(Unit – 3)

Pharmaceutics – II

(Unit Operations I, including Engineering Drawing)

" Material Handling Systems "

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Pump:

A generic definition of a *pump* is "*A machine or device for raising, compressing, or transferring fluids.*"

In practice - it is common to differentiate between

- Pumps
- Compressors
- Blowers
- Fans

Pumps

- A pump is a machine for raising a liquid - a relatively **incompressible** fluid - to a higher level of pressure or head.

Compressors

- A compressor is a machine for raising a gas - a **compressible** fluid - to a higher level of pressure

Blowers

- A blower is a machine for moving volumes of a gas with **moderate increase of pressure**

Fans

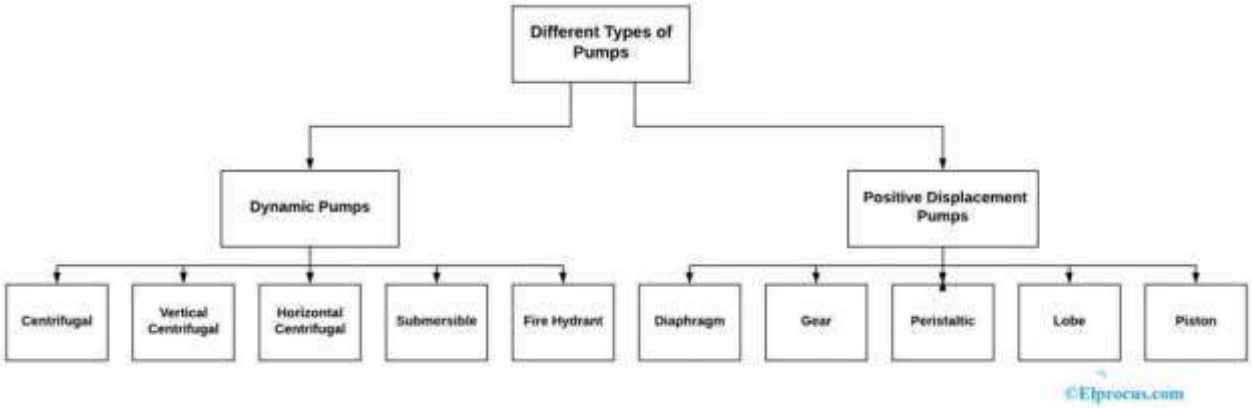
- A fan moves large amounts of gas with low increase in pressure

Different Types of Pumps: Working and Their Applications

There are different types of pumps available in the market. This article will assist you to know the main functionalities of each type of pump. The type of pump, as well as selection, mainly depend on our requirement. The application mainly includes the type of fluid you desire to pump, the distance you desire to move the fluid, and the quantity you require to get over a particular time frame. However, it is complicated to recognize accurately what kind of pump you must select. The identifying of the pump can be done with the design as well as positions. To make simpler things while seeking to choose your exact pump, and the pumps can be classified into two types which function in extremely dissimilar ways & generally summarize most of the pump designs.

Types of Pumps

Pumps are classified into two types namely Dynamic pumps as well as Positive Displacement Pumps.



TYPES OF PUMPS

A.) Dynamic Pumps

Dynamic pumps are classified into different types but some of them are discussed below like

1. Centrifugal,
2. Vertical centrifugal,
3. Horizontal centrifugal,
4. Submersible, and
5. Fire hydrant systems.

1) Centrifugal Pumps

These types of pumps are most commonly used worldwide. The working is very simple, described well and carefully tested. This pump is strong, efficient and fairly cheap to make. Whenever the pump is in action, then the fluid pressure will increase from the inlet of the pump to its outlet. The change of pressure will drive the liquid throughout the system.

This kind of pump produces an enhancement within force by transmitting mechanical power from the electrical motor to the liquid throughout the revolving impeller. The flow of liquid will enter the center of impeller and exits along with its blades. The centrifugal power hereby enhances the velocity of fluid & also the energy like kinetic can be altered to force.

2). Vertical Centrifugal Pumps

Vertical centrifugal pumps are also called as cantilever pumps. These pumps use an exclusive shaft & maintain design that permits the volume to fall within the pit as the bearings are external to the pit. This mode of pump utilizes no filling container to cover the shaft however in its place uses a throttle bushing. A parts washer is the common application of this kind of pump.

3) Horizontal Centrifugal Pumps

These types of pumps include a minimum of two otherwise more impellers. These pumps are utilized in pumping services. Every stage is fundamentally a divide pump.

All the phases are in a similar shelter & mounted on a similar shaft. On a solo horizontal shaft, minimum eight otherwise additional stages can be mounted. Every stage enhances the head by around an equal amount. Multi-stage pumps can also be single otherwise double suction on the first impeller. All kinds of pumps have been providing as well as servicing this type of centrifugal pumps.

4) Submersible Pumps

These pumps are also named as storm water, sewage, and septic pumps. The applications of these pumps mainly include building services, domestic, industrial, commercial, rural, municipal, & rainwater recycle applications.

These pumps are apt for shifting storm water, subsoil water, sewage, black water, grey water, rainwater, trade waste, chemicals, bore water, and foodstuffs. The applications of these pipes mainly include in different impellers like closed, contra-block, vortex, multi-stage, single channel, cutter, otherwise grinder pumps. For different applications, there is an extensive selection is accessible which includes high flow, low flow, low head, otherwise high head.

5) Fire Hydrant Systems

Fire hydrant pump systems are also named as hydrant boosters, fire pumps, & fire water pumps. These are high force water pumps intended to enhance the capacity of firefighting of construction by increasing the force within the hydrant service as mains is not sufficient. The applications of this system mainly include irrigation as well as water transfer.

B.) Positive Displacement Pumps

Positive displacement pumps are classified into different types but some of them are discussed below like

1. Diaphragm,
2. Gear,
3. Peristaltic,
4. Lobe, And
5. Piston Pumps.

1) Diaphragm Pumps

Diaphragm pumps also known as AOD pumps (Air operated diaphragms), pneumatic, and AODD pumps. The applications of these pumps mainly include in continuous applications like in general plants, industrial and mining. AOD pumps are particularly employed where power is not obtainable, otherwise in unstable and combustible regions. These pumps are also utilized for transferring chemical, food manufacturing, underground coal mines, etc.

These pumps are responding pumps and include two diaphragms which are driven with condensed air. The section of air by transfer valve applies air alternately toward the two diaphragms; where every diaphragm contains a set of ball or check valves.

2) Gear Pumps

These pumps are a kind of rotating positive dislocation pump, which means they force a stable amount of liquid for every revolution. These pumps move liquid with machinery coming inside and outside of mesh for making a non-exciting pumping act. These pumps are capable of pumping on high forces & surpass at pumping high thickness fluids efficiently.

A gear pump doesn't contain any valves to cause losses like friction & also high impeller velocities. So, this pump is compatible for handling thick liquids like fuel as well as grease oils. These pumps are not suitable for driving solids as well as harsh liquids.

3) Peristaltic Pumps

Peristaltic pumps are also named as tube pumps, peristaltic pumps. These are a kind of positive displacement pumps and the applications of these pumps mainly involve in processing of chemical, food, and water treatment industries. It makes a stable flow for measuring & blending and also capable of pumping a variety of liquids like toothpaste and all kinds of chemicals.

4) Lobe Pumps

These pumps offer different characteristics like an excellent high efficiency, rust resistance, hygienic qualities, reliability, etc. These pumps can handle high thickness fluids & solids without hurting them. The working of these pumps can be related to gear pumps, apart from the lobes which do not approach into contact by each other. Additionally, these pumps have superior pumping rooms compare with gear pumps that allow them to move slurries. These are made with stainless steel as well as extremely polished.

5) Piston Pumps

Piston pumps are one kind type of positive dislocation pumps wherever the high force seal responds through the piston. These pumps are frequently used in **water irrigation,** scenarios requiring high, reliable pressure and delivery systems for transferring chocolate, pastry, paint, etc.

Thus, this is all about classification of pumps like centrifugal & positive displacement. These are used in different kinds of buildings to make simpler the movement of liquid materials. The pumps which are used in housing & commercial can handle water. Fire pumps supply a rushed water supply for automatic sprinklers and firefighters, and booster pumps supply clean water to higher floors in apartments. Here is a question for you, what is the function of Hydronic Pumps within HVAC systems?

What is the difference between fan, blower and compressor?

- A fan moves large amounts of gas with a low increase in pressure: you'll find these in your home.
- A blower is a machine used for moving gas with a moderate increase of pressure: a more powerful fan, if you will. By changing the angle of the blades, a blower will be able to push air in any direction you want it.
- A compressor is a machine for raising gas to a higher level of pressure, actually making the air denser by cramming air into a small space.

- In general a fan moves air but not intended to increase air pressure, example are household fans.
- A blower moves air, typically into a restricted space, and has a fair amount higher pressure on the outlet than the intake. Examples are super charger, and leaf blower
- A compressor compresses air (and liquids) to high pressures in a very limited space that is either completely enclosed or having a valve to allow limited release over time such that you have compressed fluid on one side and decompressed fluid on the other side for efficient thermal exchange. Examples are Air Compressors and AC Compressors.

TYPES OF FAN

It is common to classify fans in

- Axial and/or propeller fans
- Centrifugal (radial) fans
- Mixed flow fans
- Cross flow fans

The pressure head of different types of fans with equal periphery speed of the wheel are compared in the capacity diagram below:

Centrifugal fans with forwarded blades are suited for application with higher air flow volumes and pressures. Axial propeller fans are more suited for applications with lower volumes and pressures.

1. **Axial and Propeller Fans**

In an axial fan the air flows in parallel to the shaft. It is common to classify axial fans upon their wheel like:

- C-wheel - Blades can be adjusted when running. High efficiency, small dimensions, variable air volume
- A-wheel - Blades can be adjusted only when the fan is standing still. High efficiency, small dimensions, adaptive to recommended air volume
- K-wheel - Blades cannot be adjusted. Simple, small dimensions

The pressure head developed for single stage is up to 300 N/m^2. Axial fans are suited for relatively large volumes compared to pressure.

2. **Centrifugal fans (Radial fans)**

In a centrifugal fan the air flows is in a radial direction relative to the shaft. Centrifugal fans can be classified by their wheel like:

- F-wheel - Curved forward blades. High efficiency, small dimensions, changing in pressure have little influence on pressure head.
- B-wheel - Curved backward blades. High efficiency, low energy consumption, changing in pressure have little influence on air volume. Low noise emission, stable in parallel running.
- P-wheel - Straight backward blades. High efficiency, self-cleaning, changing in pressure have little influence on air volume
- T-wheel - Straight radial blades. Self-cleaning. Suitable for material transport

Types of blades used in centrifugal fans are

- Straight steel plate paddle wheel
- Forward multi-vane multi-blade
- Backward turbo-vane

The different blades can be characterized as shown in the capacity diagram below:

3. **Mixed flow fans**

In a mixed flow fan, the air flows in both axial and radial direction relative to the shaft. Mixed flow fans develop higher pressures than axial fans.

4. Cross-flow fans

In a cross flow fan, the air flows in an inward direction and then in an outward radial direction.

WHAT IS BLOWER?

Blower is a machine which is used to move air at moderate pressure. OR simply, blowers are used for blowing air/gas in a specific or given area. A blower can develop a maximum pressure of about 202 kilopascals, which is equal to 2 atmospheres.

WORKING PRINCIPLE:

Blowers increase the pressure of the absorbed gas by the centrifugal movement of the impeller. when the impeller is rotating, the channels in the impeller push the air forward by centrifugal movement and a helical movement occurs. Then the gas is continuously compressed along the channel and the pressure increases linearly. Then the pressurized air is transferred from outlet duct of the blower.

*In a blower the inlet pressure is low and the outlet pressure is high. Because the kinetic energy of the blades increases the pressure of the air at the outlet.

TYPES OF BLOWERS:

Blowers are classified into two types they are

1. Positive displacement blowers
2. Centrifugal blowers

Blowers also use blades in various designs like fans. Such as backward curved, forward curved and radial, they are mainly operated by an electric motor.

1.) Positive Displacement Blowers:

Positive displacement blowers or Rotary air blower is used to move gas or air for a variety of applications.

Positive displacement blowers are almost similar to positive displacement pumps, which squeezes fluid that in turn increases pressure.

Positive displacement blowers are preferred over a centrifugal blower because a high pressure is required in a process.

EX: Cycloidal or Lobe blowers

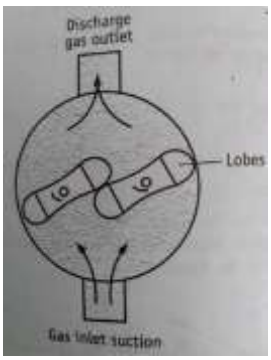
Cycloidal or Lobe blowers:

Construction:

The general construction of a lobe blower consists of only two or three lobes as rotating parts. They run in close contact with each other and with casing to run efficiently.

Working Principle:

It consists of two or three lobe impellers mounted on parallel shafts, rotating in opposite with in a casing closed at the ends by side plates. These blowers are constant volume machines and deliver a fixed discharge of air at a high velocity from the outlet.



Advantages:

1. They provide a large volume of flow which ranges from 30 to 15000m^3/ hr.
2. Sustainable energy efficiency
3. Low maintenance time and costs

Disadvantages:

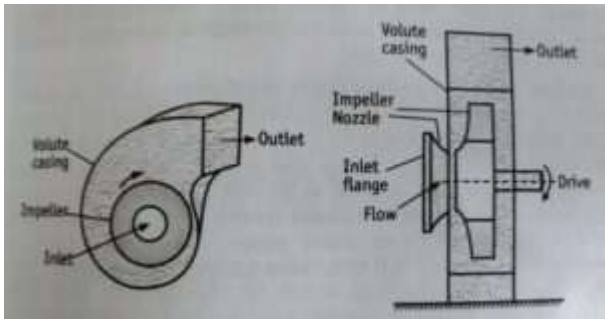
(1) Leakages between the lobes is possible

(2) It produces high noise during working

2.) CENTRIFUGAL BLOWERS:

Centrifugal blowers are also called as turbo blowers

Turbo blowers deliver gases at constant pressure, constant suction pressure, constant volume and at constant weight.



Principle:

In centrifugal blower the energy is transferred from a rotating shaft to air or gas. A pressure rise is achieved by adding kinetic energy to a continuous flow of air through the rotor or impeller.

Construction:

The construction of the centrifugal blower resembles a centrifugal pump. But in centrifugal blower the parts are made as light as possible and the size is smaller than the centrifugal pump it consists of an enclosed type impeller.

Applications:

1. Waste water treatment
2. Flue Gas desulfurization and lead recycling

Disadvantages:

1. The cost of the centrifugal blowers is high

2. Since the pressure developed is low, multistage centrifugal blower has to be used for generating high pressure

Compressors, Fans & Blowers – Basic Understanding

Compressors, fans, and blowers are widely used in various industries. These devices are quite suitable for complex processes and have become indispensable for some specific applications. They have been defined in simple terms as below:

- **Compressor:** A compressor is a machine which reduces the volume of gas or liquid by creating a high pressure. We can also say that a compressor simply compresses a substance which is usually gas.
- **Fans:** a Fan is a machine used to move fluid or air. It is operated through a motor via electricity which rotates the blades that are attached to a shaft.
- **Blowers:** Blower is a machine to move air at a moderate pressure. Or simply, blowers are used for blowing air/gas.

The basic difference between the above three devices is the way they move or transmit air/gas and induce system pressure. Compressors, Fans & Blowers are defined by ASME (American Society of Mechanical Engineers) as the ratio of the discharge pressure over the suction pressure. Fans have the specific ratio up to 1.11, blowers from 1.11 to 1.20 and compressors have more than 1.20.

Types of Compressors

Compressor types can be mainly grouped into two:

1. Positive Displacement Compressor
2. Dynamic Compressor

1. Positive displacement compressors are again of two types:

   a.) Rotary

   b.) Reciprocating

❖ Types of Rotary compressors are

   i) Lobe,
   ii) Screw,
   iii) Liquid Ring,
   iv) Scroll, and
   v) Vane.

- Types of Reciprocating compressors are

   i) Diaphragm,
   ii) Double acting, and
   iii) Single acting.

Dynamic Compressors can be categorized into

a.) Centrifugal and
b.) Axial.

Let us understand these in detail.

Positive displacement compressors use a system which induces in a volume of air in a chamber, and then reduce the volume of the chamber to compress the air. As the name suggests, there is a displacement of the component that reduces the volume of the chamber thereby compressing air/gas. On the other hand, in a **dynamic compressor**, there is a change in velocity of the fluid resulting in kinetic energy which creates pressure.

Reciprocating compressors use pistons where discharge pressure of air is high, the quantity of air handled is low and which has a low speed of the compressor. They are suitable for medium and high-pressure ratio and gas volumes. On the other hand, rotary compressors are suitable for low and medium pressures and for large volumes. These compressors do not have any pistons and crankshaft. Instead, these compressors have screws, vanes, scrolls etc. So, they can be further categorized on the basis of the component they are equipped with.

Types of Rotary compressors

- **Scroll:**

  In this equipment, air is compressed using two spirals or scrolls. One scroll is fixed and does not move and the other one moves in circular motion. Air gets trapped inside the spiral way of that element and gets compressed at the middle of the spiral. These are often with oil-free designs and require low maintenance.

- **Vane:**

  This consists of vanes that move in and out inside an impeller and compression occurs because of this sweeping motion. This forces the vapor into small volume sections, changing it into high pressure and high temperature vapor.

- **Lobe:**

  This consists of two lobes which rotate inside a closed casing. These lobes are displaced with 90 degrees to one another. As the rotor rotates, air is drawn into the inlet side of the cylinder casing and is pushed with a force out from the outlet side against the system pressure. The compressed air is then delivered to delivery line.

- ***Screw*:**

  This is equipped with two inter-meshing screws which traps air between the screw and the compressor casing, which results in squeezing and delivering it at a higher pressure from the delivery valve. The screw compressors are suitable and efficient in low air pressure requirements. In comparison to a reciprocating compressor, the compressed air delivery is continuous in this type of compressor and it is quiet in operation.

- **Scroll:**

The scroll type compressors have scrolls driven by the prime mover. The scrolls outer edges trap air and then as they rotate, the air travel from outwards to inwards thus getting compressed due to a reduction in the area. The compressed air is delivered through central space of the scroll to the delivery airline.

- ***Liquid ring*:**

In this type of compressor vanes are built inside a cylindrical casing. When the motor rotates, gas gets compressed. Then liquid mostly water is fed into the device and by centrifugal acceleration, it forms a liquid ring through the vanes, which in turn forms a compressing chamber. It is capable of compressing all gases and vapors, even with dust and liquids.

Reciprocating Compressor

- **Single-Acting Compressors:** It has piston working on air only in one direction. The air is compressed only on the top part of the piston.
- **Double-Acting Compressors:** It has two sets of suction/intake and delivery valves on both sides of the piston. Both sides of the piston are utilized in compressing the air.

Dynamic Compressors

The main difference between displacement and dynamic compressors is that a displacement compressor works at a constant flow, whereas a dynamic compressor such as Centrifugal and Axial works at a constant pressure and their performance is affected by external conditions such as changes in inlet temperatures etc. In an axial compressor, the gas or fluid flows parallel to the axis of rotations or axially. It is a rotating compressor that can continuously pressurize gases. The blades of an axial compressor are relatively closer to each other. In a centrifugal compressor, fluid enters from the center of the impeller, and moves outward through the periphery by guide blades thereby reducing the velocity and increasing pressure. It is also known as a turbo compressor. They are efficient and reliable compressors. However, its compression ratio is lesser than axial compressors. Also, centrifugal compressors are more reliable if API (American petroleum Institute) 617 standards are followed.

Types of fans

Depending on their designs, the following are main types of fans:

- ***Centrifugal fans***: In this type of fan, airflow changes direction. They can be inclined, radial, forward curved, backward curved etc. These kinds of fans are suitable for high temperatures and low and medium blade tip speeds at high pressures. These can be effectively used for highly contaminated airstreams.

- ***Axial Fans*:** In this type of fan, there is no change in direction of air flow. They can be Van axial, Tube axial, and Propeller. They produce lower pressure than the Centrifugal fans. Propeller-type fans are capable of high-flow rates at low pressures. Tube-axial fans have low/medium pressure and high flow capability. Vane-axial fans have an inlet or outlet guide vanes, exhibit high pressure and medium flow-rate capabilities.

The air flow required in the process along with required outlet pressure are key factors determining the selection of type and size of a fan. Fan enclosure and duct design also determine how efficiently they can work.

Blowers

Blower is equipment or a device which increases the velocity of air or gas when it is passed through equipped impellers. They are mainly used for flow of air/gas required for exhausting, aspirating, cooling, ventilating, conveying etc. Blower is also commonly known as Centrifugal Fans in industry. In a blower, the inlet pressure is low and is higher at the outlet. The kinetic energy of the blades increases the pressure of the air at the outlet. Blowers are mainly used in industries for moderate pressure requirements where the pressure is more than the fan and less than the compressor.

Types of Blowers:

Blowers can also be classified as Centrifugal and Positive displacement blowers. Like fans, blowers use blades in various designs such as backward curved, forward curved and radial. They are mostly driven by electric motor. They can be single or multistage units and use high speed impellers to create velocity to air or other gases.

Positive displacement blowers are similar to PDP pumps, which squeezes fluid that in turn increases pressure. This kind of blower is preferred over a centrifugal blower where high pressure is required in a process.

Applications of Compressors, fans and blowers

- ❖ Compressors, Fans and blowers are mostly used for processes such as Gas Compression, Water Treatment Aeration, Air Ventilation, Material Handling, Air Drying etc. Compressed air applications are widely used in various fields such as Aerospace, Automotive, Chemical Manufacturing, Electronics, Food and Beverage, General Manufacturing, Glass Manufacturing, Hospitals/Medical, Mining, Pharmaceuticals, Plastics, Power Generation, Wood Products and many more.

- ❖ The main benefit of an air compressor includes its usage in the water treatment industry. The waste water treatment is a complex process that requires breaking down millions of bacteria as well as the organic waste.

- ❖ Industrial fans are also used in a variety of applications such as chemical, medical, automotive, *agricultural*, *mining*, food processing, and construction industries, which

can each utilize industrial fans for their respective processes. They are mainly used in many cooling and drying applications.

- Centrifugal blowers are routinely used for applications such as dust control, combustion air supplies, on cooling, drying systems, for fluid bed aerators with air conveyor systems etc. Positive displacement blowers are often used in pneumatic conveying, and for sewage aeration, filter flushing, and gas boosting, as well as for moving gases of all kinds in the petrochemical industries.

- Compressors, fans, and blowers, largely cover Municipal, Manufacturing, Oil & Gas, Mining, Agriculture Industry for their various applications, simple or complex in nature.

- These are available from various manufacturers in different designs. Few of the well-known brands are Roots, *Hoffman*, Bosch, *Sutter built*, *Sullair* and *Joy*.

- A detailed study of all the designs and specifications is required to buy an appropriate compressor, fan or a blower that is available in the market so that it can match the requirements of your process and ensure reliability and durability at the same time.