JHARKHAND Rai University

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Laboratory Manual

Refrigeration & Air Conditioning Lab

Bachelor of Technology

VIth Semester

Mechanical Engineering

B.TechSem- 6 ME
Sub Code- 7P.353
Refrigeration & Air Conditioning Lab.

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List of Experiments:

1. Study on refrigeration Test Rig.

2. To study function and working of different parts of an Air Conditioning equipment.

3.Study on Heat Exchanger.

4.Study on compression system.

5.Visit report on Ice Plant.

EXPERIMENT No: 1

AIM:
Study on refrigeration Test Rig.

THEORY:
Theory of Vapour compression refrigeration cycle is explained.

Figure 1: Vapor Compression Test Rig

A vapour compression 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 vapour 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 vapour compression refrigeration cycle is based on the following factor:

1. Refrigerant flow rate.
2. Type of refrigerant used.
3. Kind of application viz air-conditioning, refrigeration, dehumidification etc.
4. The operation design parameters.
5. The system equipments/ 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 ambient conditions by controlling 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.

The components used are:

1. Evaporator
2. Compressor
3. Condenser and receiver
4. Throttling device

The refrigeration cycle can be explained schematically in the two diagrams i.e.. Pressure enthalpy diagram Temperature entropy diagram.

The working of vapour compression refrigeration cycle and function of each above component is given below.

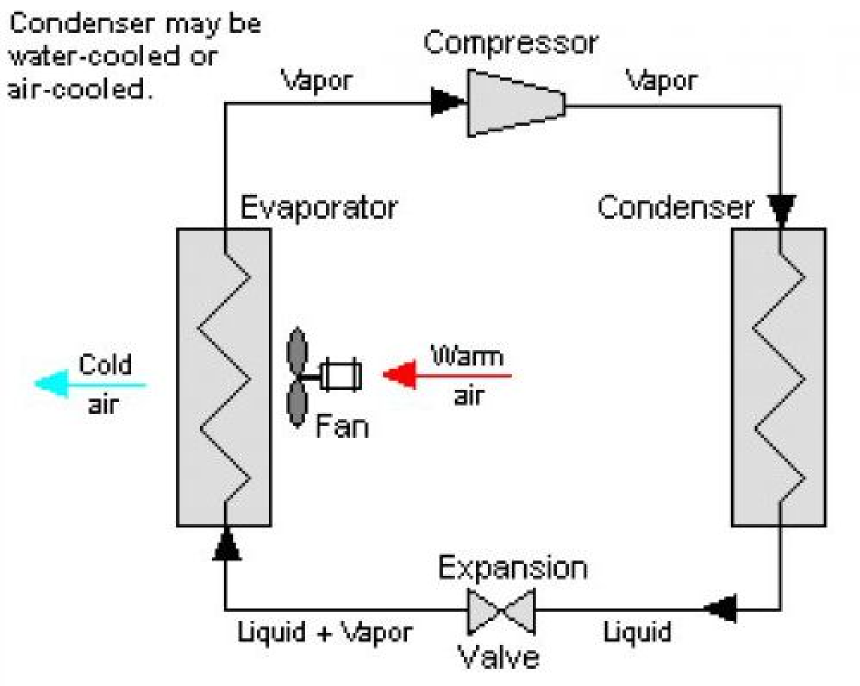


Figure 2: Components of vapour refrigeration system

Evaporator:

The liquid refrigerant from the condenser at high pressure is fed through a throttling device to an evaporator at a low pressure. On absorbing the heat to be extracted from Media to be cooled, the liquid refrigerant boils actively in the evaporator and changes state. The refrigerant gains latent heat to vaporize at saturation temperature/ pressure and further absorbs sensible heat from media to be cooled and gets fully vaporized and super heated.

Compressor:

The low temperature, pressure, superheated vapour from the evaporator is conveyed through suction line and compressed by the compressor to a high pressure, without any change of gaseous state and the same is discharge into condenser. During this process heat is added to the refrigerant and known as heat of compression ratio to raise the pressure of refrigerant to such a level that the saturation temperature of the discharge refrigerant is higher than the temperature of the available cooling medium, to enable the super heated refrigerant to condense at normal ambient condition. Different types of compressors are reciprocating, rotary and centrifugal and are used for different applications.

Condenser:

The heat added in the evaporator and compressor to the refrigerant is rejected in condenser at high temperature/ high pressure. This super heated refrigerant vapour enters the condenser to dissipate its heat in three stages. First on entry the refrigerant loses its super heat, it then loses its latent heat at which the refrigerant is liquefied at saturation temperature pressure. This liquid loses its sensible heat, further and the refrigerant leaves the condenser as a sub cooled liquid. The heat transfer from refrigerant to cooling medium (air or water) takes place in the condenser. The sub-cooled liquid from condenser is collected in a receiver (wherever provided) and is then fed through the throttling device by liquid line to the evaporator.

There are several methods of dissipating the rejected heat into the atmosphere by condenser. These are water-cooled, air cooled or evaporative cooled condensers.
In the water-cooled condenser there are several types viz. Shell and tube, shell and coil, tube in tube etc. In Evaporative cooled condenser, both air and water are used. Air-cooled condensers are prime surface type, finned type or plate type. The selecting of the type depends upon the application and availability of soft water.

Throttling device:

The high-pressure liquid from the condenser is fed to evaporator through device, which should be designed to pass maximum possible liquid refrigerant to obtain a good refrigeration effect. The liquid line should be properly sized to have minimum pressure drop.
The throttling device is a pressure-reducing device and a regulator for controlling the refrigerant flow. It also reduces the pressure from the discharge pressure to the evaporator pressure without any change of state of the pressure refrigerant.

The types of throttling devices are:

1.Capillary tubes 2. Hand expansion valves 3. Thermostatic expansion valve

The most commonly used throttling device is the capillary tube for application upto approx. 10 refrigeration tons. The capillary is a copper tube having a small dia-orifice and is selected, based on the system design, the refrigerant flow rate, the operating parameters (such as suction and discharge pressures), type of refrigerant, capable of compensating any variations/ fluctuations in load by allowing only liquid refrigerant to flow to the evaporator.

CONCLUSION:

Various components of the vapour compression system have been studied.

EXPERIMENT No:2

AIM:
To study function and working of different parts of an Air Conditioning equipment.

APPARATUS:
A model of window room air conditioner.

THEORY:
A room air conditioner is a compact air conditioner unit which can be placed in a particular room for its air conditioning. The room may be an office, a residential room such as bed room, living room etc. The window type units are air cooled and are mounted in a window or wall of room to be air conditioned. They do not need any ductwork. It has a complete refrigeration plane, i. e. compressor, condenser, refrigerant, valves and evaporator coils

The units are also provided with thermostat control and filtering equipment.
A window room air conditioner is shown in Fig.
A window type air conditioner consists of following sub-assembles:

Sub assembly	Parts
1. System assembly	a. Evaporator b. Capillary c. Condenser d. Strainer e. Compressor
2. Motor, fan and blower assembly	a. Fan b. Blower motor c. Motor mounting brackets
3. Cabinet and grill assembly	a. Cabinet b. Grill
4. Switch board panel	a. Selector switch b. Relay c. Thermostat d. Fan motor capacitor

WORKING:

The cool and low pressure vapour refrigerant is drawn from the evaporator to the compressor and it is compressed to high pressure and temperature. Generally, in this refrigerant is Freon gas i.e. R-12 or R-22 and a hermetic compressor is used. The high pressure and temperature gas runs through a set of coils so it can dissipate its heat and it condenses into liquid. The liquid is passed through the capillary and then flows into the evaporator. As refrigerant comes out of capillary, its temperature and pressure falls. This low temperature and pressure gas runs through a set of coils that allow the gas to absorb heat and cool down the air inside the building. The compressor draws this low pressure vapour and cycle is repeated. Most air conditioner also functions as dehumidifiers. They take excess water or moisture from the air and exit to atmosphere through the pipe.

Some factors should be kept in mind while selecting an air conditioner for a room:

1. Size of the room
2. Wall construction, whether light or heavy
3. Heat gain through ceiling and proportion of outside wall area which is covered with glass
4. Whether the room is to be used in the day time or at night only. The exposure to the sun of the walls of the room to be air conditioned and Room Ceiling height
5. Number of persons likely to use the room
6. Miscellaneous heat loads such as wattage of lamps, radio, television, computer, etc.

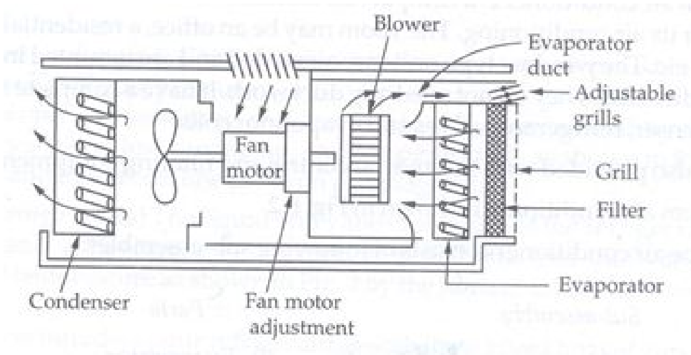


Fig. 1

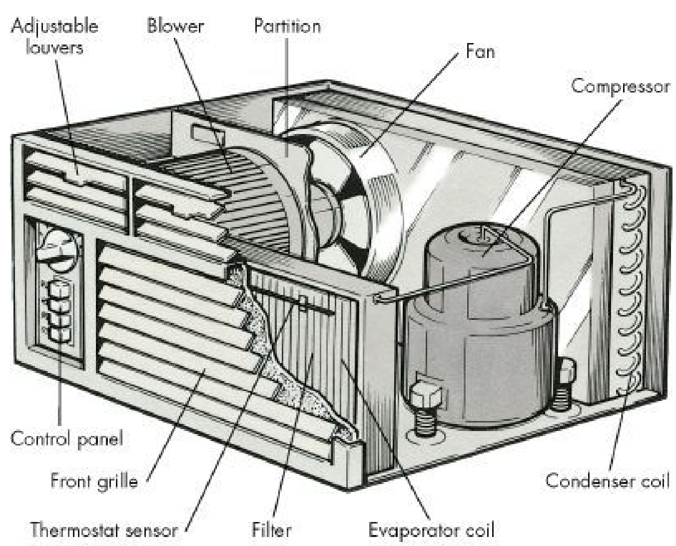


Fig. 2

CONCLUSION:

The model of Air conditioner was demonstrated and its working was studied.

EXPERIMENT No: 3

AIM:

Study on heat exchanger

THEORY:

A heat exchanger is a device used to transfer heat between a solid object and a fluid, or between two or more fluids. The fluids may be separated by a solid wall to prevent mixing or they may be in direct contact.

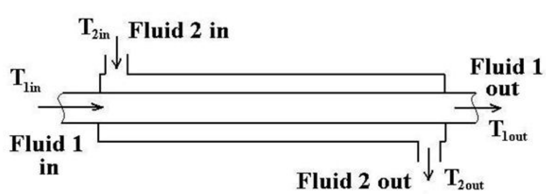
They are widely used in space heating, refrigeration, air conditioning, power stations, chemical plants, petrochemical plants, petroleum refineries, natural-gas processing, and sewage treatment.

The classic example of a heat exchanger is found in an internal combustion engine in which a circulating fluid known as engine coolant flows through radiator coils and air flows past the coils, which cools the coolant and heats the incoming air. Another example is the heat sink, which is a passive heat exchanger that transfers the heat generated by an electronic or a mechanical device to a fluid medium, often air or a liquid coolant.

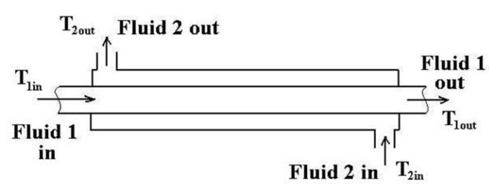
Types of Heat Exchanger:

1. Double pipe heat exchanger:

Double pipe heat exchangers are the simplest exchangers used in industries. On one hand, these heat exchangers are cheap for both design and maintenance, making them a good choice for small industries. On the other hand, their low efficiency coupled with the high space occupied in large scales, has led modern industries to use more efficient heat exchangers like shell and tube or plate. However, since double pipe heat exchangers are simple, they are used to teach heat exchanger design basics to students as the fundamental rules for all heat exchangers are the same.



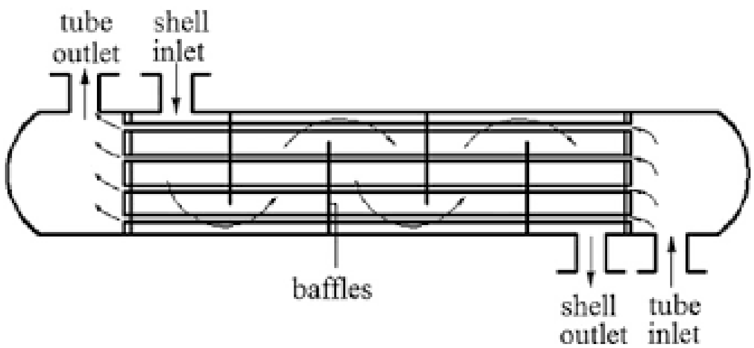
Double Pipe Heat Exchanger Parallel Flow



Double Pipe Heat Exchanger Counterflow

2. Shell and tube heat exchanger:

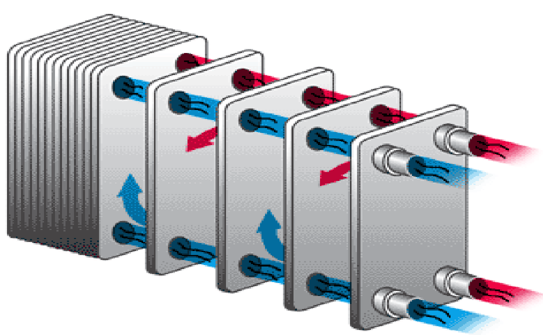
Shell and tube heat exchangers consist of series of tubes. One set of these tubes contains the fluid that must be either heated or cooled. The second fluid runs over the tubes that are being heated or cooled so that it can either provide the heat or absorb the heat required. A set of tubes is called the tube bundle and can be made up of several types of tubes: plain, longitudinally finned, etc. Shell and tube heat exchangers are typically used for high-pressure applications (with pressures greater than 30 bar and temperatures greater than 260 °C).This is because the shell and tube heat exchangers are robust due to their shape.



3. Plate heat exchanger:

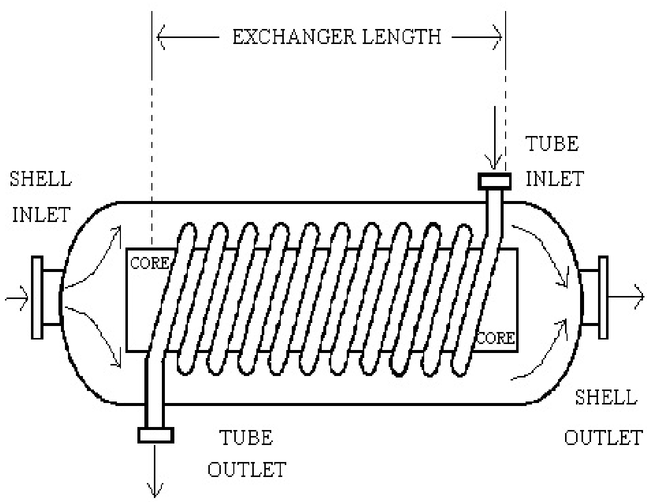
Another type of heat exchanger is the plate heat exchanger. These exchangers are composed of many thin, slightly separated plates that have very large surface areas and small fluid flow passages for heat transfer. Advances in gasket and brazing technology have made the plate-type heat exchanger increasingly practical.

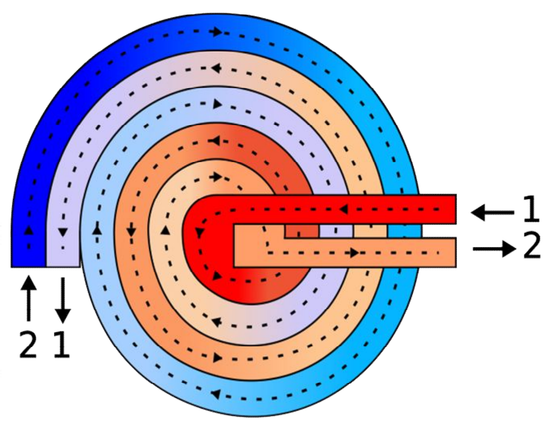
When compared to shell and tube exchangers, the stacked-plate arrangement typically has lower volume and cost. Another difference between the two is that plate exchangers typically serve low to medium pressure fluids, compared to medium and high pressures of shell and tube. A third and important difference is that plate exchangers employ more countercurrent flow rather than cross current flow, which allows lower approach temperature differences, high temperature changes, and increased efficiencies.



4. Helical-coil heat exchanger:

The main advantage of the HCHE, like that for the SHE, is its highly efficient use of space, especially when it's limited and not enough straight pipe can be laid. Under conditions of low flow rates (or laminar flow), such that the typical shell-and-tube exchangers have low heat-transfer coefficients and becoming uneconomical. When there is low pressure in one of the fluids, usually from accumulated pressure drops in other process equipment.When one of the fluids has components in multiple phases (solids, liquids, and gases), which tends to create mechanical problems during operations, such as plugging of small-diameter tubes. Cleaning of helical coils for these multiple-phase fluids can prove to be more difficult than its shell and tube counterpart; however the helical coil unit would require cleaning less often.These have been used in the nuclear industry as a method for exchanging heat in a sodium system for large liquid metal fast breeder reactors since the early 1970s.





5. Spiral Heat Exchanger:

A modification to the perpendicular flow of the typical HCHE involves the replacement of shell with another coiled tube, allowing the two fluids to flow parallel to one another, and which requires the use of different design calculations. These are the Spiral Heat Exchangers (SHE), which may refer to a helical (coiled) tube configuration, more generally, the term refers to a pair of flat surfaces that are coiled to form the two channels in a counter-flow arrangement. Each of the two channels has one long curved path. The main advantage of the SHE is its highly efficient use of space. This attribute is often leveraged and partially reallocated to gain other improvements in performance, according to well known tradeoffs in heat exchanger design. (A notable tradeoff is capital cost vs operating cost.) A compact SHE may be used to have a smaller footprint and thus lower all-around capital costs, or an oversized SHE may be used to have less pressure drop, less pumping energy, higher thermal efficiency, and lower energy costs.

CONCLUSION:

Different types of heat exchangers were studied.

EXPERIMENT No: 4

AIM:

Study on compression system.

APPARATUS USED:

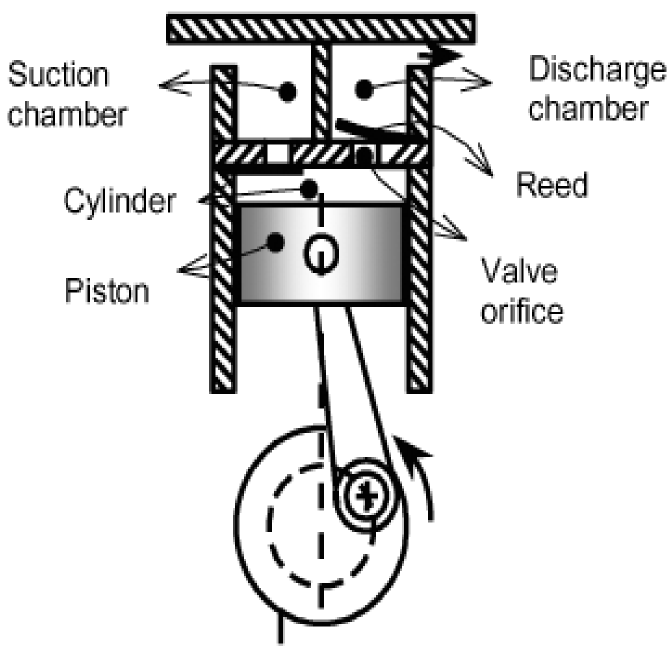
Model of Reciprocating, Centrifugal and Rotary compressor

THEORY:

1. **Reciprocating compressor:**

The compressors in which the vapour refrigerant is compressed by reciprocating motion of the piston are called reciprocating compressors. These compressors are used for refrigerant which have comparatively low volume per Kg and a large differential press. Such as NH_3(R-717), R-12, R-22. The reciprocating compressors are available in sizes as small as ½ KW which are used in small domestic refrigeration and up to about 150 KW for large capacity.

The single acting compressors usually have their cylinder arranged vertically radially or in 'V' or 'W' form. The double acting compressors usually have their cylinder arranged horizontal.



When the piston moves downwards, the refrigerant left in the clearance space expands. Thus, the volume of the cylinder increase and the pressure inside the cylinder decreases. When the pressure become slightly less then the valve gets opened and the vapour refrigerant flows into the cylinder. This flow continuous until the piston reaches the bottom of the stroke. At bottom of the stroke, the suction valve closes because of spring action. Now, when the piston moves upwards, the volume of the piston moves upwards, the volume of the cylinder decreases and the pressure inside the cylinder increases. When the pressure inside the cylinder becomes greater than that on the top of the discharge valve, the discharge valve gets opened & the vapour refrigerant is discharged into the condenser and the cycle is repeated.

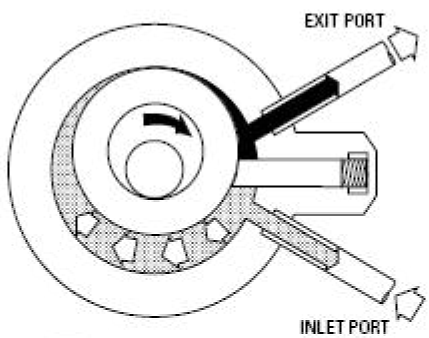
2. Rotary compressor:

In rotary compressor, the vapour refrigerant from the evaporator is compressed due to movement of blades. The rotary compressors are positive displacement type compressor. Since, the clearance in rotary compressors is negligible; therefore, they have high η_{vol}. These may be used for refrigerants like R-12, R-22, and R-144 & NH_3.

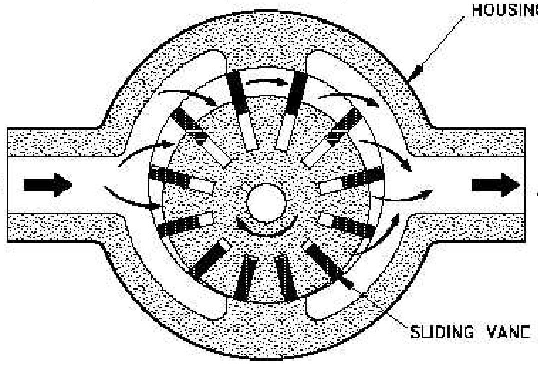
The two types of rotary compressors are: -

a. **Single stationary blade type**
b. **Rotating blade type**

Single stationary blade type consists of a stationary cylinder, a roller and a shaft. The shaft has an eccentric on which the roller is mounted. A blade is set into the slot of a cylinder in such a manner that it always maintains contacts with a sloter by means of a spring. The blade moves in and out of the slot to follow the rotor when it rotates. Since the blade separates the suction and discharge parts, therefore it is often called a sealing blade. When the shaft rotates, the roller also rotates the roller rotates so that it always touches the cylinder wall.



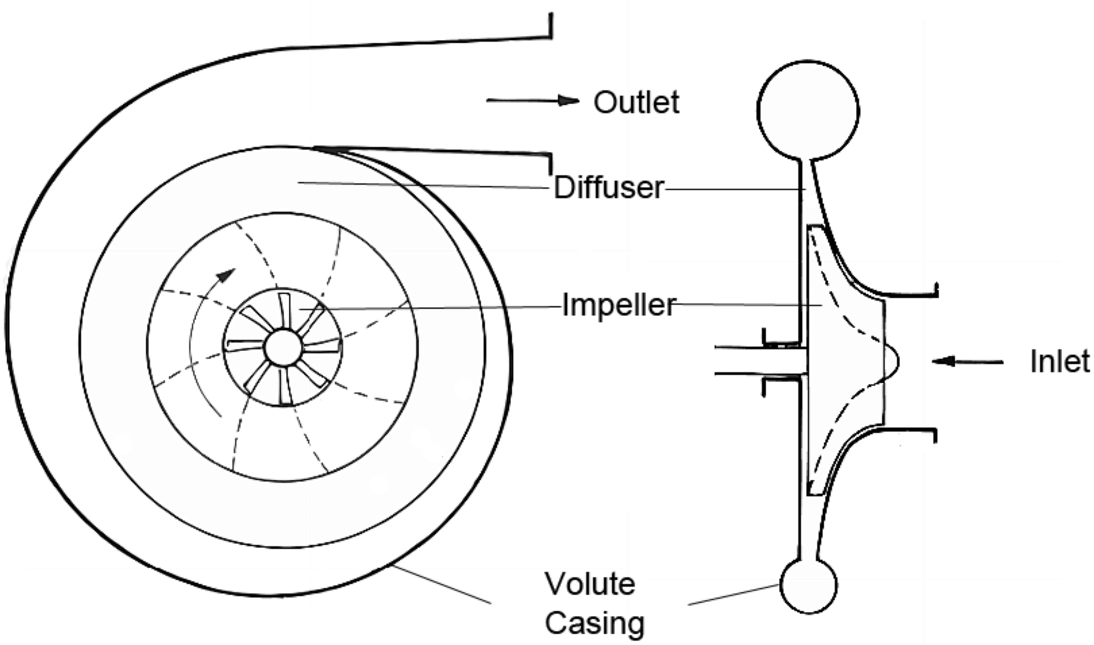
Rotating Blade type consists of a cylinder and a slotted rotor containing a number of blades. The centre of the rotor is eccentric with the centre of the cylinder. The blades are forced against the cylinder wall by the centrifugal action during the rotation of the motor. The low pressure and temperature vapour refrigerant from the evaporator is drawn through the suction port. As the rotor turns, the suction vapour refrigerant entrapped between the two adjacent blades is compressed. The compressed refrigerant at high pressure and temp is discharged through the discharge port to the condenser.



3. Centrifugal Compressor

The centrifugal compressor increases the pressure of low pressure vapour refrigerant to a high pressure by centrifugal force. The centrifugal compressor is generally used for refrigerants that require large displacement and low condensing pressure, such as R-12. However, the refrigerant R-12 is also employed for large capacity applications and low-temperature applications.

A single stage centrifugal compressor, in its simplest form, consists of an impeller to which a number of curved vanes are fitted symmetrically. The impeller rotates in an air volute casing with inlet and outlet points. The impeller draws in low pressure vapour refrigerant from the evaporator. When the impeller rotates, it pushes the vapour refrigerant from the centre of the impeller to its periphery by centrifugal force. The high speed of the impeller leaves the vapour refrigerant at a high velocity at the vane tips of the impeller. The kinetic energy thus attained at the impeller outlet is converted into pressure energy when the high velocity vapour refrigerant passes over the diffuser. The diffuser is normally a vane less type as it permits more efficient part load operation which is quite and it further converts the kinetic energy into pressure energy before it leaves the refrigerant to the evaporator.



CONCLUSION:

Various compression systems were studied.