

# Refrigerant Recovery Unit

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**Abstract—** In this project we are fabricating the Refrigerant Recovery unit. It is a simple unit which is used for recovery the refrigerants in refrigeration system and air conditioning systems. It is used to recover the refrigerants and other refrigerants also. The refrigerant or gas which is stored in recovery unit is reusable. The refrigerants are very hazardous and harmful. Due to concerns about environmental pollution caused by the release of refrigerants into the environment, and ozone layer depletion due to chloro-for a carbons present in the refrigerant gas so, we use recovery unit to recover that gases when any Leakages or repairs occur in refrigeration system and Air conditioning system. We know that refrigerants are very cost .so, we use recovery unit to store the refrigerants in recovery cylinder and we reuse it. It is very is useful in central AC plants (Air handing units and fan coil units) in industries. In future international Refrigeration society banned the present refrigerants in that time recovery unit is so useful to recover that refrigerants or gases .It is very useful to protect our Atmosphere and Environment.

**Keywords—** Refrigerant Recovery unit, Air conditioning system, refrigerants, ozone layer, Atmosphere.

## INTRODUCTION

Refrigerant recovery system is very useful unit in Refrigeration and Air-conditioning field. It is used when a system that leaks may be topped-up or repaired. Topping-up may have a lower immediate cost, whereas repairing the leak takes more time and therefore costs more. However, in the long-term, the repaired system is less likely to leak thus the costs cease, whereas repeatedly topping-up a system over months and years results in a very high accumulated cost. Obviously, preventing leakage and thus fewer journeys to the equipment and better resulting efficiency is much more desirable from an environmental perspective.

Now a days the vapour refrigeration systems are universally used for all purpose refrigeration. The vapour refrigeration systems are being used for the last 100 years but with the development in design of compressors and an increase in their speed has increased its economy from the last few decades only. It is generally used for all industrial purposes from a small domestic unit of 0.5 ton capacity to an air-conditioning plant of cinema hall of 200 tons capacity, Air-conditioning plant of central AC systems of 3000 tons. The refrigerants are used for to produce cooling effect in refrigeration, air-conditioning and central ac plants. With the development of non-toxic and non-flammable

refrigerants, this is generally used for all purpose refrigeration, from the comfort cooling in air-conditioning plant and food conservation to the production of medicine which are to be preserved in very low temperatures.

Over recent years, attention on the issue of ozone depletion has remained focused on the obligatory phasing out of ozone depleting substances (ODS). At the same time, awareness of climate change has increased, along with the development of national and regional greenhouse gas (GHG) emissions reduction targets. In order to achieve reduction in emissions of both ODSs and GHGs, attention has to be paid to activities at a micro-level. This includes reducing leakage rates, improving energy-efficiency and preventing other environmental impacts, by directing the activities of individuals, and influencing the design and maintenance of equipment.

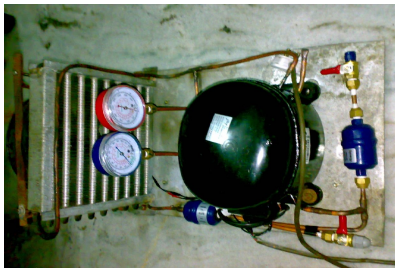
Refrigeration, air conditioning and heat pump applications represent the major consumer of halogenated chemical substances used as refrigerants; it is also one of the most important energy sector users in our society today. It is estimated that, on average, for developed countries, the RAC sectors are responsible for 10-20% of electricity consumption. Refrigerant recovery unit is very useful in this type of applications.

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### REFRIGERANT RECOVERY UNIT

A refrigerant recovery machine is a device which can be used to remove refrigerant from a cooling system such as a freezer, refrigerator, or air conditioning system. Refrigerant recovery and there are a number of applications for these devices. Due to concerns about environmental pollution caused by the release of refrigerants into the environment, and ozone layer depletion due to chlorofluorocarbons present in the refrigerant gas. So, every central AC plants and every refrigeration technician, and every industry to need this recovery unit. To protect our nation and our environment.

Refrigerant recovery system is used when a system that leaks may be topped-up or repaired. Topping-up may have a lower immediate cost, whereas repairing the leak takes more time and therefore costs more. However, in the long-term, the repaired system is less likely to leak thus the costs cease, whereas repeatedly topping-up a system over months and years results in a very high accumulated cost. Obviously, preventing leakage and thus fewer journeys to the equipment and better resulting efficiency is much more desirable from an environmental perspective. It is very useful in industrial applications.



**Refrigerant Recovery Unit**

When any device which uses refrigerant is brought in for service, the refrigerant recovery machine is used to drain the device first, to ensure that refrigerant is not accidentally released during servicing and repairs. Once removed, the refrigerant can be filtered to remove impurities, and pumped back into the device after the cleaning and servicing is over. Refrigerants can also be reclaimed, which involves more extensive processing to purify the refrigerant so that it can be released for sale, and they can also be disposed of in locations which are designed to process refrigerants.

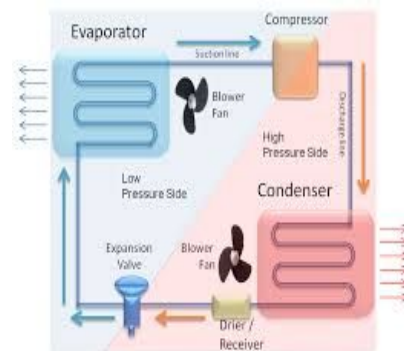
In cases where appliances which contain refrigerant are being disposed of, it is necessary to extract the refrigerant first. A refrigerant recovery machine is used to pull out the refrigerant before the device is broken down so that its components can be recycled and discarded. The extracted refrigerant may be reclaimed or disposed of, depending on policies at the processing site and the type of refrigerant

involved. Many nations hold the final custodian of the appliance responsible for extracting the refrigerant, requiring scrap yards and appliance recyclers to maintain records which indicate that they are handling refrigerant responsibly.

Refrigerant recycling is environmentally important because it reduces the need to produce more refrigerants. Processing facilities are also slowly removing and disposing of harmful refrigerants like Freon by taking the refrigerant out of old appliances. Proper disposal is critical for older refrigerants which have been linked with damage to the Earth's atmosphere, and for modern refrigerants which are considered safe, recycling still saves money and reduces stress on the environment.

#### 2.1 Working Principle

Refrigerant Recovery unit based on working principle of vapour compression cycle.



**Simple Vapour Compression Cycle**

It is simplest form there are four fundamental operations required to complete one cycle:

1. Compression
2. Condensation
3. Expansion
4. Vaporization

#### **Compression:**

The flow pressure vapour in dry state is drawn from the evaporator during the suction stroke of the compressor. During compression stroke, the pressure and temperature increases until the vapour temperature is greater than the temperature of condenser cooling medium (air or water).

#### **Condensation:**

When the high pressure refrigerant vapour enters the condenser, heat flow condenser medium, thus allowing the vaporized refrigerant to return to liquid state.

#### **Expansion:**

After condenser, the liquid refrigerant is stored in the liquid until needed. From the receiver it passes through an expansion valve. Where the pressure is

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reduced sufficiently to allow the vaporization of liquid at low temperature of about -100.C

### Vaporization:

The low pressure refrigerant vapour after expansion in the expansion valve enters the evaporator or refrigerated space. Where a considerable amount of heat is absorbed by it and refrigeration is furnished

### 2.2. Components of Refrigerant Recovery Unit:

The components of refrigerant recovery unit are:

1. COMPRESSOR
2. CONDENSER
3. FILTER
4. DRIER
5. RECOVERY CYLINDER
6. PRESSURE GUAGES
7. WEIGHTER

### 2.3 Operation of Refrigerant Recovery Unit:

A circuit for recovering refrigerant from a disabled refrigeration unit consists a compressor in series with a compressor for drawing gaseous refrigerant from the disabled unit. The series arrangement of the vacuum source and the compressor provides approximately -29 inches of mercury at the suction side of the vacuum source.

A condenser in series with the compressor converts the gaseous refrigerant into a liquid refrigerant and a storage tank in series with the condenser receives liquid refrigerant from the condenser. In one preferred arrangement a valve system connected in series between the condenser and the storage tank allows the storage tank to be disconnected from the circuit without release of refrigerant from the tank to the atmosphere. The circuit may also include a coil in parallel with the condenser and the compressor and helically disposed around the storage tank for cooling the storage tank.

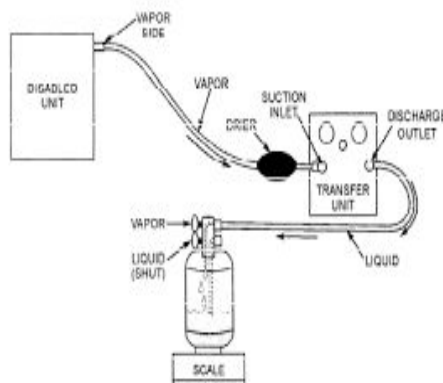


Figure 6-57.—The vapor recovery method.

A separator may be connected in series between the vacuum source and the compressor for removing impurities from the gaseous refrigerant and another coil connected in series between the compressor and

the condenser and helically disposed around the separator may be used to heat the separator. In addition to the gaseous refrigerant recovery line, a liquid refrigerant line in series between the unit and the storage tank drains liquid refrigerant from the unit into the storage tank prior to operation of the gaseous refrigerant recovery line.

### 2.4 The Refrigerant Recovery System is When The System is:

#### Repair:

Whether to repair and refill with the same refrigerant.

#### Retrofitting:

Whether to repair and retrofit with a new refrigerant, and if so, which refrigerant to use.

#### Redesign:

Whether to repair, and add refrigerant, but also carry out other improvements to improve the reliability and efficiency.

#### Replacement:

Whether to replace the entire system with a new one, and if so, which system and which refrigerant.

#### Type of refrigerant and its availability:

If a system uses a chlorofluorocarbon (CFC) then it is likely to be difficult to obtain, or even prohibited. The same will apply to hydro chlorofluorocarbons (HCFCs) in the future.

#### Severity of leakage:

For systems that have a history of high leakage, perhaps due to poor manufacture or construction, or being positioned in a vulnerable location, consideration should be given to replacing them, or redesigning/reinstalling the susceptible parts.

#### Charge of refrigerant:

If a system has a small charge of controlled or less available refrigerant, then it may not be so problematic to retain it, whereas if the charge is large then it would be sensible to replace it.

#### Availability of alternative refrigerant:

The choice of alternative refrigerant should ideally be a substance with zero ozone depleting potential (ODP) i.e. not a CFC or HCFC or a blend that contains either. It should have as low a GWP as possible.

#### Physical size of the system:

If a system is very large, replacing it with a new system may require considerable cost.

#### Availability of expertise associated with the type of system:

Involved types of work or replacing parts or the entire system should only be done provided that sufficient expertise is available.

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### **Degree of integration into application:**

Where a system is partially integrated into an application or a building, or is part of a much larger mechanical installation, it is likely to be much easier and more cost effective to carry out minimal work rather than trying to replace it with a new system.

### **Condition/state of equipment:**

For systems in a very poor condition, where perpetual maintenance and repairs are likely, then installation of a new system may be appropriate.

### **Age of system:**

If a system is very old and is using outdated technology and parts, it could be appropriate to replace it, whereas newer equipment may have modern design and already use suitable refrigerants.

### **Current level of reliability:**

If the reliability of the system and its components are poor, resulting in repeated service visits and losses of parts and refrigerant, then a replacement system may be the preferred option.

## REFRIGERANTS

Any substance capable of absorbing heat from another required substance can be used as refrigerant, i.e., ice, water, air or brine. A mechanical is a refrigerant which will absorb the heat from the source, (which is at lower temperature) and dissipate the same to the sink (which is at higher temperature than source) either in the form of sensible heat (as the case of air-refrigeration) or in the form latent heat (as the case of vapour refrigeration). The refrigerants which carry the heat in the of latent heat and also dissipate in the form of latent heat are more efficient than the refrigerants which carry the heat in the form of sensible heat. The refrigerants of the first group must possess such physical properties which will enable them to repeat continuously a liquid to gas and gas to liquid transformation. These transformations must be performed at temperatures required for particular purpose for which they are selected. The operating pressures of the refrigerant must be convenient and appropriate for design, construction and economic operation also.

### **3.1 Classification of Refrigerants:**

The refrigerants are classified into two groups:

1. Primary refrigerants,
2. Secondary refrigerants

Primary refrigerants directly take the part in the refrigeration system where secondary refrigerants are first cooled with the help of the primary refrigerants and are further used for cooling purposes.

### **1. HALO CARBON COMPOUNDS:**

This group of refrigerants was invented and developed by Charles Kettering and Dr. Thomas Migley in 1928. These refrigerants are sold in the market under made trade names as Freon, Genetron, Istron and Arcton. This group includes refrigerants which contain one or more of three halogens, chlorine fluorine and bromine.

The most of the refrigerants used for domestic, commercial and industrial purposes are selected from this group due to their outstanding advantages over the refrigerants from other groups.

### **2. AZEOTROPES:**

The refrigerants under this group consist of mixtures of different refrigerants which do not separate into their components with the changes in pressure or temperature or both. They have fixed thermodynamic properties.

Refrigerants '500' which contains 73.8% F-12 and 26.2% F-152 is an example of azeotrope.

### **3. HYDRO-CARBONS:**

Most of the organic compounds are considered as refrigerant under this group. Many hydrocarbons are successfully used as refrigerants in industrial and commercial installations. Most of them possess satisfactory thermodynamic properties but are highly flammable.

### **4. IN-ORGANIC COMPOUNDS:**

The refrigerants under this group were universally used for all purposes before the introduction of halocarbon group. They are still used for different purposes due to their inherent thermodynamic and physical properties. These refrigerants under this group are listed below with their number chemical formula and specific use.

### **5. UNSATURATED ORGANIC COMPOUNDS:**

The refrigeration under this group are mainly hydrocarbon group with ethylene and propylene base.

### **3.2 DESIRABLE PROPERTIES OF AN IDEAL REFRIGERANT:**

The desirable properties of the refrigeration are subdivided into three main groups:

- (a) Thermodynamic properties.
- (b) Safe working properties.
- (c) Physical properties
- (d) Other properties

### **A) THERMO DYNAMIC PROPETIES:**

#### **BOILING POINT:**

Low boiling temperature at atmospheric pressure of the refrigerant is required for an efficient refrigerant. It becomes necessary to operate the compressor at high vacuums if the boiling point of the refrigerant is high at atmospheric pressure. High boiling point



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of the refrigerant at atmospheric pressure reduces the capacity of the system and lowers the operating cost.

### **FREEZING POINT:**

Low freezing point of the refrigerant is necessary because the refrigerant should not freeze under required evaporator temperature. The refrigerant must have a freezing point well below the operating evaporator temperature.

The freezing point of most of the refrigerant are below  $-30^{\circ}\text{C}$  so that this property is not seriously considered for normal refrigeration systems. This requirement is taken into consideration for selecting the refrigerant when used for cryogenic applications.

### **EVAPORATOR CONDENSER PRESSURE:**

It is always desirable to have positive pressures in evaporator and condenser for the required temperatures, but the pressures should not be too high above atmosphere. Too high pressures require the robust construction of the refrigeration system which requires high initial cost and high operating cost also. Positive pressures in a evaporator are necessary to prevent the leakage of air and moisture into refrigeration system. The operating pressure range is one the major considerations in the selection of refrigerant for the economical working of the refrigeration system.

The selection of compressor for a refrigeration system depends upon the selection of the refrigerants for a particular job (required evaporator temperature).

Reciprocating compressors are commonly used with refrigerant having low specific volumes, high operating pressures and high operating pressures differences. The reciprocating compressors are used for the refrigerant given below:

$\text{NH}_3$ ,  $\text{CO}_2$ , F-12, F-22 and  $\text{CH}_3\text{Cl}$

Centrifugal compressors are preferred for refrigerants operating under low evaporator and condenser pressures and low pressure differentials.

High difference between evaporator and condenser pressure results in high compression ratio. The power required to run the compressor increases with increasing pressure ratio and that is because of high compression ratio which requires more power and gives low volumetric efficiency.

### **CRITICAL TEMPERATURES AND PRESSURES:**

The critical temperature of the vapour is defined as the temperature above which the vapour cannot be condensed irrespective of any high pressure. The critical temperature of the refrigerant used should be higher than the temperature occurring within the condenser for easy condensation of the refrigerant vapour. The critical temperatures of all widely used

refrigerant are well above the temperature occurring within the condenser except  $\text{CO}_2$ .

The air cannot be used as cooling medium in condenser for  $\text{CO}_2$  refrigeration system because the critical pressure of  $\text{CO}_2$  at critical is slightly above the required condenser pressure of normally operated system. The condensation of  $\text{CO}_2$  using air as cooling medium is more or less impossible during summer when the temperature of atmospheric air is above the critical temperature of  $\text{CO}_2$ .

### **LATENT HEAT OF REFRIGERANT:**

High latent heat of refrigerant at evaporator temperature is desirable because the refrigerating effect per kg of refrigerant will be high. The weight of refrigerant required to be circulated in the system per ton of refrigeration will be low if the latent heat of refrigerant is high. Thus also reduces the initial cost of the refrigerant used in the system. The refrigerants with low latent heats can be used by increasing the size, number and speed of the cylinder if other properties are satisfactory.

### **B) SAFE WORKING PROPERTIES:**

In the section of the refrigerant, the safe working properties of the refrigerant are the prime considerations. There are few refrigerants which are highly desirable from thermodynamic point of view but they find limited use due to unsafe properties. Ammonia is one of them which is used for limited applications.

The safe properties of the refrigerant include the followings:

- It should be chemically inert.
- It should be non-flammable, non-explosive and non-toxic both in pure state and when mixed with air in any proportion.
- It should not react with lubricating oil and with materials used in construction of refrigeration system.
- It should of the refrigerant in condenser should be above the temperature of the coolant used in condenser for positive heat transfer.
- Few safe working properties are given below:

### **TOXICITY:**

The effect of refrigerant on the human body is one of the major considerations in the selection of the refrigerant and that is because of the possibility of the leakage of refrigerant from refrigeration system. Toxic nature of the refrigerant may cause the injury to the human body or death depending upon its percentage in air. It increases and poisons the air used for breathing.

This is one of the major considerations in selecting a refrigerant when the refrigeration system is used for

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air-conditioning hospital, or direct expansion cold storages.

The use of the toxic refrigerants is limited for cold storage systems as they affect the palatable qualities of many foods. They are used with indirect cooling methods in which a secondary coolant such as water or brine is used in the system.

Some refrigerants which are non-toxic in nature become toxic when mixed with air with certain percentage. This is particularly true with all fluorocarbon refrigerants

Co<sub>2</sub> and F-12 are particularly used for marine applications because of their non-toxic and non-irritating properties.

In the following table, the toxic effects of different refrigerants are listed.

### **FLAMMABILITY:**

Ideal refrigerant should not have any danger of explosion in the presence of air or in association with lubricating oil.

Most of the refrigerants commonly used are non-flammable so the danger of explosion does not exist. Freon's and co<sub>2</sub> come under this group. NH<sub>3</sub> and CH<sub>3</sub>Cl burn with certain concentrations in air. The refrigerants of hydrocarbon family are highly flammable. Methane, ethane and propane come under this group.

### **CORROSIVE PROPERTY:**

The chemical reaction of the refrigerant on the material used in refrigeration system is not the prime consideration in the selection of the refrigerant, but the selected refrigerant decides the material to be used for the construction of the system. The refrigerant must be non-corrosive in order to use more common materials.

Refrigerants must be chemically inert with materials as well as the must also remain inert in the presence of water or air.

The Freon refrigerants are non-corrosive with all materials such as brass, copper, zinc, iron, tin, lead and aluminium. The refrigerants become acidic in the presence of air and water. Magnesium and aluminium should not be used with Freon refrigerants as they are readily attacked by acids. Freon's have high solvent action on natural rubber so that synthetic rubber is used for gaskets and other sealing purposes to avoid this difficulty.

Iron and steel are commonly used with ammonia refrigerant as it act on copper, brass and other cuprous alloys in the presence of water.

Sulphur-dioxide is non-corrosive to all metals in the absence of water but it acts on all common engineering metals in the presence of water and air.

### **CHEMICAL STABILITY:**

An ideal should not decompose at temperatures normally encountered in the system. Some refrigerants disintegrate forming non-condensable gases which increase condensing pressure and sometimes cause vapour lock.

Many times, the disintegration of the refrigerant is due to the catalytic action of some metal. to avoid this, the refrigerant must be inert with all materials used in refrigeration system.

Freon is unstable above 600.c and forms corrosive and poisonous products. Sulphur dioxide does not decompose below 1600.c; therefore it is one of the most stable refrigerants. Such high temperature are never reached under normal conditions in refrigerant systems.

### **EFFECT ON STORED PRODUCT:**

The refrigerants used in cold storage plants and in domestic refrigerators should not affect the quality (colour, test, etc.) of the material when it comes in contact with stored product.

Ammonia is readily dissolved in water and becomes alkaline in nature. Most vegetables, fruits and meat are slightly acidic in nature, therefore, ammonia reacts with these products and spoils the test.

Sulphur-dioxide is readily dissolved in water and becomes acidic in nature. There is no chemical reaction of so<sub>2</sub> on foods as most of the foods are acidic in nature. It has bleaching action on flowers, plants and furs.

Methyl-chloride vapour has no bad effect on flower, furs or any other household articles. There is no danger in eating the foods and drinking the drinks which are exposed to Methyl-chloride vapour.

Freon's have no effect on foods, meat, vegetables, flowers, furs and dairy products. These will not be any change in colour, test or texture of the material which is exposed to Freon.

### **C) PHYSICAL PROPERTIES**

#### **SPECIFIC VOUME:**

Low specific volume of the refrigerant at the suction into the compressor is always desirable, because it reduces the size of the compressors for the same refrigeration capacity. The reciprocating compressors are always used with low specific volume at suction where the centrifugal compressors are desirable with high specific volume of the refrigerant at suction.

#### **SPECIFIC HEAT OF LIQUID AND VAPOUR:**

Low specific heat of liquid refrigerant and high specific heat of vapour refrigerant are desirable because both tend to increase the refrigerating effect per kg of refrigerant. The low specific heat of liquid refrigerant helps in increasing the sub-cooling of

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liquid and high specific heat of vapour helps in decreasing the superheating of vapour. A refrigerant having both properties gives considerably high refrigerating effect per kg of refrigerant.

### **THERMAL CONDUCTIVITY:**

The thermal conductivities of liquids and gaseous refrigerants are required for finding the heat transfer coefficients in evaporators and condensers. This data is necessary for designing evaporators and condensers. High conductivities of refrigerant in both states are desirable.

### **VISCOSITY:**

This property of refrigerant in both states carries importance for calculating heat transfer coefficients in evaporators and condensers. This also helps in designing the pumping units of the system. Low viscosities of refrigerant in both states are desirable for better heat transfer and low pumping power.

### **DIELECTRIC STRENGTH:**

The electric resistance of the refrigerant becomes an important factor when it is used in hermetically sealed unit where the motor is exposed to the refrigerant.

The dielectric strengths of different refrigerants vapours are compared with dielectric strength of nitrogen therefore, the relative dielectric strengths of refrigerant vapour are given by a ratio of:

$$= \frac{\text{Dielectric strength of refrigerant vapour}}{\text{Dielectric strength of nitrogen}}$$

### **D) OTHER PROPERTIES:**

#### **ODOUR:**

Odour may be an average or a disadvantage to a refrigerant. Distinct odour of the refrigerant helps in detecting the leak of the refrigerant. Some refrigerants having specific odours spoil the refrigerated products when they come in contact with them. Refrigerants having irritating odours cause panic and headache to the people. Some eatables as meat and butter which are highly sensitive to odours lose their taste when exposed to ammonia and sulphur-dioxide.

In small concentrations, ammonia has a pleasant odour but it becomes irritating with an increase in concentration. Sulphur-dioxide has heavy irritating and obnoxious odour even with very small concentrations. Methyl and methylene chlorides have sweet odour and it is non-irritating. The Freon's 11, 12, 22 and 113 are more or less odourless.

#### **LEAK-TENDENCY:**

The leakage of refrigerant outside the system or leakage of the air inside the system is due to the openings in the joints or flaws in material used for

construction. The tendency of leakage is more predominant in high pressure side.

A dense fluid has less tendency to leak than lower density fluid. The possibility of leakage is more with high discharge pressure side.

The leak of ammonia can be easily detected by its odour. The entire Freon charge may leak unnoticed because all refrigerants of Freon group are odourless. To overcome this difficulty, electronic leak detector is generally used in big refrigerating plants.

### **REFRIGERANT AND OIL RELATIONSHIP:**

The lubrication of piston and cylinder, bearings and valves is essential to reduce the friction and increase the life of the unit. The refrigerant should not act with lubricating oils the refrigerant. This property is also important for the smooth running of the system.

The miscibility of the oil and refrigerant (ability of refrigerant to mix with oil) is an important characteristic in the selection of the refrigerant. This Property is also important for the smooth running of the system.

The refrigerant NH<sub>3</sub>, CO<sub>2</sub> and SO<sub>2</sub> are immiscible refrigerants. All freons, CH<sub>3</sub>CL, CH<sub>2</sub>CL<sub>2</sub> and most refrigerants from hydrocarbon group are miscible. High viscous lubricating oils must be used with miscible refrigerants as the effect of miscibility is to reduce the viscosity.

The relative merits and demerits of both refrigerants are discussed below in the light of these effects on the working of the system.

When the lubricating oil is carried by the refrigerant of immiscible type, it forms a coating over the heat transfer surfaces of the evaporator and there by reduces the heat transfer capacity of the evaporator which in turn decreases the load capacity of the system. Some means must be provided to remove the lubricating oil before entering into the evaporator and leaving the compressor.

The lubrication is provided with a mixture of lubricating oil and refrigerant in case of miscible refrigerants. It is not necessary to provide oil returns lines and oil separating devices in case of miscible refrigerants.

### **C.O.P AND POWER REQUIREMENT:**

The requirement of power per ton refrigeration is most important consideration from the economic unit of view. Low power consumption per ton of refrigeration is always desirable.

### **COST AND AVAILABILITY:**

The refrigerant must be available readily and with lesser price. The cost of the refrigerant is not too important in small amount of refrigerant is required for make up in the event of leaks. The cost of

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refrigerant is very important in high capacity refrigerating systems like industrial and commercial.

The relative cost of the three commonly used refrigerants are given below:

AMMONIA  
CHEAPEST

F-12 more  
expensive

F-22 most  
expensive

### 3.3: IMPORTANT REFRIGERANTS:

#### AMMONIA:

It is the only refrigerant from inorganic group which was used universally for many applications and still used to great extent at the present time. It possesses many properties required for ideal refrigerant. It has wide applications because of its low volumetric displacement. Low cost, low weight of liquid refrigerant per ton of refrigeration and high efficiency. Presently it is widely used in cold storages. Ice manufacturing plants and skating rinks due to its low production and maintenance cost.

#### FEW PROPERTIES OF AMMONIA ARE LISTED BELOW:

- It is toxic, flammable, irritating and food destroying.
- Anhydrous ammonia has no effect on lubricating oil but in presence of moisture, ammonia forms an emulsion with oil that causes operating difficulties. The formed emulsion becomes effective when the percentage of Water exceeds 0.01%. It is not oil miscible therefore it will not dilute the oil in the crank case of the compressor.
- It is highly volatile and becomes explosive when mixed with air and compressed therefore air leaks must be avoided in ammonia refrigeration systems.
- Ammonia attacks on non-ferrous metals in the mixed with air and compressed therefore air leaks must be avoided in ammonia refrigeration systems.
- Ammonia can be used economically for -70.c evaporator temperature and its applications for further low temperature becomes highly uneconomical and difficult to maintain low vacuum required in the evaporator.
- Ammonia is commonly used in ice factories and breweries without exception. The reasons for this have been well documented as follows:

- (a) Lowest running cost,
- (b) smallest pipe lines
- (c) Cheapest refrigerant,
- (d) leaks easy to detect.

- Low side equipment can be readily added to or taken away with no operating problems.
- Different forms of refrigerant-circulating can be used incorporated into the main system, e.g., dry expansion, flooded, overfeed or recirculation.
- Easier maintenance with no evacuation and drying.
- largest latent heat per unit mass combined with the smallest liquid density and low viscosity allows smaller liquid pumps and liquid supply lines in overfeed system.
- The possibility of fire hazard with NH<sub>3</sub> is minimum.
- The major engineering disadvantage of NH<sub>3</sub> is its high discharge temperature which requires more efficient separators and can cause oil carbonisation problems when it is single staged with high compression ratios. However, this is not a problem with oil injected screw compressors which can operate successfully with compression ratio of 25 down to suction temperature of -45.c and condensing at 35.c. h toxic nature of NH<sub>3</sub> is the another disadvantage as pigs were killed when exposed to concentrations (5000 ppm) for half an hour. This can be avoided by making the system leak-tight.

#### CARBON DIOXIDE:

CO<sub>2</sub> is odourless, non-toxic, non-flammable, non-explosive and non-corrosive. It has all excellent properties therefore it was widely used for air-conditioning hospitals, theatres, hotels and marine services where safety was the prime considerations. Now days, it is replaced by Freon group and there is hardly any installation except considerably old one. Presently its use as refrigerant is limited only for the production of dry-ice.

#### FEW PROPERTIES OF CO<sub>2</sub> ARE LISTED BELOW:

- It is non-toxic, non-poisonous and non-flammable but causes death due to suffocation when present in large quantities.
- It is chemically stable under all pressure and temperature conditions occurring in the system. It remains unaffected either with metals or oil in the pressure of air and water, therefore, any metal can be used with is refrigerant.
- It is immiscible in oil and therefore will not dilute the oil in the crankcase of the compressor.

The major drawbacks of carbon-dioxide are bad thermodynamic properties.

#### FEW OF THEM ARE LISTED BELOW:

- The chief disadvantage of CO<sub>2</sub> is its high operating pressures under standard temperature conditions. This requires heavy piping and robust condenser and evaporator.



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- Another major disadvantage of CO<sub>2</sub> is high power requirement. The KW-power required per ton of refrigeration using CO<sub>2</sub> as refrigerant is nearly twice than other commonly used refrigerant.
- CO<sub>2</sub> does not exist in liquid state at atmospheric pressure as its boiling temperature (-78.6.c) at atmospheric pressure is far below its freezing temperature (-56.6.c) another major disadvantage of this refrigerant is the requirement of low temperature coolant in the condenser because of its low critical temperature (31.c)

### **SULPHUR-DIOXIDE:**

SO<sub>2</sub> was widely used for domestic refrigerator during the period 1920 to 1930. It is replaced almost by Freon refrigerants. It is colourless and suffocating fluid.

SO<sub>2</sub> has many disadvantage irrespective of its better thermodynamic properties. Few of them are listed below:

- It forms sulphurous acid in the presence of water and sulphuric acid in the presence of water and air which are highly corrosive to most of the metals.
- It has low refrigerating effect and high specific volume per kg of refrigerant compared with other refrigerants therefore, large compressors with higher speed are required with its refrigerant for same refrigerating capacity. Its piston displacement is 2.3 times greater than NH<sub>3</sub> and 8.5 times greater than CO<sub>2</sub>.
- Its heavy irritating and high toxic nature even with small concentrations eliminate its use for refrigeration used for human comfort conditions.

Sulphur dioxide is not oil miscible. Liquid SO<sub>2</sub> is heavier than oil therefore oil floats on the top surface of liquid sulphur-dioxide which simplifies the problem of oil removal and return.

All hydrocarbon refrigerants are made from two elements, carbon and hydrogen. The refrigerants of this group are highly explosive and flammable in the presence of air. Most of them do not absorb moisture and they do not attack the metals used. All of them are extremely miscible with oil. The main refrigerants of this group which are in use for different purposes are methane, ethane, butane, propane, ethylene, and isobutene, ethane, methane and ethylene are used in low temperature applications, isobutene was used for domestic purposes and now it is widely used in water desalting plants.

### **ISOBUTANE:**

Butane and isobutane are made from same number of hydrogen and carbon atoms but they have

different chemical structure [Butane C<sub>4</sub>H<sub>10</sub> and isobutane has more advantages over butane as a refrigerant. It has low boiling point and high vapour density at atmospheric pressure compared with butane. The compression ratio is low compared with butane for the required temperature range.

It is flammable in the presence of air. It is highly miscible with oil. It has slight sweetish odour does not affect metals but does affect the rubber. It is popular with trade name freezol.

The refrigerants of chlorine group of halogenated hydrocarbons are better in thermodynamic properties than the straight hydrocarbons.

### **METHYL CHLORIDE (CH<sub>3</sub>Cl):**

It has many good thermodynamic and physical properties which are required for an ideal refrigerant. It has widely used for domestic and commercial purposes in past.

- It is flammable and explosive when mixed with air in concentrations between 8 to 17.5%.
- It is corrosive to zinc, aluminium and magnesium and it forms the explosive compounds with the action on these metals, therefore these metals should not be used with this refrigerant.
- It forms weak HCL in the presence of moisture which is corrosive to both ferrous and non-ferrous metals. Natural and synthetic rubber are soluble in liquid methyl chloride. So these cannot be used as gasket materials with methyl chloride system.
- It is oil miscible so oil return in methyl chloride system is simplified.

### **METHYLENE CHLORIDE (carren.1):**

It is non-flammable and non-toxic. It is also non-corrosive to metals in the presence of the moisture. This refrigerant was extensively used for air-conditioning theatres. Auditoriums and office buildings because of its safety properties. The volume of vapour handled is considerably large (2.02 cu. m/min/Ton at -15.c) as evaporator and condenser pressures are both below atmospheric pressure. The centrifugal compressors are adopted to handle large volume of vapour at low pressure. Oil miscibility of methylene chloride carries less importance. Oil and refrigerants do not come in contact with each other due to the use of centrifugal compressors.

The refrigerants from fluorinated hydrocarbon group meet all demands of an ideal refrigerant. These used for ultralow to high temperature ranges. The refrigerants of this group are normally non-toxic, non-irritating, non-flammable and non-corrosive in the absence of moisture. They do not act chemically with lubricating oil and maintain the required

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properties. The properties of few refrigerants of this group are described below.

### **FREON -11 (CCL3F):**

It is a fluorocarbon methane series. Due to the low operating pressures, centrifugal compressors are used to handle the large volume at low pressure. It is non-corrosive, non-toxic and non-flammable. It is mainly used for air-conditioning office buildings, factories, department stores theatres.

### **FREON- 12(CCl2F2):**

This is most widely used and popular refrigerant of this group. It is commonly used for all refrigeration purposes (low, medium and high temperatures). It is colourless and odourless liquid. It is non-toxic, non-flammable, non-explosive and non-corrosive. It condenses at moderate pressure under normal atmospheric conditions and boils at -29.5.C at atmospheric pressure. This property makes it suitable refrigerant for all-purpose refrigeration and it can be used with all three types of compressors. It simplifies the problem of oil return as it has good oil miscibility. This refrigerant is commercially available in different cylinders sizes. Generally 0.7 kg of refrigerant is required in refrigeration system per cubic metre of air-conditioned space'

F-22 can be used with all types of condensing units, water-cooled, air-cooled and evaporative type. Normally the design of water cooled and evaporative type condensers will range between temperatures of 40.5.C to 43.5.C corresponding to pressures of 8.65 to 9.25 bar whereas air -cooled installations are designed for a condensing temperatures of 54.5.C corresponding to the pressure of 12.3 bar.

### **FREON -22 (CHClF2):**

This refrigerant is also successfully used in air-conditioning units and commercial purposes. It is commonly used in fast freezing units where the temperature requirement is -40.C. Now days it is commonly adopted for industrial low temperature refrigeration, as low as -90.C

Freon-22 is miscible with oil at condenser temperature but rises to separate at evaporator temperatures when the system is used for low temperatures applications. Under these circumstances, oil separators should be used to insure to return of oil from the evaporator. The solubility in water is three times greater than freon-12, therefore special driers must be used to remove the water.

### **FREON-22 HAS SOME OUTSTANDING ADVANTAGES OVER FREON-12 WHICH ARE LISTED BELOW:**

- The compressors displacement is 60% less with F-12 compared with F-22 for the same refrigerating effect, therefore, a compressors

gives 60% more refrigerating effect with F-22 then F-12. This property reduces the size of the pipe line required with F-22 compared with F-12.

- The pressures in the evaporator are above atmosphere for the evaporator temperatures between -30 to 10.C with F-22 where the evaporator pressure with F-12 are below atmosphere for this temperatures range.
- Toxicity of F-22 is about same as that of CO2 which we breathe all the time. The safe concentrations of F-22 is 10.0 ppm, where the highest number for any substance except CO2 is 500 ppm.

F-22 can be used with all types of condensing units, water cooled, air-cooled, and evaporative type. Normally the water cooled and evaporative type condensers are designed for a condensing temperatures of 38.C corresponding to the pressure of 13.5 bar where as air-cooled installations are designed for a condensing temperature of 49.C corresponding to the pressure of 18 bar.

The major disadvantage with F-22 compared with F-12 is the high discharge temperature which requires the water-cooling of the compressors head and cylinder.

The Freon family of refrigerants is one of the major factors responsible for the tremendous growth of the refrigeration and the air-conditioning industries. The properties of these refrigerant have permitted their use under flammable conditions as in petroleum industries. A brief survey of fields of applications served by this group of refrigerants is given in the table.

Refrigerant	Compressor Type	Applications
Freon -11	Centrifugal	Air-conditioning systems ranging from 200 to 2000 tons in capacity. Cooling industrial process-water or brine. It is used where low freezing point and non-corrosive properties are important.
Freon -12	Reciprocating Centrifugal	It is used for the most of the applications.

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	Rotary	Air-conditioning plants, refrigerators, frozen food and ice cream cabinets, food locker, plants, water-coolers, window air-conditioners, automobile air conditioning.			refrigeration upto-50.C in cascade systems.
Freon -22	Reciprocating Centrifugal	Greatest use in commercial air-conditioning, it is also widely used in frozen food plants, frozen food storages and display cases. For low temperature applications.			For low temperatures refrigeration - 90.C in cascade systems
Freon -502	Reciprocating	Frozen food and ice-cream display cases and warehouses and food-freezing point plants. Truck refrigeration and heat pumps.			For considerably low temperatures up to -130.C in triple cascade systems.
Freon -113	Centrifugal	Excellent General low temperature refrigerant.			Commercial air-conditioning and for household refrigeration mostly where 50 cycle current is common.
Freon -114	Centrifugal Rotary	Small to medium air-conditioning system and industrial cooling.			
Freon -13B1	Reciprocating	It is used in household refrigerators and with rotary compressors used in large industrial process cooling.			
Freon -13	Reciprocating	Medium low temperatures			

### **REFRIGERANT-500 (carren-7):**

Refrigerant-500 is commercially known as careen - 7. It is an azeotropic mixture of F-12 and F-152d in the proportion of 73.8% and 26.2% by weight respectively. This refrigerant is commonly used for both commercial and industrial applications, only with reciprocating compressors.

The solubility of Refrigerant -500 in water is highly critical of special arrangements should be made to remove the moisture from the system.

The principal advantage of this refrigerant over F-12 is, it gives 18% more refrigerating effect with the same compressors. This particular property helps in using the same compressors with 50 or 60 cycle power without any change in refrigerating capacity, this is because motor operating with 50 cycle power will give 5/6<sup>th</sup> of the speed when operating with 60 cycle power, and displacement of the direct connected compressors is reduced by 18% when change is made from 60 to 50 cycle power.

The flash point is the lowest temperature at which a fuel will ignite when exposed to an ignition source. The flashpoint of the fuel affects the shipping and storage classification of fuels and the precautions that should be used in handling and transporting the fuel. In general, flash point measurements are typically dominated by the fuel component in the blend with the lowest flash point. The flashpoint of ethanol–diesel blend fuels is mainly dominated by ethanol.

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### 3.4. Secondary Refrigerants:

Under many circumstances, it is not desirable to carry the heat from has generating source directly by refrigerant, then it is carried by using the secondary refrigerant as air, water or brine. The heat carried by the secondary refrigerant from the generating source is given to the refrigerant in the evaporator and recirculated again and again.

The secondary refrigerant circuit is commonly used in all big commercial and industrial refrigeration plants. This indirect cooling with help of secondary refrigerant has the following advantages over the direct cooling system.

When the temperature requirements of the different parts in large building are varied, then these different temperatures can be easily maintained by controlling the amount of brine flowing to the part. Another advantage is easy to handle and easy to control compared with primary refrigerant.

The pipe line used for carrying the heat by secondary refrigerant from the source is considerably smaller compared with the pipe line used with direct expansion refrigeration system and this is because the specific volume of the refrigerant vapour. Therefore, the pipe line diameter required for secondary refrigerant is considerably lower than the refrigerant pipe line diameter.

The use of brines is advisable in order to keep coils and pipes containing a toxic refrigerant away from load places. The secondary refrigerant also eliminates long refrigerant lines in a system using a non-toxic refrigerant. Secondary refrigerant also eliminates long refrigerant lines with their possibilities of leakage and their penalizing pressure drops.

The commonly used secondary refrigerant are water, sodium-chloride brine, calcium chloride brine and propylene glycol.

#### **WATER:**

When the required temperature to be maintained is above the freezing point of water, then water is universally used as secondary refrigerant most in air-conditioning plants, chilled water is used for cooling and dehumidifying the air either with help of cooling or with the help of water spray unit.

#### **BRINES:**

When the temperature required to be maintained are below the freezing point of water then the water cannot be used as secondary refrigerant. In such cases, brine solutions are commonly used.

Brine is a solution containing the salt in dissolved condition in water. The freezing temperature of the brine is lower than the freezing temperature of water and it decreases with the increased in salt

concentration but if the concentration is increased beyond a certain point. The freezing temperature of the brine increases temperature is achieved at eutectic point. The eutectic temperature of sodium chloride brine corresponding salt concentration salt concentration of 23% by weight.

Calcium chloride brine is more preferable over sodium chloride brine when the required temperatures is below -20.C. it is commonly used for product freezing and industrial process cooling and ice-making plants. The major disadvantage of this brine is dehydrating effect on foods with which it may come in contact. Whenever calcium chloride brine is used for food freezing, it is necessary to design the system so as to prevent the brine from coming into contact with refrigerated foods.

Sodium chloride brine is used where the use of calcium chloride brine is objectionable. This brine is commonly used for freezing the meat and fish with the help of brine spray.

The thermal properties of both brines are less satisfactory than those of water. The properties of both brines are given in Appendix.

#### **ANTI-FREEZE SOLUTIONS;**

Certain compounds, soluble in water, when added in the water, the freezing point of the water decreases.

Glycerine is an anti-freeze agent obtained from carbohydrates. A freezing point of -40.C can be obtained by adding 70% glycerine by weight to water. Methyl alcohol known as 'Wood Alcohol' as also used as anti-freeze.

Glycols which are the by-products of the petroleum are gaining industrial importance as anti-freeze agents. The ethylene glycol and propylene glycol are miscible in all proportions with water and act to lower the freezing point of the solution in proportion to the amount of glycol added. The 15% ethylene glycol by volume, decreases freezing temperatures to -9.3.C and with 65%, the freezing temperatures goes to -41.5.C. the 65% of the glycol in water is a eutectic solution.

### 3.5 Effects of ozone layer depletion on the environment due to refrigerants:

With the loss of the shield from ultraviolet radiation, serious damage can result on all living organisms. The severity of the situation is augmented by the fact that each one percent depletion of ozone results in up to two percent increased exposure to ultraviolet radiation.

Plant and marine life could be adversely affected by increased exposure to ultraviolet radiation caused by depletion of the ozone layer. The sensitive ecosystem of the oceans may be adversely affected. The phytoplankton and larvae of many species that



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live from the surface of the ocean down to several metres below the surface could well be sensitive to increased exposure to ultraviolet radiation. Increased exposure results in reduced productivity, which means less plant life and fewer fish harvested from the seas.

The Global Solar UV Index, developed by the World Health Organization in collaboration with UNEP and the World Meteorological Organization, is a tool to describe the level of UV radiation at the Earth's surface. It uses a range of values from zero upwards, taking into account all the factors to indicate the potential for adverse health effects due to UV radiation. The higher the value, the greater the amount of dangerous UV rays.

### 3.6 Direct global warming of refrigerants:

The halocarbons, and among them the main refrigerants, absorb the infrared radiation in a spectral range where energy is not removed by CO<sub>2</sub> or water vapour, thus causing a warming of the atmosphere. In fact these halocarbons are strong GHGs since their molecules can be thousands of times more efficient at absorbing infrared radiation than a molecule of CO<sub>2</sub>. CFCs and HCFCs have also a significant indirect cooling effect, since they contribute to the depletion of stratospheric ozone that is a strong UV radiation absorber, but this effect is less certain and should vanish with the reduction of the ozone hole. The direct warming potential of a molecule is proportional to its radiative effect and increases with its atmospheric lifetime. The direct global warming effect of a given mass of substance is the product of the GWP and the amount of the emissions: this explains why CO<sub>2</sub> has a much greater overall contribution to global warming than halocarbons, since the total mass of CO<sub>2</sub> emitted around the world is considerably more massive than the mass of emitted halocarbons.

Direct emissions of GHGs may occur during the manufacture of the GHG, during their use in products and processes and at the end of their life. Thus, the evaluation of their emissions over all their life, cycle is necessary. It is noteworthy that at present a large amount of halogenated refrigerants is in banks (i.e. CFC, HCFC and HFC that have already been manufactured but have not yet been released into the atmosphere such as contained in existing equipment, products and stockpiles, etc.) It is estimated that in 2002, the total amount of refrigerants (CFC and HFC) banked in domestic refrigeration, i.e. the sum of refrigerant charge contained in all refrigerators in operation or wasted, amounted to 160,000 tonnes. Despite the fall in the production of CFCs, the existing bank of CFCs, as refrigerant in all RAC applications and including the amount contained in foams, is over 1.1 million tonnes and is therefore a significant source of

potential emissions. Banks of HCFCs and HFCs are being established as use increases. The management of CFC and HCFC banks is not controlled by the Montreal Protocol or taken into account under the United Nations Framework Convention on Climate Change (UNFCCC). The emission of these banks could give a significant contribution to global warming in the future.

### ADVANTAGES

- It is use to store the refrigerants, because refrigerants are high cost.
- we reuse the stored refrigerants.
- It is very useful to protect ozone layer from harmful choro-fora carbons present in refrigerants.
- It is useful to protect our atmosphere from global warming
- It is very low cost.

### DIS-ADVANTAGES

- It is not suitable to small applications

### APPICATIONS

- It is very useful in large industrial applications.
- It is very useful to 'AC' technicians.
- we reuse the stored refrigerants.
- It is very useful in future to recover the banned refrigerants.
- It is very useful to protect our atmosphere.

### CONCLUSION

This project is made with preplanning, that it provides flexibility in operation.

This innovation has made the more desirable and economical. This project "REFRIGERANT RECOVERY UNIT SYSTEM" is designed with the hope that it is very much economical to recover the refrigerants and useful to small and large industrial applications.

With the use of refrigerant recovery unit we can recover the refrigerant from Any Repair or service or leakage systems (central AC systems).It is very cost but we fabricate it as very low cost.

It is very useful to recover the refrigerants in central 'AC' Plants because in that they use 50-3000 tons.

By the using of refrigerant recovery unit, we protect the ozone layer from the choro-fora carbons present in the refrigerants when they exposed to atmosphere. We can also protect the atmosphere from global warming temperature.

These systems are used for most of air conditioning and refrigeration applications such as comfort air conditioning industrial applications. It is very useful in future to recover the banned refrigerants. It is very useful in every house.

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This project helped us to know the periodic steps in completing project work. Thus we have completed our project successfully.

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### ACKNOWLEDGEMENT

We gratefully acknowledge the unstinted help and guidance given by **Y.TRINADH RAO, BTech** Department of Mechanical Engineering, throughout this project work.

We profoundly thank **G.S.D.K SRAVANI, MTech Assistant Profeser**, Department, Mechanical Engineering and to other faculty members of Mechanical Engineering for their valuable support and encouragement during the entire course of this work.

We express our heartfelt thanks to Principal, Management and Non-Teaching Staff for providing necessary facilities in the course of our project work.

We are thankful to the students of Department of Mechanical Engineering for their valuable help and encouragement extended during the course of this project.

We also thank our parents and all those directly or indirectly helpful to make this project a success.