4

Air Preparation and Service Unit

Contents

4.1 Introduction

Pneumatic control systems operate on a supply of compressed air, which must be made available in sufficient quantity and at a pressure that suits the capacity of the system. Impurities in the compressed air such as scale, rust and dust as well as the liquid constituents in the air which deposit as condensate can cause a great deal of damage in pneumatic systems. These impurities adversely affect the functioning and performance of the pneumatic components. In order to eliminate these effects, compressed air has to be prepared with great care.

4.2 Stages of Air Preparation

- There are four distinct stages in the preparation of air.
- **Stage 1:** This stage comprises the air intake system whose role is to ensure that the intake air is free of moisture or pollution. The quality of air is judged by its temperature, humidity and cleanliness.
- **Stage 2:** This stage involves compressors (some with drives and controls), inter-cooling, compressor cooling, waste heat recovery and air inlet filtration
- **Stage 3:** In this stage, the outlet temperature of the compressor is reduced, solid contaminants large than 100 microns are removed, and the air is dried to reduce to its humidity. This stage includes conditioning equipment consisting of air receivers, aftercoolers, separators, traps (also frequency called drain traps or drains), filters and air dryers.
- **Stage 4:** In this stage, moisture and fine dirt particles are removed, pressure is regulated and a fine oil mist is introduced to lubricate the machine. It involves air distribution sub¬systems, including main trunk lines, valving, additional filters and traps (drains), air hoses and possible supplement air conditioning equipment.

4.3 Classification of Air Compressors

- A compressor is a machine that compresses air or any other type of gas from a low inlet pressure (usually atmospheric pressure) to a higher desired pressure level.
- ***Classification of Compressors***

1. **Positive displacement types**
   a) Reciprocating types
      - Piston Compressor
      - Diaphragm Compressor
   b) Rotary types
      - Twin Screw
      - Rotary Vane
      - Lobe type
      - Liquid ring
2. **Dynamic displacement types**
   a) Centrifugal Compressor
   b) Axial flow Compressor

4.3.1 Single Cylinder Compressor

- The construction and working of a piston type reciprocating compressor is very similar to that of an internal combustion engine.

Construction:

- The piston type compressor consists of a cylinder, cylinder head, a piston with piston rings, inlet and outlet spring-loaded valves, connecting rod, crankshaft and bearings.

Operation:

- Compression is accomplished by the reciprocating movement of a piston within a cylinder. This motion alternately fills the cylinder and then compresses the air.

- A connecting rod transforms the rotary motion of the crankshaft into the reciprocating motion of piston in the cylinder. The schematic diagram of a single cylinder compressor is *Fig.4.1*.

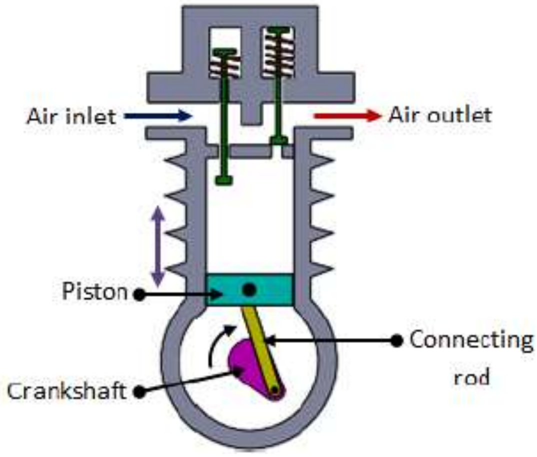

Fig.4.1 Single Cylinder Compressor

Inlet stroke:
- The suction or inlet stroke begins with the piston at the top dead centre (a position providing a minimum clearance volume). During the downward stroke, the piston motion reduce the pressure inside the cylinder below the atmospheric pressure.
- The inlet valve then opens against the pressures of its spring and allows air to flow into the cylinder. The air is drawn into the cylinder until the piston reaches a maximum volume position (bottom dead centre). The discharge valve remains closed during this stroke.

Outlet stroke:
- During the compression stroke, the piston moves in the opposite direction (bottom dead centre to top dead centre), decreasing the volume of the air.
- As the piston starts moving upwards, the inlet valve is closed and pressure starts to increase continuously until the pressure inside the cylinder is above the pressure of the delivery side which is connected to the receiver.
- Then the outlet valve opens and air is delivered to the receiver during the remaining upward motion of the piston.
- The single cylinder compressor gives significant amount of pressure pulses at the outlet port. The pressure developed is about 3-40 bar.

Application

- Smaller working environments like kitchens, garages, workshops and homes

4.3.2 Double Acting Compressor

- The pulsation of air can be reduced by using double acting compressor as shown in *Fig.4.2*. It has two sets of valves and a crosshead.

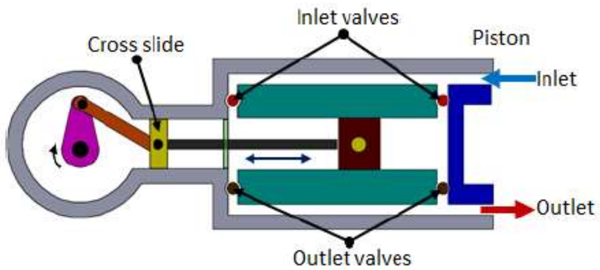

Fig.4.2 Double Acting Compressor

Construction:

- The piston type compressor consists of a cylinder, cylinder head, a piston with piston rings, two inlet and outlet spring-loaded valves, connecting rod, crankshaft and bearings.

Operation:

- Compression is accomplished by the reciprocating movement of a piston within a cylinder.
- A connecting rod transforms the rotary motion of the crankshaft into the reciprocating motion of piston in the cylinder. The schematic diagram of a single cylinder compressor is *Fig.4.2*

Forward Stroke:

- As the piston moves in right side, the air is compressed on right side of the piston, at the same time the air is sucked in left side due to increse in volume. So during this stroke on a right side of piston delivery and left side of piston suction take place.

Reversed Stroke:

- As the piston moves in left side, the air is compressed on left side of the piston, at the same time the air is sucked in right side due to increse in volume. So during this stroke on a right side of piston suction and left side of piston delivery take place.
- Due to the reciprocating action of the piston, the air is compressed and delivered twice in one piston stroke. Pressure higher than 30 bar can be produced.

Application:

- It can be used where high force is required in both directions of travel.
- Packing products

4.3.3 Multistage Compressor

- As the pressure of the air increases, its temperature rises. It is essential to reduce the air temperature to avoid damage of compressor and other mechanical elements.

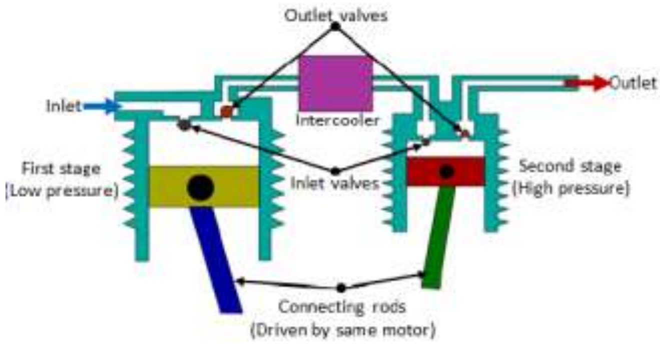

Fig.4.3 Multistage Compressor

- The multistage compressor with intercooler as shown in *Fig.4.3*. It is used to reduce the temperature of compressed air during the compression stages.
- The compressed air from the first stage enters the intercooler where it is cooled. This air is given as input to the second stage where it is compressed again.
- The multistage compressor can develop a pressure of around 50 bar.

Advantages of piston type compressors

- Piston type compressors are available in wide range of capacities and pressures.
- Very high air pressure (250 bar) and air volume flow rate is possible with multi¬staging.
- Better mechanical balancing is possible by multi-stage compressor by proper cylin¬der arrangement.
- High overall efficiency compared to other compressors.

Disadvantages of piston type compressors

- Reciprocating piston compressors generate inertia forces that shake the machine. Therefore, a rigid frame fixed to solid foundation is often required.

- Reciprocating piston machines deliver a pulsating flow of air. Properly sized pulsa¬tion damping chambers or receiver tanks are required.
- They are suited for small volumes of air at high pressures.

4.3.4 Diaphragm Compressor

- In piston compressors, there is a likelihood of small amounts of lubricating oil from the piston walls contaminating the lubricating air. This very small contamination may prove very harmful in food, pharmaceutical and chemical industries. For applications in such industries, diaphragm compressors may be used as a power source.

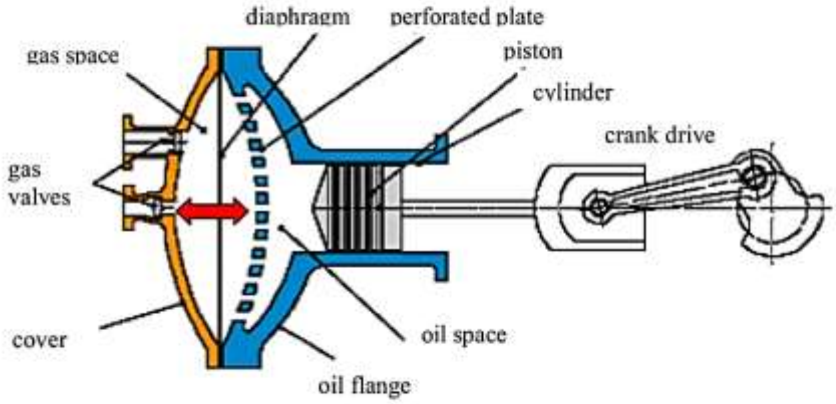

Fig.4.4 Diaphragm Compressor

Operation:

- The operation of diaphragm compressor can be explained using *Fig.4.4*. There are two strokes, namely, suction stroke and delivery stroke. Suction stroke On the drive side, when the piston moves from left to right, the movement of piston and hydraulic oil causes the diaphragm also to move towards right till it touches the perforated plate.
- This movement of diaphragm creates a vacuum on the gas side and the inlet valve opens and suction of air takes place on the gas side of the compressor.
- Delivery During the compression stroke, the piston in the drive side presses the hy¬draulic oil into the diaphragm through the perforated plate, and the diaphragm pushes the air through the delivery valve on the gas side.

Advantages of a diaphragm compressor

- Oil-free clean air can be obtained from a diaphragm compressor.
- Hermitically sealed, resulting in exceptionally low leakage rates
- High efficiency of the order of 80 to 85%
- High stage pressure ration, allowing for very high final pressures

Disadvantages of a diaphragm compressor

- Excessive back pressure can rupture the diaphragm.
- Smooth pulse-free discharge is not possible.
- Low suction capacity (1000 m^3/hour)
- Lateral forces caused by the crank drive reduce the lifetime of sealing components.

4.3.5 Screw Compressors

- The screw compressor, introduced commercially in the 1960s, has become increasingly popular for industrial plant air applications.

Construction:

- The construction features of a screw compressor are shown in *Fig.4.5*. The screw type compressor consists of two mating helically grooved rotors, one male and the other female. The male rotor drives the female rotor. The male rotor has lobes, while the female rotor has flutes.

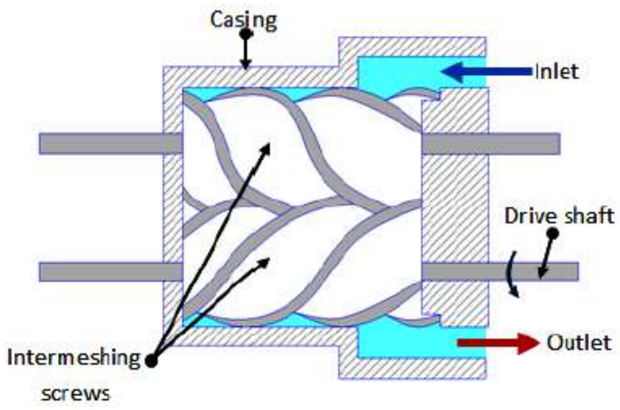

Fig.4.5 Twin screw compressors

Operation:

- *Fig.4.5* shows screw compressor. When the male rotor rotates at 3600 RPM, female rotor rotates at 2400 RPM. The flow is mainly in the axial direction. Suction takes place as the rotors unmesh and delivery takes place as they mesh.
- Meshing and unmeshing takes place depending upon the location of the suction port, delivery port and geometry of the compressor.
- Range Single stage screw compressors are generally designed to operate for capacities pressures less than 10 bar. Higher pressures can be attained by multistage compression and higher capacity by parallel operation.

Advantages of screw type compressors

- Simple design and low-to-medium initial cost
- There is no surface-to-surface contact, so there is no cooling needed.
- Low noise levels
- Small loss of efficiency
- Fewer moving parts rotating at a high constant speed
- Supply steady delivery of compressed air without pressure fluctuation.
- Normally they rotate at high speeds and can handle fairly large amount of air
- Compared to reciprocating compressors, they are more balanced and give less vibration.
- Easy to install and low maintenance cost

Disadvantages of screw type compressors

- Shorter life expectancy compared to other designs
- They are difficult to operate in dirty environments
- Single stage designs have lower efficiency
- Higher rotational speeds.
- For two stages, oil-free designs have higher initial cost.

4.3.6 Rotary Vane Compressors

- Rotary vane compressors are used for low pressure and moderately high volume applications. They are commonly used for instruments and in laboratory works.
- Rotary vane units generally have lower pressure ratings than piston units because of the difficult sealing problems and greater sensitivity to thermal effects.

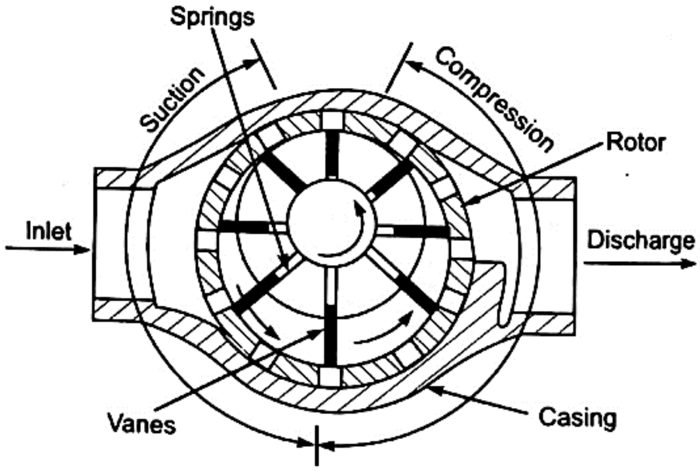

Fig.4.6 Rotary Vane Compressors

Construction:

- The rotor is mounted eccentrically, i.e., not in the center of the casing. It consists of a number of slots with sliding vanes as shown in the *Fig.4.6*. During the running of the compressor, the sliding vanes, which are normally made of non-metallic materials, are held against the cylinder due to centrifugal forces.

Operation:

- The operation of the vane compressor is explained with the help of *Fig.4.6* For the sake of clarity, only four vanes are shown.

Suction:

- Suction As the rotor rotates, the vanes move outward and are held against the cylinder body by centrifugal and pressure loading forces. This creates a series of air compartment of unequal volume (because of the rotor's eccentricity).
- The compartments formed between the adjacent vanes gradually become larger during the suction part of the cycle, and air is drawn into the compartment from the inlet port.

Discharge:

- Delivery During the discharge portion of the cycle, the compartment volume gradually becomes smaller, compressing the air.
- When the rotating compartment reaches the dis¬charge port, the compressed air escapes to the delivery system.

Advantages of rotary vane compressors

- The suction and exhaust flows are relatively free of pulsation because the inlet and discharge ports do not have valves, and the air is moved continuously rather than intermittently.
- Smooth, pulse-free discharge without air receiver tanks
- Compact with very few moving parts
- Simple design and easy to install
- Low to medium cost
- Long serviceable air end
- Low rotational speed
- Can operate in dirty environments

Disadvantages of rotary vane compressors

- Single stage designs have lower efficiency
- Oil injected designs have oil carry-over
- They cannot be used for high pressure
- Oil-free designs are unavailable

4.3.7 Lobe Type Compressors

- The lobe type compressor shown in *Fig.4.7*. They are extensively used in applications such as pneumatic conveying, aeration applications, cement plants and water treatment plants.

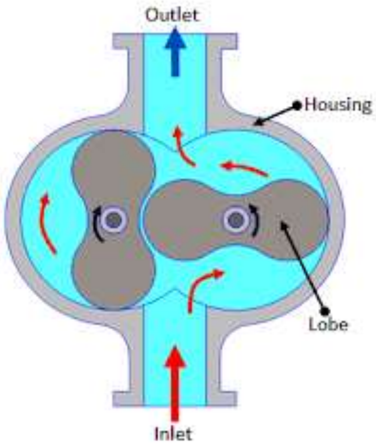

Fig.4.7 Lobe Type Compressors

- The lobe type air compressor is very simple with no complicated moving parts. Single or twin lobes are attached to the drive shaft driven by the prime mover. The lobes are displaced by 90 degrees.
- Thus, if one of the lobes is in horizontal position, the other at that particular instant will be in vertical position. The air gets trapped in between these lobes and as they rotate, gets compressed and delivered to the delivery line.
- Lobe type compressors have higher efficiency at moderate compression ratios and are most efficient for compression ratios of 1.1 to 2. They find use in applications that require relatively constant flow rate at varying discharge pressures.
- They are generally available for capacities of 150 LPM to 150000 LPM for pressures up to 1 bar in single stage construction.

4.3.8 Liquid ring Compressors

- Liquid ring compressors belong to the positive displacement compressor family. They use liquid that is centrifuged in a specifically shaped casing.

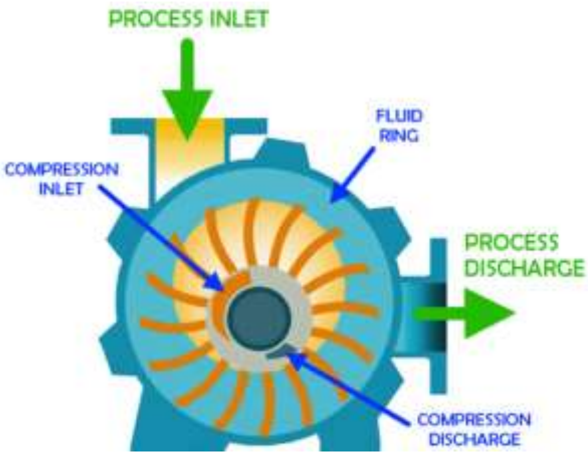

Fig.4.8 Liquid ring Compressors

- The liquid can be water, sulphuric acid, crude oil, gasoline or any other liquid that does not react with the gas that has to be compressed. This specific feature reduces the wearing off of the metallic parts theoretically to zero, and therefore maintain their efficiency for a long time.

4.3.9 Centrifugal Compressors

- The schematic of centrifugal is shown in *Fig.4.9*. This type of multi-stage application is often used in the oil and gas and process industries.

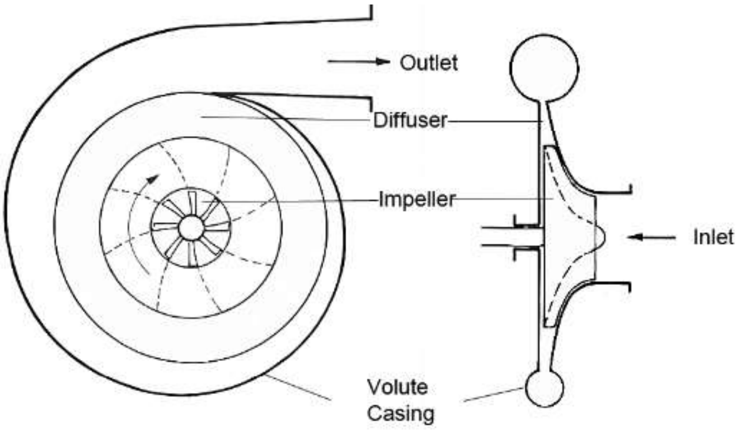

Fig.4.9 Centrifugal Compressors

- Air is drawn into the center of a rotating impeller with radial blades and is pushed toward the center by centrifugal force. This radial movement of air results in a pressure rise and the generation of kinetic energy. Before the air is led into the center of the impeller, the kinetic energy is also converted into pressure by passing through a diffuser and volute.
- Each stage takes up a part of the overall pressure rise of the compressor unit. Depending on the pressure required for the application, a number of stages can be arranged in a series to achieve a higher pressure.

Application
- Food industry
- Manufacturing process
- Oil refineries, natural-gas processing
- Refrigeration, air-conditioning

Advantages of centrifugal compressor
- Low weight
- Easy to design and manufacture
- Provide continues flow
- Oil free
- High flow rate
- Energy efficient
- Low maintenance
- Not require special foundation

Disadvantages of centrifugal compressor
- Limited pressure
- High speed

4.3.10 Axial Flow Compressors

Construction:
- Axial flow compressor consists of casing fitted with several rows of fixed blades & several rows of moving blades which are attached on rotor as shown in fig. The fixed blades are placed on alternative rows. The fixed blades & moving blades are as possible for efficient flow.
- The length of blades is reduced in direction of flow to compensate for the reduction in volume resulting from the increased pressure.
- The blades are so arranged that the spaces between blades form diffuser passage & hence velocity of air is reduced as it passes through them & pressure increases.

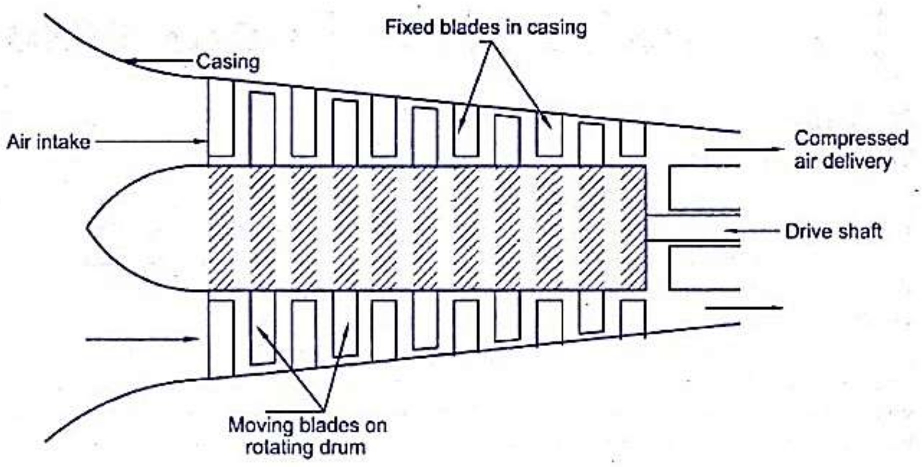

Fig.4.10 Axial Flow Compressors

Working:

- As the fluid enters and leaves in the axial direction, the centrifugal component in the energy equation does not come into play. Here the compression is fully based on diffusing action of the passages.
- The diffusing action in stator converts absolute kinetic head of the fluid into rise in pressure. The relative kinetic head in the energy equation is a term that exists only because of the rotation of the rotor.

Application

- Jet engines
- High speed ship engines
- Small scale power stations
- Large volume air separation plants
- Blast furnace air
- Fluid catalytic cracking air

4.4 Control of Compressors

- There is a growing variety of control systems available for compressed air installations. These most often concern electric driver controls and compressor controls. The compressor control systems are listed below.
    1) Continuous Capacity Regulation
    2) Load/Unload Regulation
    3) Start/Stop And Load/Unload Controls
    4) Pressure Relief Valve Control
    5) Bypass Regulation

Continuous Capacity Regulation

- Capacity can be controlled by starting and stopping the motor
- Adjust the suction flow to match the process demand
- Save energy

Load/Unload Regulation

- In a load/unload control scheme, the compressor remains continuously powered.
- However, when the demand for compressed air is satisfied or reduced, instead of disconnecting power to the compressor, a device known as a slide valve is activated
- The pilot opens and pressurizes the unloader valve, causing the unloader valve to open and excess air from the compressor to vent to atmosphere

Start/Stop Controls

- The motor driving the compressor is turned on or off in response to the discharge pressure of the machine.
- Typically, a simple pressure switch provides the motor start/stop signal

Pressure Relief Valve Control

- A relief valve or pressure relief valve (PRV) is a type of safety valve used to control or limit the pressure in a system;
- Reduce chances of failure instrument

Bypass Regulation

- Bypass regulation serves the same function as pressure relief, in principle.
- Pressure relieved air is cooled and returned to the compressor inlet.

4.5 Selection Criteria For Compressors

- A number of factors arc involved in the selection criteria of a suitable air compressor. These are discuss here briefly.

Pressure

- First of all, the pressure needed must be determined. Most air operafed systems and tools are designed to operate at pressure from 6 to 7 kg/cm^2. A compressor of normal make and type would normally be suitable if this can assure a pressure of 6 kg/cm^2 in the distribution lines laid down for pneumatic tools and systems.
- Where long distribution lines are required, it may be desirable to install a machine discharging a pressure of 8 to 9 kg/cm^2 to compensate the line or leakage losses. Where two or more operations require air at a higher pressure, it may usually be more economical and more convenient to install a separate small compressor to supply air for these operations. Sometimes even for one operation, separate compressors arc essential.
- Where small amount of air is required at pressures lower than that carried in the main distribution lines, they may be obtained by installing a reducing valve in the branch line leading to the area requiring low-pressure air.
- If large amount of low-pressure air is required, it is more economical to install a separate compressor for the purpose.
- Where the air pressure required is less than 2 kg/cm^2 and the volume required is comparatively large, a turbo-blower or low-pressure rotary-type compressor may be considered.

Capacity

- Another important factor in compressor selection is the capacity or volume of air required. This factor is sometimes extremely difficult to evaluate. Obviously, the unit selected should be large enough to supply all the-air devices which will be operating at any given time.
- If all the air operations are continuous, the capacity required is simply the sum of the air consumption of each individual tool.
- In most plants, however, air-operated tools, such as chipping hammers, grinders, hoists, etc. are operated intermittently. The compressor capacity in this case is that required to operate as many air-consuming devices as would ever be in use at one time. This may be anywhere from 10 to 100 per cent of the total required by all the tools, depending almost entirely on the nature of the work in the plant.
- The experience of another plant doing similar work is very helpful. Manufacturers of the air compressors and air tools can often help in determining the air capacity required.

Compressor Configuration and Cylinder Geometry

1. Type of air compressor, such as reciprocating compressor or vane, screw or lobe type. If reciprocating type, then we may designate as single cylinder.
    a) Vertical—single or double acting
    b) Horizontal—usually double acting
2. Two cylinders Cylinders may be arranged in various geometrical fashions as stated below:
    a) Vertical in-line, single or double acting

b) V-typc single or double acting
c) Horizontal and vertical usually double acting
d) Horizontally opposed—single or double acting
e) Horizontal duplex, usually double acting (this arrangement essentially consists of two compressors side by side with a common crankshaft)

3. Three cylinder-one vertical, two angled usually at 60° either side from the vertical, single or double acting usually called W form

4. Four cylinder
a) Semi radial, two cylinders horizontally opposed, two at 60° upward from horizontal
b) Opposed two pairs of horizontal cylinders on single crankshaft
c) V-type two cylinders in each bank
d) Horizontal duplex compound

4.6 Air receivers

- Receivers perform several functions in compressed air systems. Firstly, they provide larger system capacity, which increases the cycle time of the compressor control systems. This makes the elimination of unstable and over correcting control cycles less difficult.
- The receiver also dampens pulsations from reciprocating compressors, acts as a reservoir to prevent excessively temporary pressure drop during sudden short-term demand, and can be used to smoothen the air flow through dryers, separators and other air-conditioning equipment. Because the air entering the receiver is lesser in velocity and cooled, some of the moisture may condensate and fall to the bottom of the receiver where it can be removed by a valve, or preferably a trap.
- Such a receiver can further reduce the amount of moisture that must be removed by a subsequent drying stage. The receiver is always equipped with a pressure relief valve.

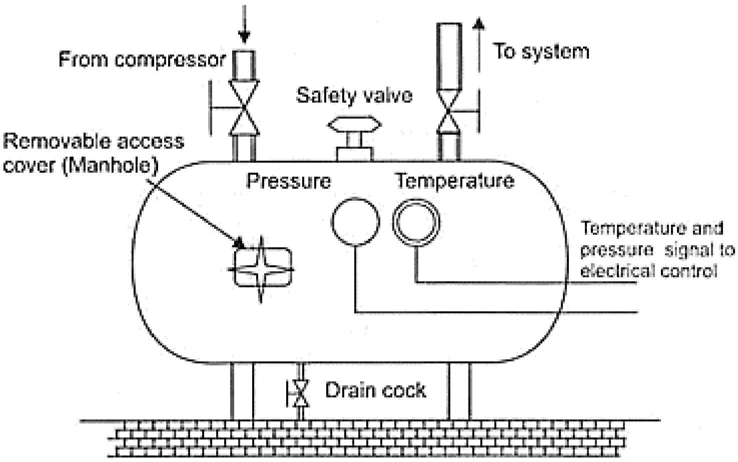

Fig.4.11 Air receivers

- A drain cock allows removal of condensed water. Access via a manhole allows cleaning. Obviously, removal of manhole cover is hazardous with a pressurised receiver, and safety routines must be defined and followed to prevent accidents.

4.7 Selection of Pipeline For Pneumatic System

- In most plants, the air compressor is positioned at a distance away from the main shop and installation area, i.e. from the actual point of consumption due to reasons of air borne noise problem or due to reasons related to machine safety and other operational problems like transmission of vibration, to other equipment.
- The compressed air is stored in an air receiver from which the air is drawn into the consumer point by means of pipeline. While laying out the pneumatic pipeline for the system, one should

take sufficient care and pay due attention to sec that the pressure drop from the generating point to the point of consumption remains as low as possible.

- For economic reasons, it is always better if the total drop of pressure is kept limited to a maximum value of 0.1 bar or even less. Some of the international standards prescribe a value of 0.01 bar for a line pressure of 6 bar due to specific operational requirement.
- The following factors are taken into account while selecting pneumatic pipes and other airline installations.
  - Pressure of compressed air in the line
  - Total flow rate per unit time through the line
  - Permissible pressure drops in the line
  - Type of tube material and type of line fittings
  - Length and diameter of tube or other pipelines
  - Working environment, etc.

4.8 Loop System In Piping Layout

- While laying out the compressed air piping system, the one single factor which is to be given paramount importance is to reduce the drop in pressure at the farthest end of the pipeline. This is very important for the overall economic use of compressed air.
- To achieve this, it is essential that the loop type of piping should be used as shown in *Fig.4.12*. and straight line type long distance piping layout is to be discarded as far as possible. Minimum number of bends are to be used in the line to keep the losses due to friction to the minimum.

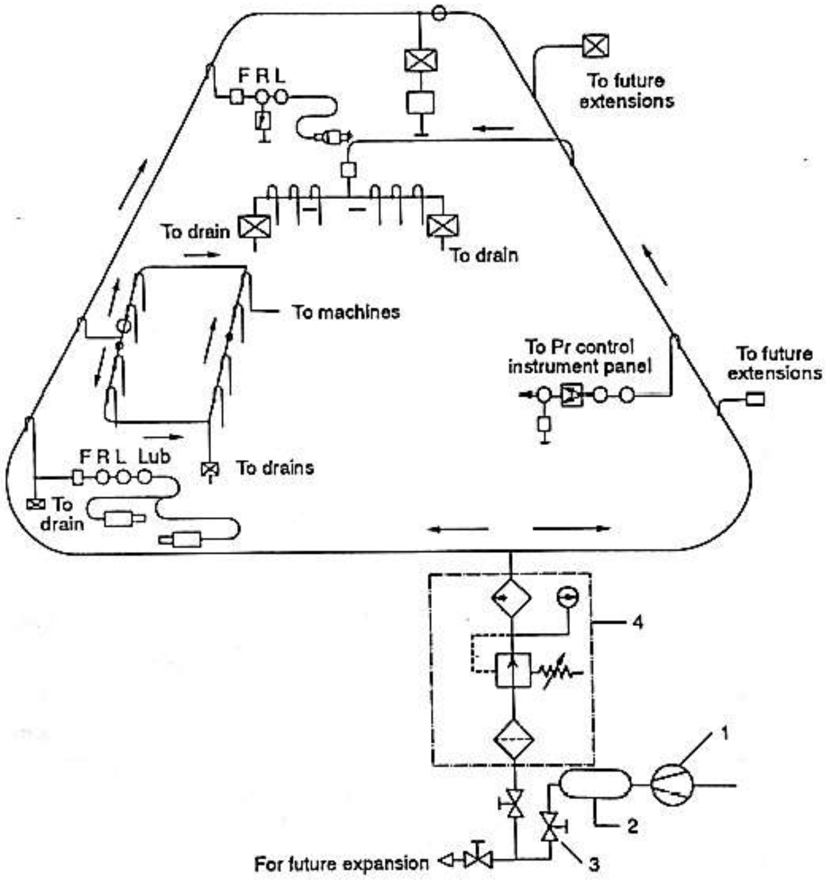

Fig.4.12 Loop System In Piping Layout

- Another factor which often poses maintenance problem in getting rid of the accumulated water in the pipeline. For this, it is essential that the pipeline (specially if a longer pipeline is to be drawn), should have a gradient of 6 to 10 mm per metre. Suitable water collectors should be provided at each point of line diversion.
- In *Fig.4.12* , various take off points from the main pipeline of a pneumatic system may be noted. The horizontal main is on the wall with a slope. The feedlines are taken from the top of the

pipeline through bends. Number of stop valves are used in each branch pipeline to act as isolators. The vertical pipe is to be drawn down to earth for water separation through a water separator.

4.9 Air Filters

- The purpose of an air filter is to clean the compressed air of all impurities and any condensate it contains.

Function of air filters

a) To remove foreign matter and enable clean, dry air to flow unrestricted to the regulator and onto the lubricator
b) To condense and remove water from the air
c) To arrest fine particles and all solid contaminants in the air

- Filters are available in a wide range; from a fine mesh wire cloth (to strain heavy foreign particles) to filters made of synthetic material (to remove very small particles).
- Inline filter elements can remove contaminants in the 5—50 microns range.

Fig.4.13 Air Filters

Sources of Contamination

- Contaminants in a compressed air system are usually attributed to the following:

a) The quality of air drawn into the compressor
b) The type and operation of the air compressor
c) The compressed air storage devices and distribution systems

Types of contamination in a compressed air system

- Atmospheric dirt
- Water vapour and condensed water
- Rust and pipe scale
- Micro-organisms
- Liquid oil
- Oil vapour

Factor affecting selection of filters

- The following factors should be taken into account while selecting filters.

a) Size of particles to be filtered from the system
b) Capacity of the filter
c) Accessibility and maintainability
d) Life of the filter
e) Ability to drain condensate

Construction:

- The construction of a typical cartridge type filter, along with graphical symbols, is shown in *Fig.4.14*. It consists of a filter cartridge, a deflector, a bowl and a water drain valve. The filter bowl is usually made of plastic and is transparent. For pressures higher than 10 bar, the bowl may be made of brass.

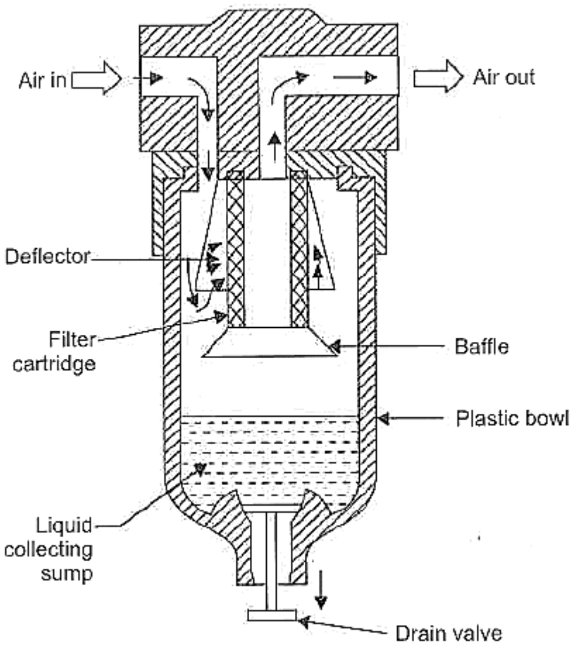

Fig.4.14 Construction of an air filter

Operation

- Air enters the inlet port of the air filter through angled louvers, which cause the air to spin as it enters the bowl. The centrifugal action of the rotating air causes the larger particles of dirt and water to be thrown against the inner wall of the filter bowl. The contaminants then flow down to the bottom of the filter bowl.
- A baffle prevents turbulent air from splashing water on to the filter element. The air which has been pre-cleaned in this manner then passes through the filter element, where the fine dirt particles are filtered out. The size of the dirt particles which can be filtered out depends on the mesh size of the filter element (usually 5—50 microns). The compressed air then exits through the outlet port.
- The pressure difference between the inlet and outlet indicates the degree to which the filter element is clogged. Commercially available filters have additional features like automatic drain facility, coalescing type filter element, service life indicator, etc.

4.10 Air Lubricator

- The function of an air lubricator is to add a controlled amount of oil to the air to ensure proper lubrication of the internal moving parts of a pneumatic system.

Lubricants are used to:

- Reduce wear on moving parts
- Reduce frictional losses
- Protect equipment from corrosion

Operation

- The operation of the air lubricator is similar to the principle of a carburettor. The schematic diagram is shown in *Fig.4.15*. As air enters the lubricator, its velocity is increased by a venture ring.
- The pressure at the venture ring is lower than the atmospheric pressure, while the oil is at atmospheric pressure. Due to this pressure difference between the upper and lower chambers, oil is drawn up the riser tube. Oil droplets mix with the in¬coming air and form a fine mist.

- The needle valve is used to adjust the pressure differential across the oil jet and control the oil flow rate. The air/oil mixture is swirled as it leaves the central cylinder so that large oil particles are forced back to the bowl and only the mist goes to the outlet.

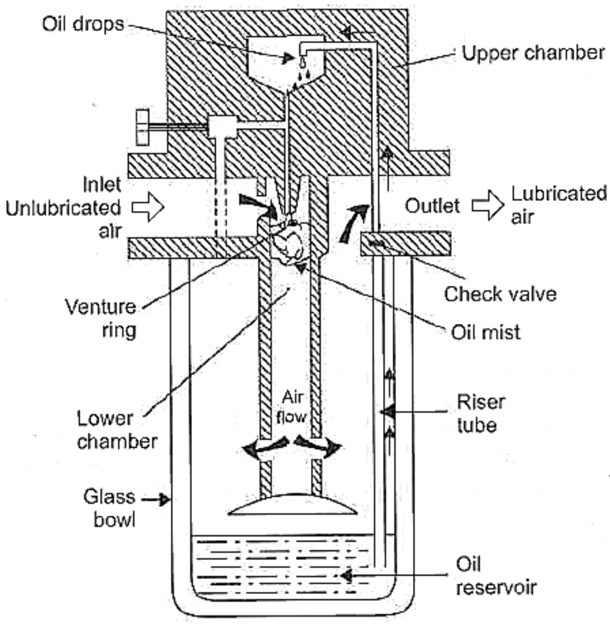

Fig.4.15 Air Lubricator

- The lubricator operates only when there is sufficient flow of air. if too little air is drawn in, the flow velocity at the nozzle is not sufficient to produce the vacuum necessary to draw the oil out of the vessel.

4.11 Pressure Regulator

- *Fig.4.16* shows the internal construction of a pressure regulator in a pneumatic system. The main function of this valve is to regulate the incoming pressure to the system So that the desired air pressure is capable of flowing at a steady condition.
- The valve has a metallic body with the two openings primary and secondary openings. The pressure regulation is achieved by opening the poppet valve to a measured amount commensurate with the desired pressure level to be achieved. This is done by an adjustable screw.
- The adjusting screw will move the diaphragm upward and thus will make the poppet to unseat, thereby creating an opening to allow air to flow from the primary side to the secondary side. The opening of the valve and thereby the pressure of air flowing through it, will be directly proportional to the compression of the spring underneath the diaphragm.
- Higher the spring compression, more will be the amount of opening and hence greater the pressure and vice versa. So in actual practice, the pressure regulator is but a pressure reducing valve and has immense application in pneumatic circuits to ensure desired pressure level at various parts of the system.

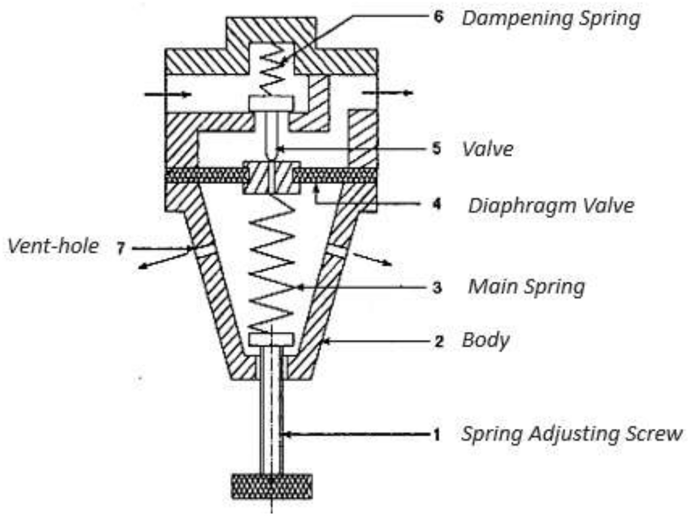

Fig.4.16 Pressure Regulator

- In many cases, the valve has two vent-hole openings through which the compressed air is let out into the atmosphere in case the secondary pressure increases to a level not desirable to the system. In most cases, the pressure once set by the screw should not be tampered with and lock-nut is tightened to ensure uninterrupted flow of air at desired pressure within the safe limit.
- The spring at the other side of the poppet helps to act as a dampening device needed to stabilise the pressure. Inlet pressure rating and downstream controlled range, as well as flow capacity must be determined before selecting a regulator. Port size should match piping size.

4.12 Filter-regulator-lubricator (FRL) unit

- The air that is sucked by the air compressor is evidently not clean because of the presence of various types of contaminants in the atmosphere. Moreover, the air that is supplied to the system from the compressor is further contaminated by virtue of generation of contaminants downstream.

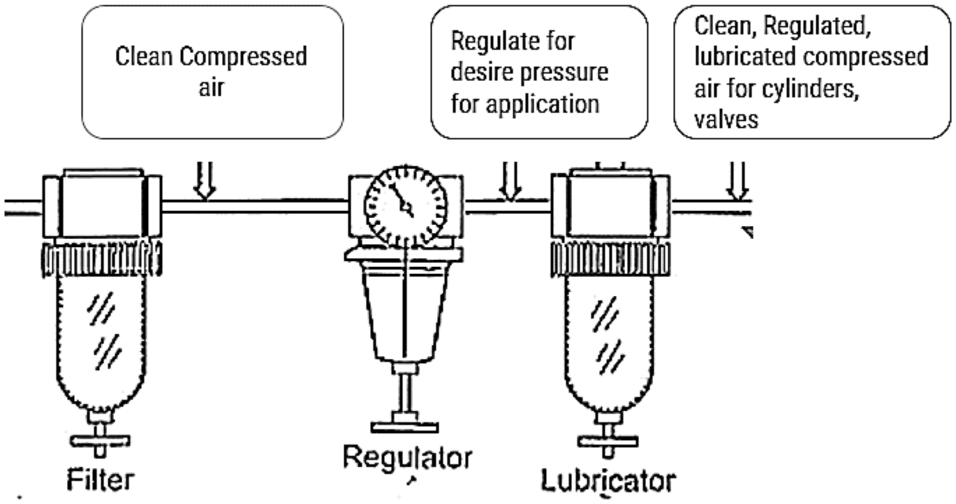

Fig.4.17 FRL units

- It is also a fact that the pressure of the air does seldom remain stable due to the possibility of line fluctuations. Hence to enable supply of clean, pure and contamination free compressed air, the air requires to be filtered.
- The system performance and accuracy depends much on the pressure-stability of the air supply.

- An airline filter and a pressure regulator therefore, find an important place in the pneumatic system along with a third component—an airline lubricator.
- The main function of the lubricator is to provide the air with a lubricating film of oil.
- These three units together are called service unit or FRL unit.

4.13 Reference Books

1. Basic Pneumatic Systems, Principle and Maintenance by S R Majumdar, McGraw-Hill
2. Pneumatics Concepts, Design and Applications by Jagadeesha T
3. Fluid Power with Applications by Anthony Esposito, Pearson