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MINE PUMPS

MINE PUMPS

❖ *SOURCES OF WATER IN MINES:-*

1) The presence of water in mines is an important problem in the mining engineers.
2) Accumulation of water in a mine may be due to either-
   i) Percolation of surface sources, such as streams, ponds and rain water,or
   ii) Seepage from water bearing horizons or aquifers, or
   iii) Influx from waterlogged old and abandoned workings, in the adjoining areas of the mines, especially from caved of goaf areas in coal fields.
   iv) Due to drilling the water is required that water is stored in pump.
   v) Due to stowing water and sand mixture is passes in the goaf area. That water is also stored in sump or u/g mine.
3) As far as mine pumping is concerned, water that derived from rain, water courses or other bodies of water, which is known as meteoric water, is the only class of importance.
4) In a general way the water level is a modification from of the surface topography, being near the surface beneath which it is, however farther from the surface.

❖ Applications of Pumps in a Mine

1. Dewatering from the main sump.
2. Removing water from the face to make them workable.
3. Pumping slurry into the mine from sand stowing plant.
4. Circulation of water in mineral processing plants.
5. Water supply to the colony for household purpose.

❖ *PUMP*:-

A pump is a device used to move fluids, such as **liquids, gases, or slurries**. It increases the mechanical energy of the fluid. The additional energy can be used to increase:-

i) Velocity (flow rate)
ii) Pressure
iii) Elevation.

❖ *Different types of mine pumps:-*

1) Centrifugal pump or Volute Pump
2) Turbine Pump
3) Reciprocating pump:-a) Single acting b) Double acting

4) Face pump or mono pump
5) Submersible pump
6) Ram pump
7) Air lift pump.

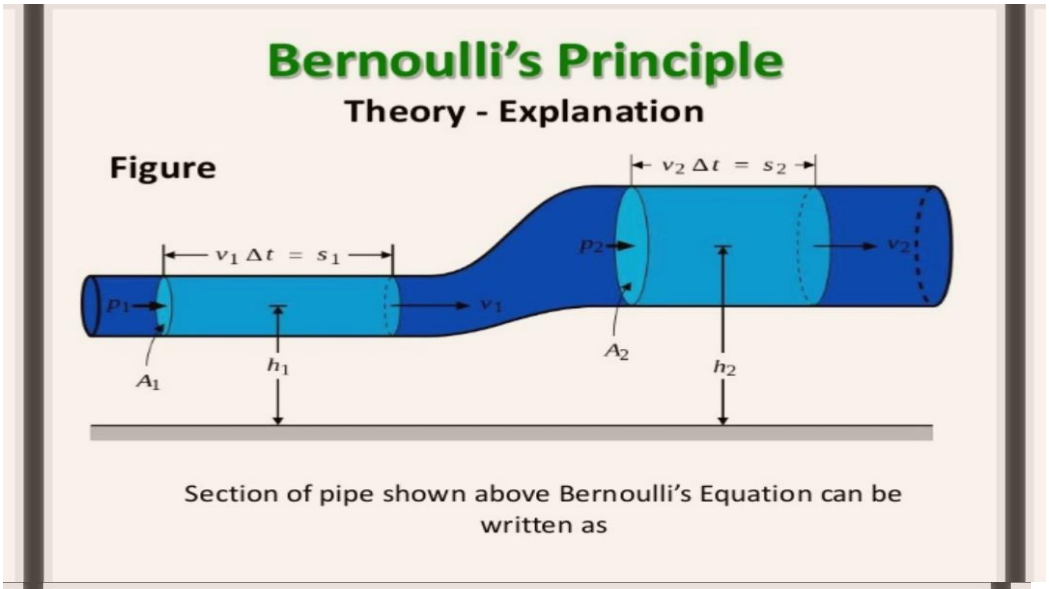
❖ ***Bernoulli's Theorem*:-**

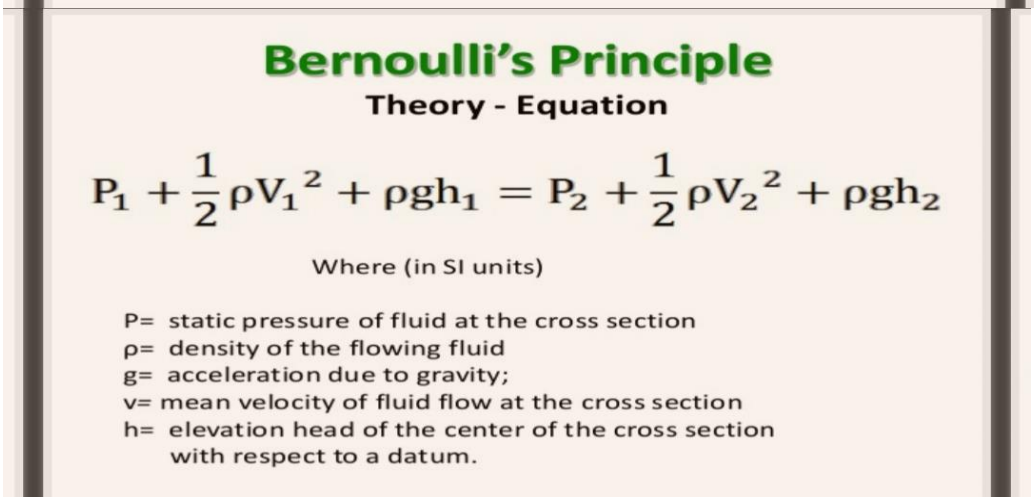
Theory statement:-

Increases in the speed of the fluid occur simultaneously with a decrease in pressure or a decrease in the fluid potential energy.

OR

In a horizontal pipe, the highest fluid pressure is in the section where the flow speed is the lowest, and the lowest pressure is at the section where the flow speed is the biggest.





❖ RECIPROCATING PUMPS:-

1) Reciprocating pumps depends for their action on the relatively slow to and fro motion of a piston, plunger or ram within a cylinder called working barrel.
2)The reciprocating motion may be given by steam or compressed air engine, either direct or through the medium of a crank and connecting rod or by an electric motor through reducing gearing.
3)Reciprocating pump may be single acting or double acting with piston or ram within the pump barrel.
4)**Piston pump** are suitable only for pumping fairly clean water to moderate height, upto about 90m to 120m.they have the merits of being light, cheap and compact.
5)**Ram pumps** are suitable when the pumping conditions are more arduous because of dirty water or high lift or combined. They may be designed to deal with any head up to 100 m or even more.

TYPES OF RECIPROCATING PUMP:-

The reciprocating pumps are of two types-

1)Single acting reciprocating pump.

If there is a single suction pipe and a delivery pipe, the reciprocating pump is known as single acting reciprocating pump.

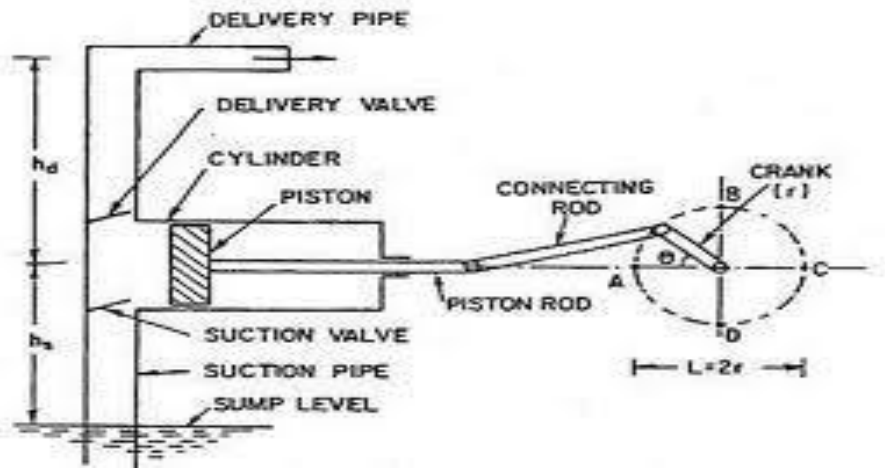
2) Double acting reciprocating pump.

If there are two suction pipes and two delivery pipes, the reciprocating pump is known as double acting reciprocating pump.

1)Single acting reciprocating pump:-

In this type of a pump a piston moves to and fro by a prime mover inside a cylinder which consists of an inlet and outlet port attached with the valve mechanism. In single acting reciprocating pump by each revolution of the prime mover the piston sucks water/liquid through the inlet valve by the backward stroke, compresses it from initial to the final pressure by the forward stroke and finally delivers it through the outlet valve in a single cylinder only. During the backward stroke a vacuum will be created inside the cylinder which will initiate to force water to fill the vacuum by opening the inlet valve.

The reciprocating pump basically consist of a piston, cylinder, suction and delivery valves, suction pipe and delivery pipe etc.



2)Double acting reciprocating pump:-

This type of pump is provided with two suction vavles,V1 and V2, and two delivery valve D1 and D2.During the stroke to the left, water entering through the suction valves V2,and being forced through the delivery valve D1.In the reverse stroke (for the stroke to the right in the figure),water enter at V1 and leaves through D2.Every stroke is effective to make the pump double-acting. Water is thus delivered during every stroke.
Volumes of water discharged during two strokes (left stroke and stroke to the right side) are not equal due the effect of piston or ram rod. The difference is about 3% to 4% and this is usually ignored during pump calculations.

Direct-driven double-acting ram pumps are specially suitable for raising water from deep workings, or for keeping dry the advancing the faces of an incline, where the water is dirty and pumps may be frequently be working on air.

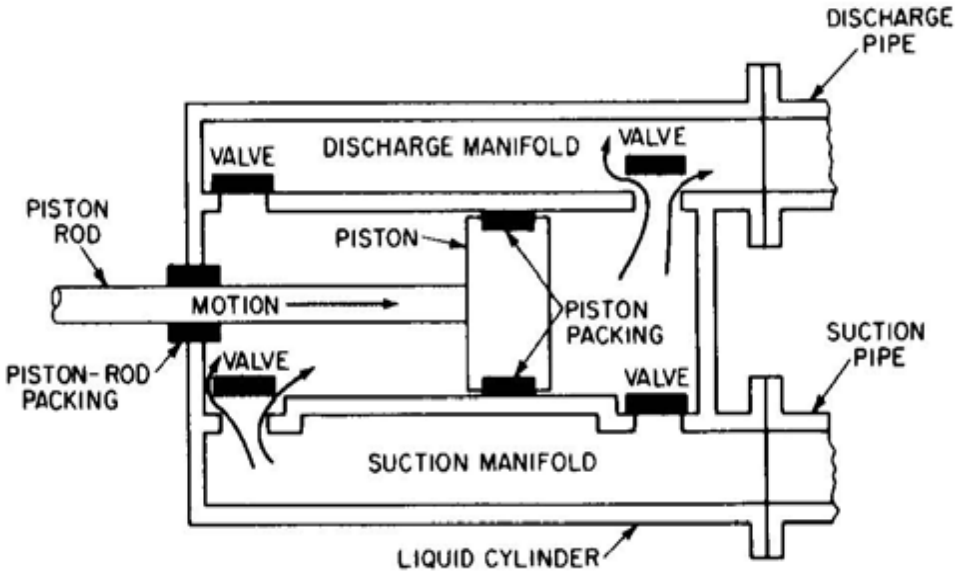


Fig. Double acting reciprocating pump

Some Important Definitions

a. ***Capacity:***Capacity means the flow rate with which water is moved or pushed by the pump to the desired point in the process. It is commonly measured in cubic meters per hour (m^3/hr). For a mine pump it depends upon the following:

- Size of the inlet and outlet sections of the pump.
- Impeller size
- Impeller rotational speed (RPM)

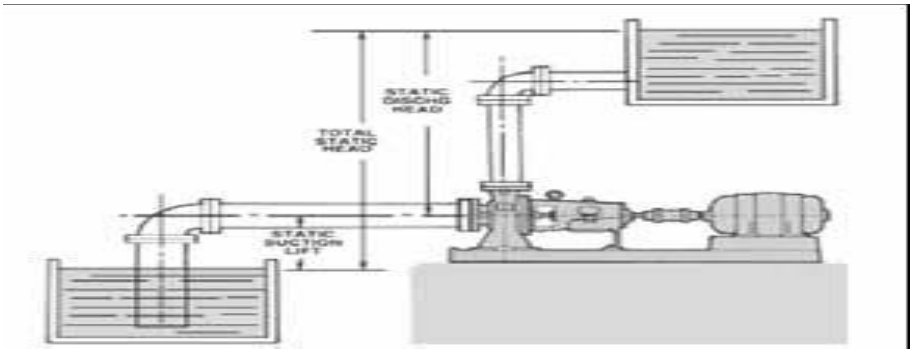
$$\text{Capacity } (m^3/s) = \text{Area}\,(m^2) \times \text{Velocity of discharge}\,(m/s)$$

b. ***Head:***The pressure at any point in a water can be thought of as being caused by a vertical column of the water due to its weight. The height of this column is called the static head and is expressed in terms of meter of water.

- The head is not equivalent to pressure. Head is a term that has units of a length and pressure has units of force per unit area.
- The main reason for using head instead of pressure is that the pressure from a pump will change if the specific gravity (weight) of the water changes, but the head will not change.
- Since any given pump can move a lot of different fluids, with different specific gravities, it is simpler to discuss the pump's head and forget about the pressure.

c. ***Static Suction Head (h_S)*** *:* Head resulting from elevation of the water relative to the pump center line. In case of mine pumps, the water level is below pump centerline, therefore $h_S$is negative. Negative h_S condition is commonly denoted as a "suction lift" condition.

d. ***Static Discharge Head (h_d)****:* It is the vertical distance in meter between the pump centerline and the surface of the water in the discharge tank.



*e.**Friction Head (h_f)****:* The head required to overcome the resistance to flow in the pipe and fittings. It is dependent upon the size, condition and type of pipe, number and type of pipe fittings, flow rate, and nature of the water.

*f.**Velocity Head (h_v):***Refers to the energy of a water as a result of its motion at some velocity 'v'. It is the equivalent head in meter through which the water would have to fall to acquire the same velocity, or in other words, the head necessary to accelerate the water.

*g.**Pump input or brake horsepower (BHP):***

It is the actual horsepower delivered to the pump shaft.

*h.**Pump output or hydraulic or water horsepower (WHP):***

It is the water horsepower delivered by the pump.

❖ ***Centrifugal pump*:-**

Types of Centrifugal Pumps

- Volute Pump (Centrifugal Pump)
- Turbine Pump

1) Volute Pump or Centrifugal Pump:

Main components of the volute Pump are as under:

• **Impeller:** It is a wheel or rotor which is provides with a series of curved blades or vanes. It is mounted on a shaft which is coupled to an external source of energy (electric motor) which supplies the required energy to impeller, thereby making it to rotate.

• **Casing:** The impeller is surrounded by a spiral shaped chamber, which is known as casing as shown in the figure. The shape of the casing is such that the sectional area of flow around the impeller generally increases from the point A towards the delivery pipe.

1) Suction Pipe: It is a pipe which is connected to its upper end to the inlet of the pump, which is known as Eye. The lower end of the suction pipe dips into the liquid which is to be pumped.

2) Foot Valve & Strainer: The lower end of the suction pipe is filled with a foot valve & strainer. The liquid first enters the strainer which is provided in order to keep the debris away from the pump and then water enters the foot valve. A foot valve is non-return valve and opens only in the upwards direction as such the liquid will pass through the foot valve only upwards and it will not allow the liquid to move downward back to the sump.

3) Delivery Pipe: It is a pipe which is connected at its lower end to the outlet of the pump and it delivers the liquid to the required height.

4) Delivery Valve: Just near the outlet of the pump on the delivery pipe a delivery valve is provided. It is a regulating valve which is required to control the flow of liquid from the pump into delivery pipe.

5) Airlock: It is used for Priming.

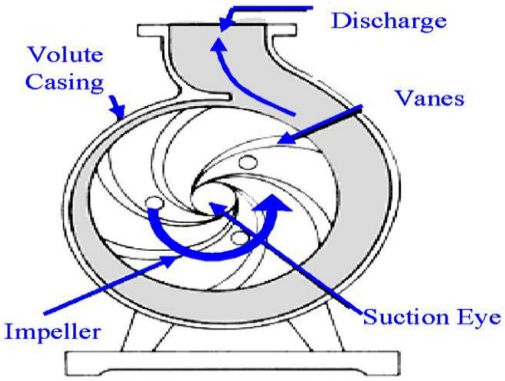


fig. Centrifugal Pump

❖ ***Different Pump Fittings*:-**

1) **Strainer**: At the lower end of the suction pipe to keep out flushing water.

2) **Foot valve**: It is fitted above the strainer to prevent water returning back from the pump and suction pipe into the sump.

3) **Main valve**: It is fitted on the delivery pipe. Used for controlling the flow.

4) **Retaining valve**: It is fitted on the delivery pipe. Used for retaining the water if the pump stops when the main valve is open.

5) **Bye-pass valve:** This valve is bye passing the main and retaining valves to enable the pump to be primed with water from the delivery column before starting up. It is fitted on delivery side. A priming funnel is also provided for priming from an outside source.

6) **Air cocks**: Fitted on the pump. Used for releasing the air during priming.

7) **Suction Valve**: It is a type of valve which is fitted in the suction pipe.

8) **Delivery valve**: It is a type of valve which is fitted in the delivery pipe.

9)**Shaft:**The basic purpose of a centrifugal pump shaft is to transmit the torques encountered when starting and during operation while supporting the impeller and other rotating parts.

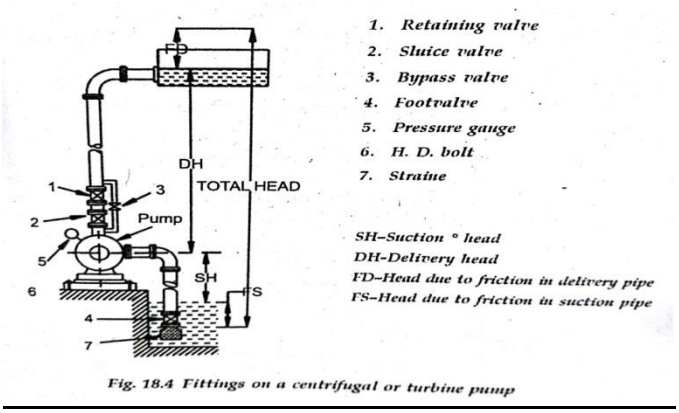


Fig. 18.4 Fittings on a centrifugal or turbine pump

❖ *What is **PRIMING** ???*

It is the operation in which the suction pipe, casing of the pump and the portion of the delivery pipe up to the delivery valve are completely filled with the liquid which is to be pumped so that no air is left in the casing.

The pressure generated by the impeller is directly proportional to the density of the liquid i.e. in contact with it. Hence if an impeller is made to rotate in the presence of air, only a negligible pressure would be produced with the result that no liquid will be lifted by the pump as such it is essential to properly bring a centrifugal pump before it can be studied.

1)Centrifugal Pump:-

➢ Introduction:-

A centrifugal pump is one of the simplest pieces of equipment. Its purpose is to convert energy of an electric motor or engine into velocity or kinetic energy and then into pressure of a fluid that is being pumped. The energy changes occur into two main parts of the pump, the impeller and the volute. The impeller is the rotating part that converts driver energy into the kinetic energy. The volute is the stationary part that converts the kinetic energy into pressure.

➢ Construction:-

1)A single stage centrifugal pump consists essentially of an impeller keyed to a steel shaft which passes through the pump casing having water sealed stuffing box at its end.

2)The other end of the casing being supported by bearings in a water tight cap.

3)The impeller somewhat resembles a wheel formed of two discs between which are fixed a no of vanes or blades, curved normally backwards from the direction of rotation.

4) An opening called the eye of the impeller is left at the centre to permit the entry of water via the suction pipe.

5) The water is then driven out tangentially by the vanes of the impeller into the delivery main.

➢ Operation(Working):-

1)A centrifugal pump can’t create its own vacuum and hence it needs priming.

2)The centrifugal pumps, like the centrifugal fan essentially consist of a stator(volute casing) and a rotor(impeller disc).

3)Water enters the casing at the central position and comes into contact with the rotor, which is driven at a high speed by an electric motor.

4)The water entering the pump is thrown from the center of the rotor of the periphery essentially by the centrifugal force and it thus acquires high velocity.

5)The initial pressure increases progressively as the water moves on the delivery side, but the momentum decreases at the same time.

6)As the water is impelled fresh water enters into impeller and thus the continuity of flow is maintained.

According to Bernoulli's principle

The head (pressure in terms of height of water) developed is approximately equal to the velocity energy at the periphery of the impeller expressed by the following well-known formula:

$$H = \frac{V^2}{2g}$$

Where, H is velocity head, m; V is velocity in m/s and g is acceleration due to gravity

$$V = \frac{\pi DN}{60}$$

Where, D is diameter, m; N is RPM.

❖ Difference between a Turbine Pump and a Centrifugal Pump.

- A centrifugal pump has only one impeller whereas the turbine pump has more than one. The maximum number is ten. The head developed by one impeller is 30 m (approx.) depending on the design parameters.
- The centrifugal pump does not have a balancing disc whereas the turbine pump has a balancing disc.
- The centrifugal pump has a volute casing whereas the turbine pump has diffusers.

❖ ***Characteristics curve of Centrifugal / Turbine Pump:-***

The characteristics curve is a curve which shows how the magnitude of one quantity varies with the changes in some other related quantity and with the help of this curve performance of pump is find out.

In the case of a pump the curves show the quantity delivered at various heads and a mechanical efficiency and power of the pump when running at a constant speed.

1) ***The efficiency curve:-***

The efficiency of any machine is the ratio of power output to power input, and in the case of a direct driven centrifugal or turbine pump.

$$\text{Mechanical efficiency of pump} = \frac{\text{H.P.in water}}{\text{H.P. input to pump shaft}} = \frac{\text{Water H.P.}}{\text{Brake H.P. of driver motor}}$$

It will be seen from the characteristics curve that the curve rises from zero with a closed main valve to a maximum at normal duty and therefore falls as the quantity increases. A pump should be run for a quantity which gives nearly maximum

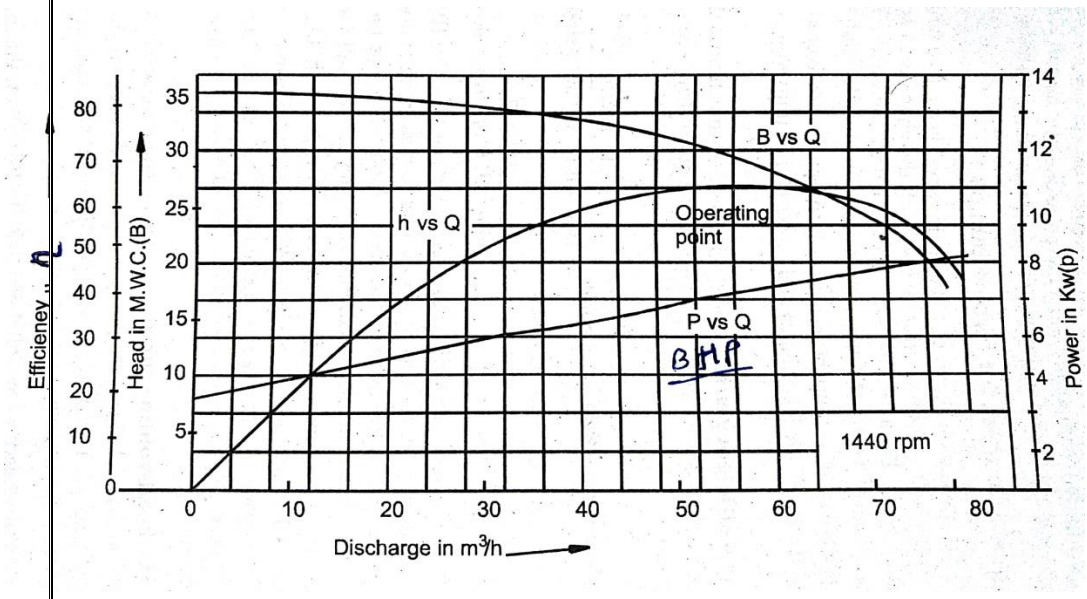
efficiencyfor a small variation in discharge. In other words the operating point of the pump should be on the flat portion of the curve depicting efficiency VS quantity.

2) <u>The head volume curve</u>:-

This curve is depends only on the impeller design and its speed. The curve is nearly flat for small discharge quantities but falls as the quantity is increased. The head at zero delivery when the sluice valve remaining closed is greater than the static head thus ensuring that the pump is able to deliver water to desired lift when the sluice valve is opened. The pump has a 'humped back' profile, the head is rising to a maximum and therefore the head decreases with increasing quantity of water due to increased friction and shock losses within the pump, until the pump ultimately chokes.

3) <u>The brake- H.P. curve</u>:-

It will be seen that the B.H.P. increases more or less uniformly with increasing quantities and it is possible to overload the motor if the head against which the pump is working is reduced. It can be further noted that the amount of overload is limited and does not become excessive.



2)Turbine Pump:-

Introduction:-

Turbine pumps are essentially meant to build up pressure to cope up with high hydrostatic head.Itdiffers from a centrifugal pump in that the single volute casing is replaced by one provided with stationary diffusing channels surrounding the impeller. This has the effect of greatly increasing the efficiency of conversion of kinetic energy into pressure energy.

Construction:-

A multi-stage turbine pump is provided with a number of impeller in series on the same shaft, with properly shaped diffusing channel leading from the periphery of one impeller to the eye of the next.

The outer casting may consists of a number of sections held together by long bolts passing through the flanges of the two end covers which form the suction and delivery chambers respectively. For very high head the casing may be a one-piece cylindrical casing with detachable end-covers.The shaft has ring-oiled bearing at each and the pump is connected to the motor through flexible bearing.

A balance disc is keyed near the delivery end of the shaft to counteract the end-thrust.

After leaving the diffuser the water travels inward readily at low velocity through the passage communicating with the 'eye' of the next impeller, and so on, stage by stage, until the delivery chamber is reached. The total pressure developed by the pump is the sum of the pressure of the individual stage.

Principle of Action:-

When the impeller of a turbine pump rotates it causes a suction effect in the pump and water enters the suction pipe as the atmospheric pressure forces the water into first impeller via the central opening or 'eye' or the impeller. In the impeller, the water is whirled around by the blades, and it leaves the periphery with an increased pressure and at high velocity, there after passing between the stationary scroll-shaped guide blades or vanes forming the diffusing channels.

The functioning of the diffusing channels is the same as the volute casing in a centrifugal pump, to convert the kinetic (or velocity) energy of the water into equivalent pressure energy by virtue of its construction causing the water to pass along the passage of gradually increasing cross-section.

The total head generated by each impeller or stage in created in two ways, partly by and within the impeller itself by centrifugal action, and partly in the guide passage by conversion of velocity into pressure energy. More than half the pressure rise takes place in the impeller, and the rest in the diffusing channel.

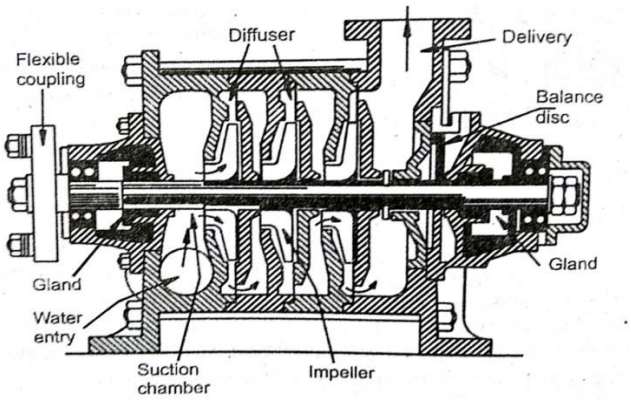


Fig. 18.5 Turbine pump in section.

❖ Laws of Turbine pumps

1. Capacity Q changes in direct proportion to impeller diameter D or to speed N

   i.e. Q α D (or N).

2. Head, H changes in direct proportion to the square of impeller diameter D or to speed N *i.e.* H α D^2 (or N^2).

3. BHP changes in direct proportion to the cube of impeller diameter D or to speed N

   i.e. BHP α D^3 (or N^3)

4. When both diameter and speed change then

   Q α (DN); H α $(DN)^2$; BHP α $(DN)^3$

These equations hold good under the conditions of constant efficiency.

❖ *Starting & Stopping the Centrifugal/ Turbine Pump:-*

Centrifugal and turbine pumps do not create a vacuum of more than few centimeters w.g. when working on air. Therefore the pumps must first be primed with water. The procedure is to be adopted-

To start the pump:-

1) Close the main valve in delivery column.

2) Open the air-cock of each stage.
3) Prime the pump and suction pipe with water.
4) Close the air-cock when the water overflow from it.
5) Check up for the any leakage of air or water on the suction pipe and upto the air-cocks.
6) Run the motor gradually up to full speed.
7) When the pump is running at full and has developed the required head as shown by the pressure gauge
8) Open the main valve slowly if the delivery range is empty or fairly rapidly if the range is full until the motor has taken up its load as shown by the ammeter.
9) If this precautions is not observed the motor gets overloaded.

To stop the pump:-

1) Close the main valve first, and then
2) Trip the motor switch.

❖ ***Water Hammer*:-**

This is a violent shock caused by a moving column of water being suddenly brought to rest. In reciprocating pumps, it is liable to occurs whenever the ram or piston returns into half empty casing and meets the still advancing water with violent shock and noise. If allowed to continue, a joint may be blown out and valves or some other parts of the pump delivery column damaged.

Causes:-

The reasons for water hammer may be as follows-

1. Suction pipe being too small.
2. Suction pipe or strainer partially choked.
3. Valve being defected.
4. Valve-seat loose
5. Suction pipe is too long.
6. The pump is suddenly started or stopped.

❖ ***Snoring of Pump:-***

When a water pump is pumping a mixture of air and fluid, the pump is said to be snore. During snoring the pump suffers high mechanical stress at the same time as the efficiency also greatly decreases.

It occurs due to improper priming of pump also any leakage from suction pipe upto the delivery head. It is also form due to overload of the motor to prevent this the proper priming of the pump is necessary and any leakage of the pump is find out then close the leakage. It also prevented from overloading of the motor.

❖ ***MONO PUMPS:-***

Mono Pumps, also known as “Screw Pumps” or “Roto Pumps”, relate to displacement until whose operating principle differs for that of reciprocating or centrifugal pumps. It is an electrically driven, valveless, rotative pump. The pump requires no priming and can on a suction life as high as 75 meter.

***CONSTRUCTION*:-**

The Mono Pump consist of

1) A stator mode of natural or synthetic rubber or of other plastic material. Torsion free stators bonded to metal sleeve arealso in use.
2) A machined cast iron or mild steel barrel inside which the stator is push fitted.
3) A single helical rotor of special abrasion-resisting non-corrosive steel.
4) Suction and delivery branches, ranging from 19mm to 75mm diameter are with the main structure of the pump.
5) A snoring by-pass pipe connecting the delivery branch back to the suction to permit the recirculation of water to keep the stator lubricated during dry running.
6) A hollow driving shaft running in ball bearing and transmitting and eccentric motion to the rotor by a coupling rod of high tensile steel.
7) A three-phase AC squirrel cage induction motor running at 580 to 1450 RPM is switched direct on to the line.

Normal capacities of the pumps rang form 30 liters per minuets up to 450 liters per minutes, at total heads (including pipe friction) ranging up to 45m for single stage pump and 90 m for two stage pump.

Action of Pump:-

The radial cross section of the rotor is circular and center are eccentric relative to it’s axis of rotation. The pitch of the stator is twice that of the rotor & the two engage in such a way that the rotor passage maintaining a constant seal across the stator. This seal is advancing continuously through the pump giving a uniform positive displacement.
Water which enters the suction branch is thus caught up in the space between the rotor and the stator and is forced through the pump as the rotor revolves. A positive pressure developed on the delivery side and there must be a free passage for water before the pump is started up.

ADVANTAGES:-

1) The action is positive and displacement is continuous without pulsation.
2) Self priming is an inherent feature since here are no valve to give rise to slip and leakage.
3) The pump can work efficiently with suction life of up to 7.5 meters.
4) The pump can really deal with grit, without serious damage to the stator or motor.
5) It is light and portable and maintenance is cheap.

DISADVANTAGES:-

1) Attainable heads are limited in region of 45m and 90m for single and two stage models.
2) It the pump run dry the stator will immediately be damage. The pumps must be first be filled with water for lubrication purpose before the pipe are connected.

3) Larger sizes of solid particles present in water if entered into the helical space may cause jumping the rotor and stator.

APPLICATION:-

The mono pump has a wide field of use fullness for following purposes:

1) For handling coal slurry in washeries.

2) For in bye works at the face or in dip headings, where the suction condition are difficult and variable and the pump may be have to work on snore.

3) It may be used for water spring, wet drilling and cutting, flushing of boreholes and infusion, blasting in coal mines.

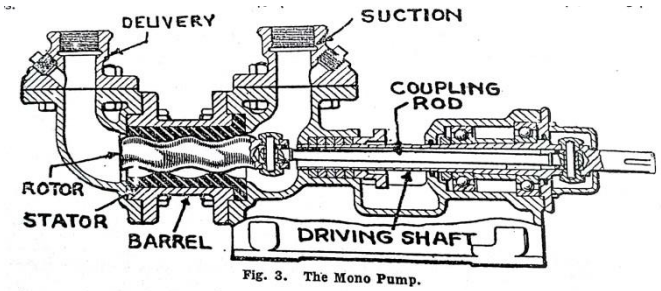


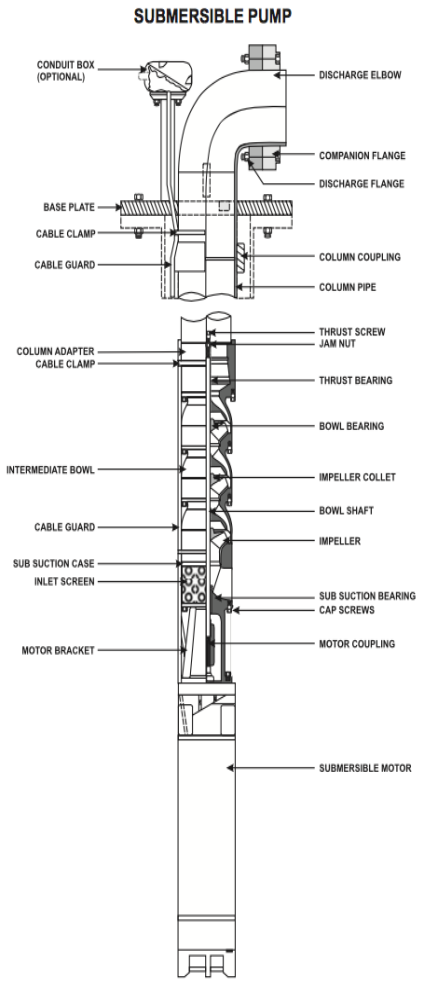
Fig. 3. The Mono Pump.

❖ ***Submersible Pump*:-**

In submersible pump the electric motor and the pump form one compact unit. The suction pipe is eliminated, but a strainer is place between the motor and the pump, the pump itself consists of a number of impellers mounted in a shaft, supported by journal bearings. The pump motor unit is housed within a cylindrical casing and is fixed at the bottom of the delivery pipe line. The pipe line is suspended from the pump deck.

The pump may be made of aluminium, stainless steel or gun metal and may be coated with chlorinated rubber. The motor has P.V.C. insulated winding. The stator winding are water cooled. The motor is totally enclosed and drip-proof type. It may be of 2900 RPM for smaller size pumps or 1450 RPM for larger sizes to impart longer life and better efficiency. PVC insulated power cable is held to the pipes by clamps and connected to the motor through flameproof coupling.

Common range of the pumps varies from 25 liters to 5000 liters per second with an average lift varying from 20 m to 200 m or more depending on the number of stage of the pump. The pumps can be arranged for automatic starting and stopping with the help of electrodes and safety devices can be fitted to stop the motor of it works on snore.



❖ ***Air Vessel*:-**

An air vessel is a chamber containing air and communicating with the delivery pipe to reduce the jark, shock and noise of pulsating effect in a reciprocating pump. The air in the vessel is regularity compressed by the incoming delivery of water under highpressure in the delivery pipe. When the pressure is lessened, the compressed air expands and drives out the excess water until the pressure has fallen to normal. The air vessel in the delivery range helps to maintain a smooth and continuous flow of water, reduces shocks on the driving mechanism, thereby increasing the efficiency of the pump.

The air vessel when fitted in the delivery side is called delivery air vessel, but where the suction pipe is long a suction air vessel is also employed to minimize water hammer.