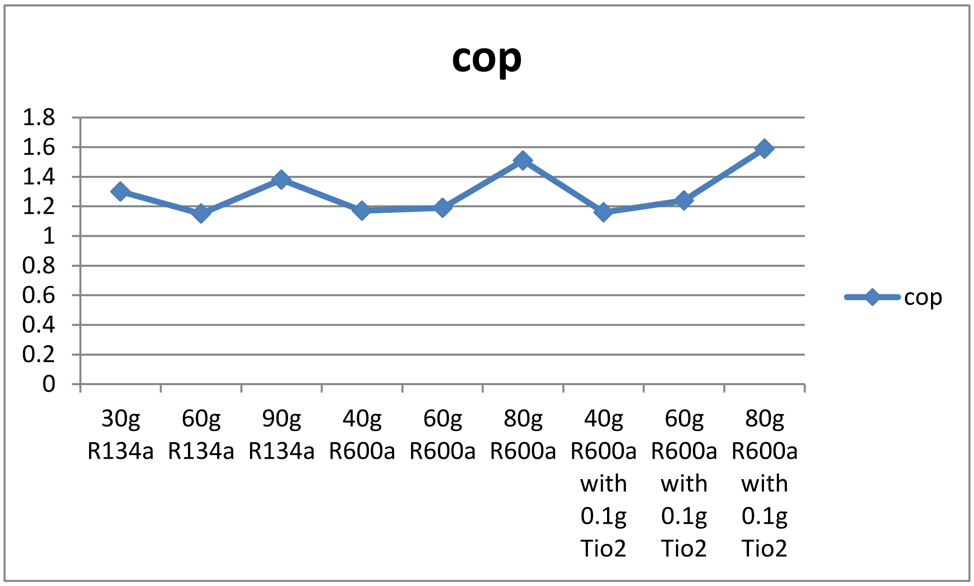
- Time of 10 revolution of energy meter of compressor- 36.46 sec = $CW = \frac{3600\times10}{3200\times35.05}$= 0.3036 KW
- Time of 10 revolution of energy meter of heater- 31.15 sec= $RE = \frac{3600\times10}{3200\times31.99}$= 0.351 KW

✓ COP= $\frac{\text{RE}}{\text{CW}} = \frac{0.351}{0.303} = \mathbf{1.16}$

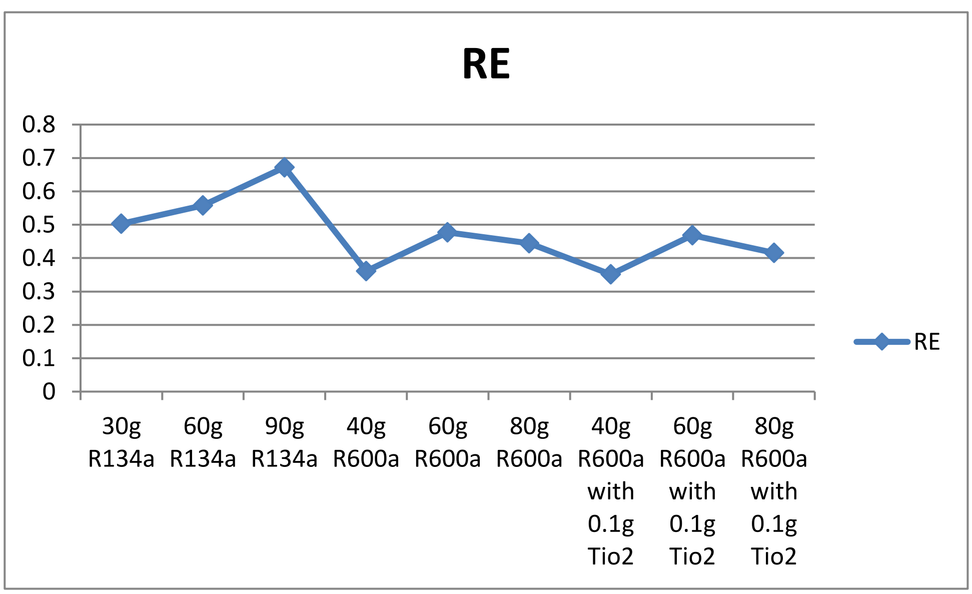
CHAPTER 7
RESULTS AND CONCLUSION

7.1 Results in the form of charts:

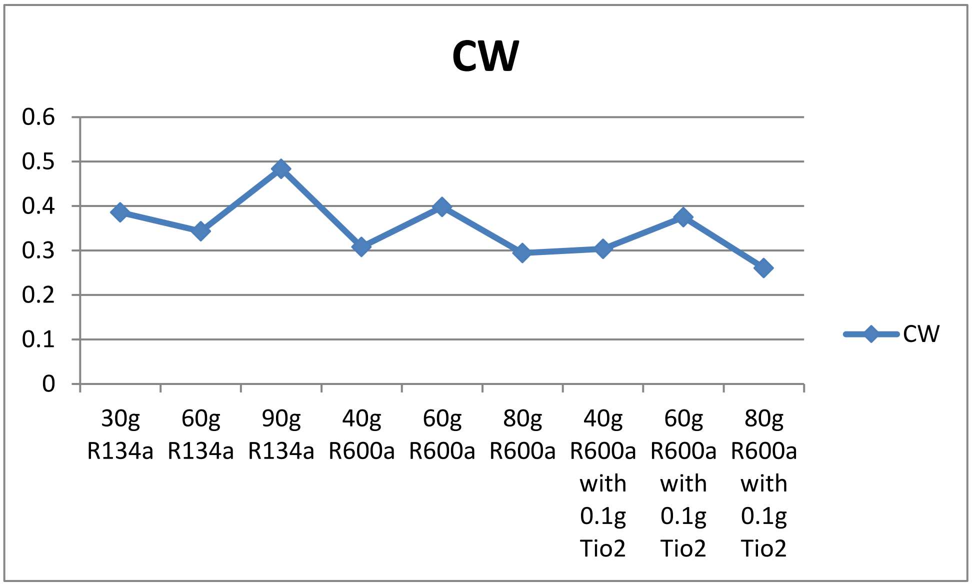
1. Coefficient of Performance vs. Mass charge



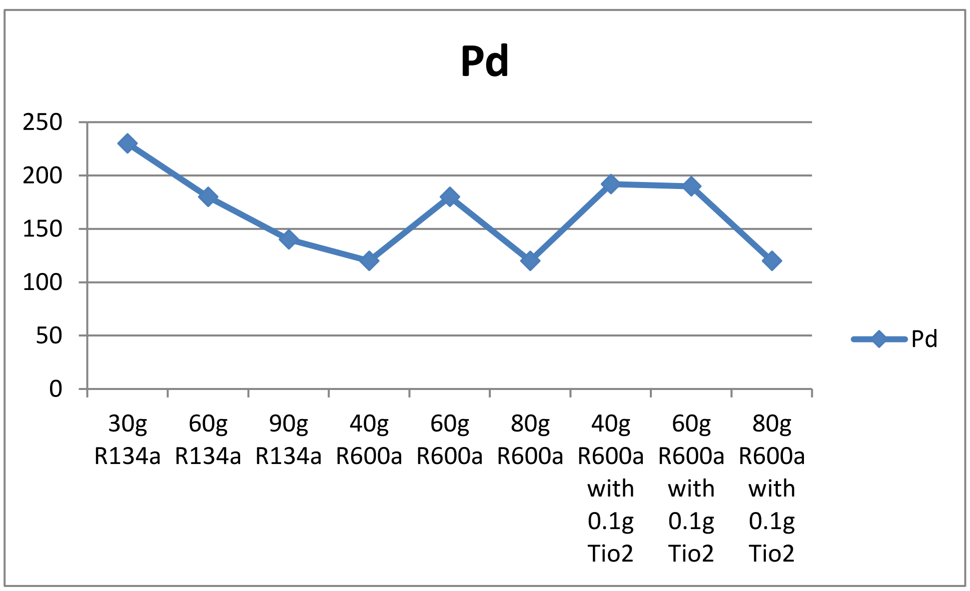
2. Refrigerating Effect vs. Mass charge



3. Compressor Work vs. Mass charge



4. Discharge Pressure vs. Mass charge



7.1. Conclusion

In this present study experimental investigation of domestic refrigerator set up was done by varying mass charge of R600a (40 gram, 60 gram,80 gram). Same results of R600a were also compared with R134a gas which has highest GWP as compared to R600a which is natural refrigerant. Also tests were conducted by adding 0.1 g/l of TiO_2 in lubricating oil. Based on experimental findings following conclusion is made 1) R600a refrigerant can be replaced easily in existing R134a domestic refrigerator without making any modifications in system. 2) R600a refrigerant has better COP than R134a refrigerant for same charge of 60 Gram & 80 Gram 3) By addition of 0.1 g/l of TiO_2 in Lubricant oil has increased COP of VCR system by 4.03 % & for 60 gram of R600a COP has increased by 5.27% for 80 Gram of R600a.

CHAPTER 8
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CHAPTER 9
PROJECT PHOTOGRAPHS

Fig.9.1 : Magnetic stirring

Fig.9.2 : Ultrasonication

Fig.9.3 vacuum pump

Fig.9.4 : Brazing process