Positive-displacement pumps

Gear Wheel Pump

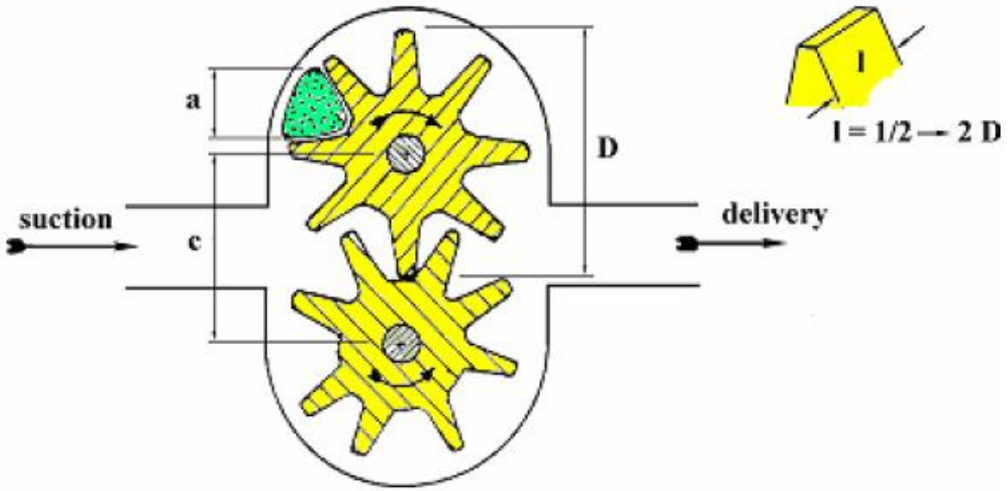
$$Q = \frac{2.a.l.n.N}{60}$$

a = area enclosed between any two adjacent teeth and the casing.

l = axial length of teeth.

n = number of teeth in each gear.

N = speed in rpm.



$$Q = K\,C\,(D - C)\,l$$

where:

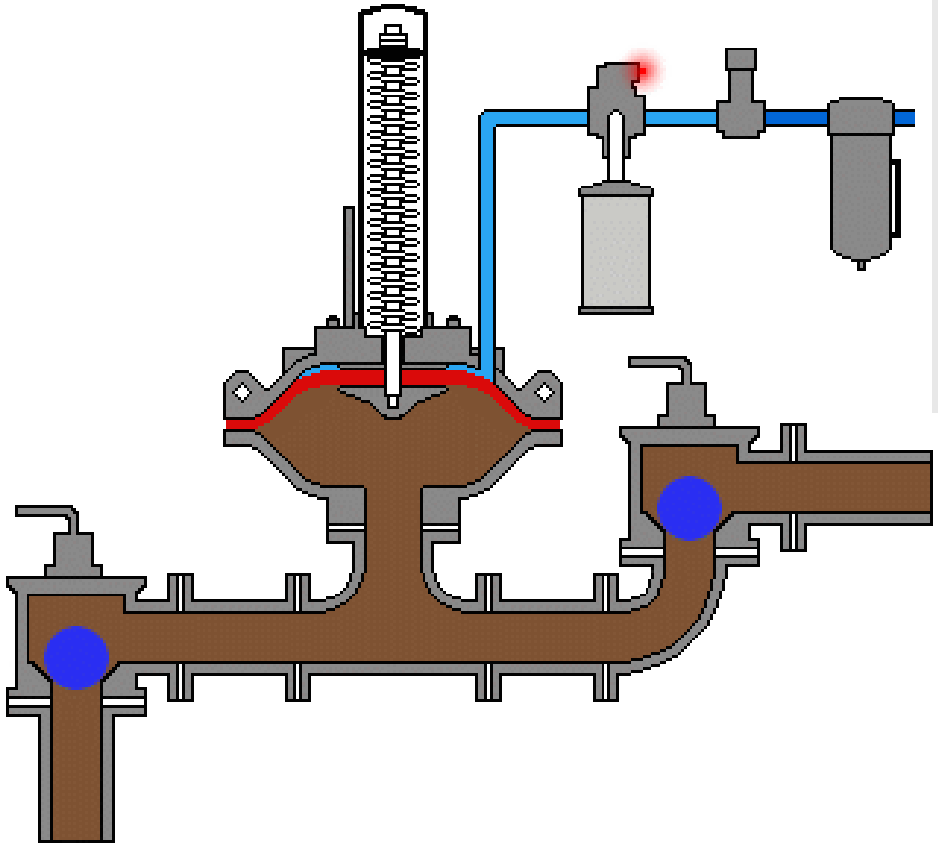
K is a constant = 2.983

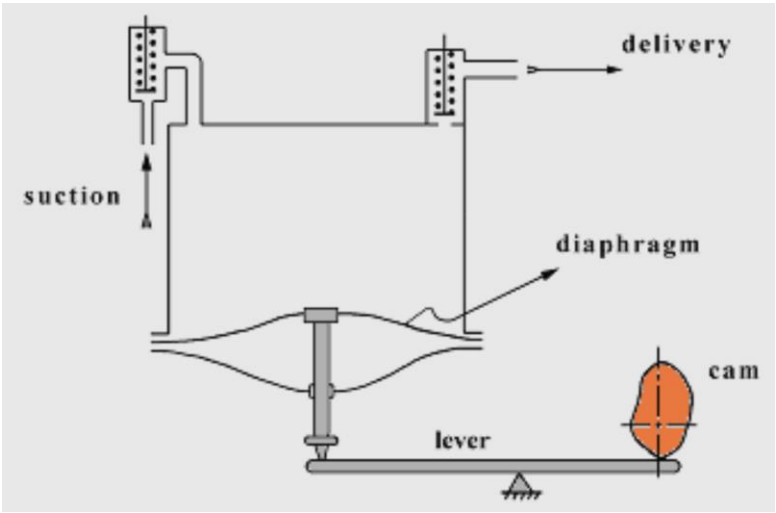
D is the gear diameter.

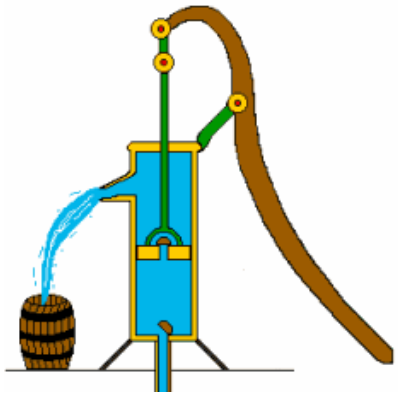
C is the distance between the two gear centers.

Positive-displacement pumps

Diaphragm pump

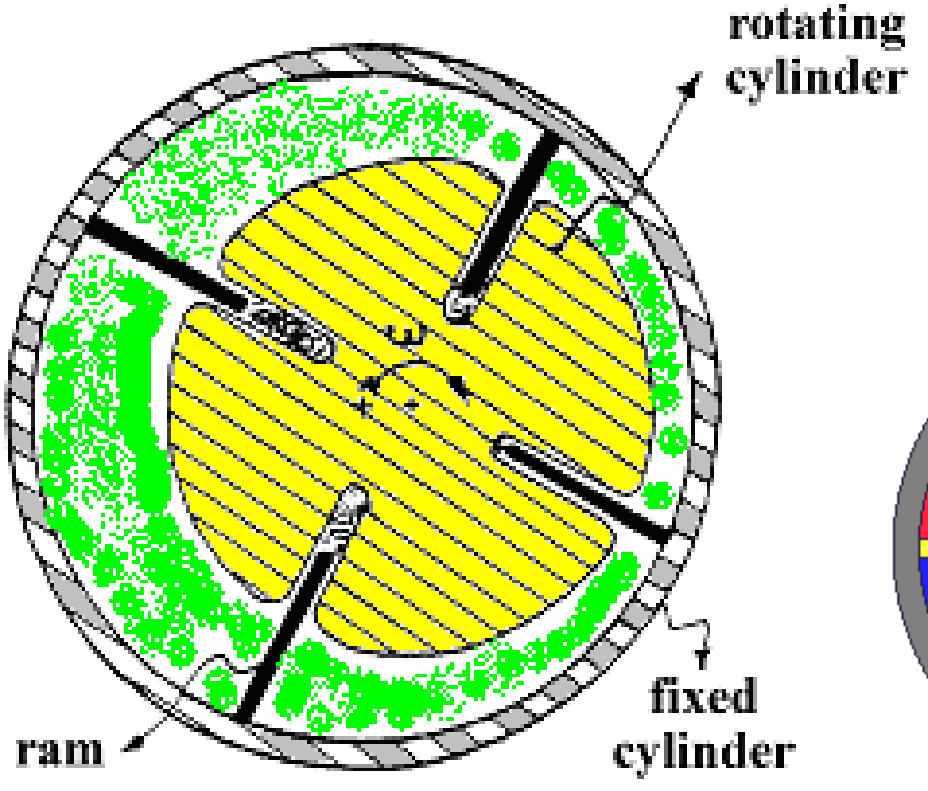


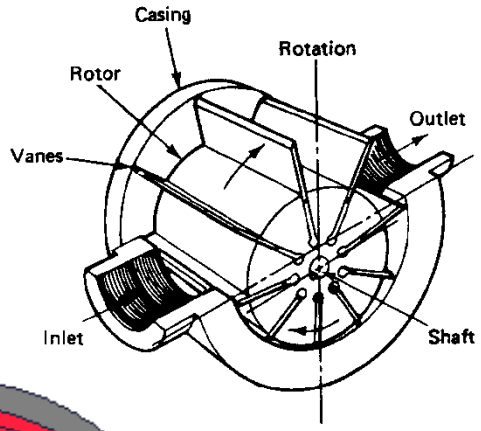


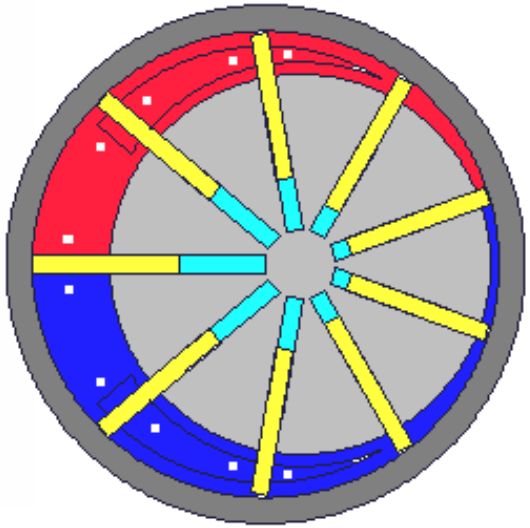


Positive-displacement pumps

Rotating cylinder pump

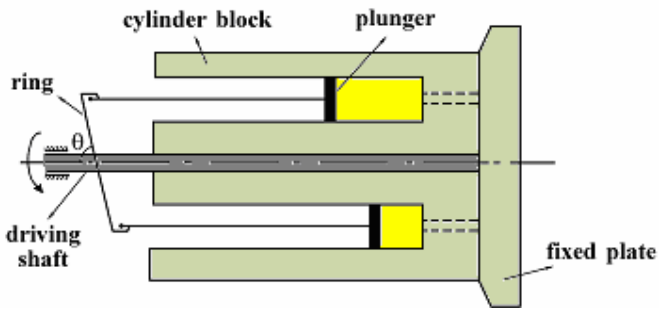


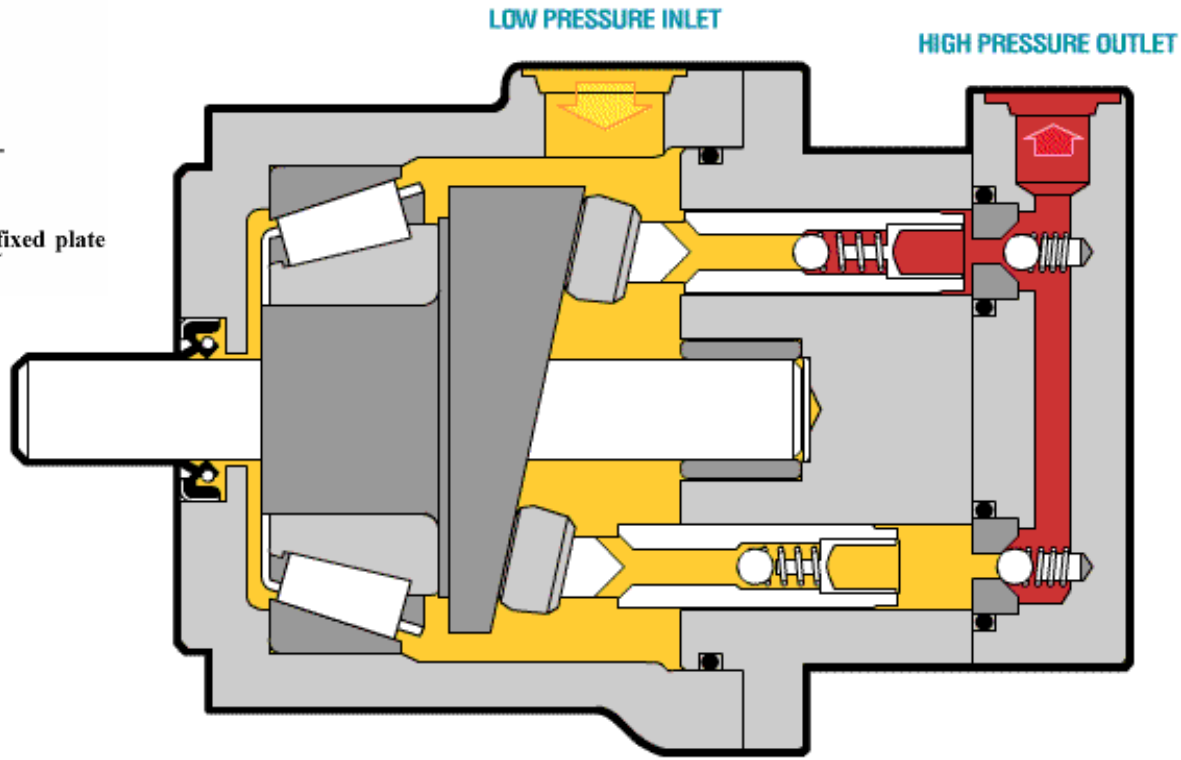




Positive-displacement pumps

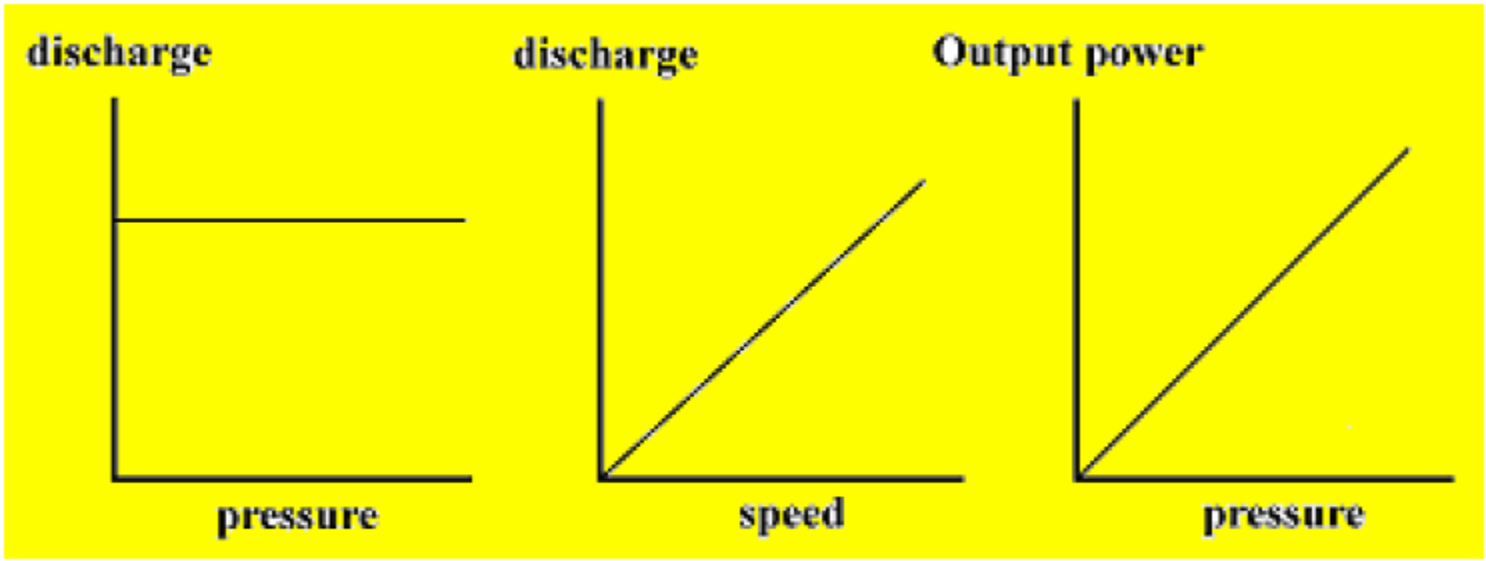
Rotating piston pump





Positive-displacement pumps

Performance of Positive Pumps:

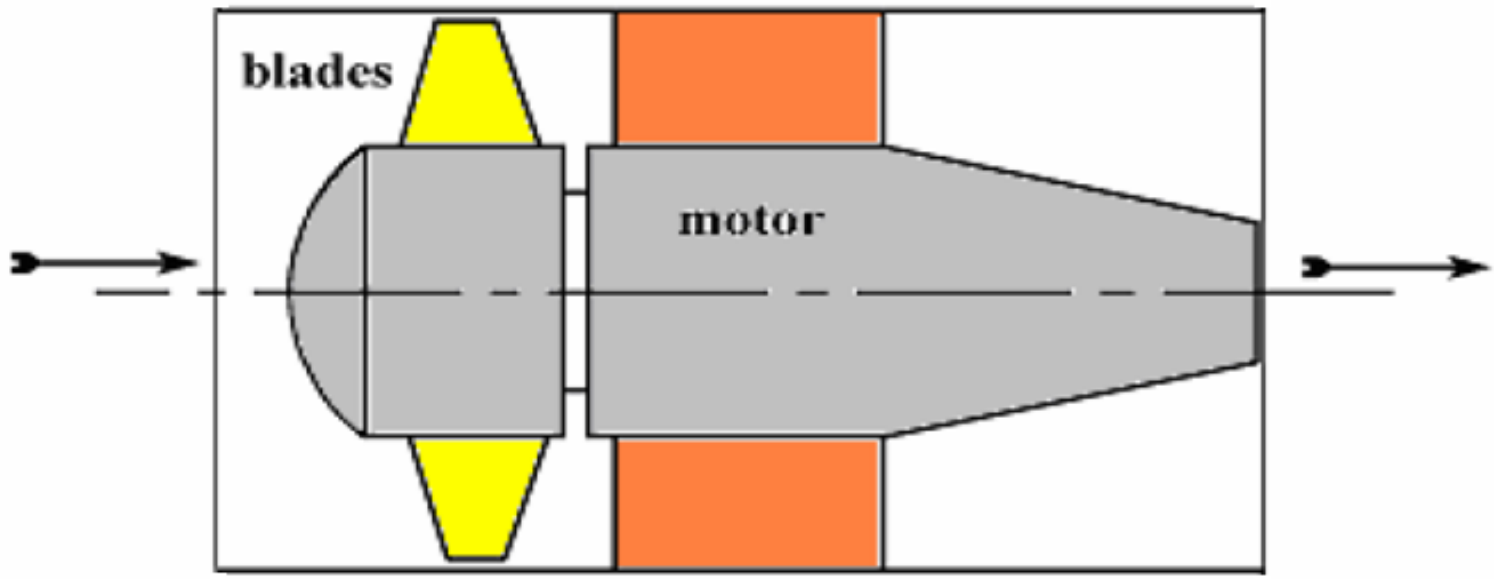


(a) constant speed (b) constant pressure (c) constant speed

Fans, Blowers, and Turbo-Compressors

Fans

Fans are usually used to circulate air and usually axial flow type. The pressure does not increase, one can assume it constant during the process. So, the problem could be simplified to an incompressible flow problem. The energy supplied by fan to fluid is mainly a kinetic energy.



Fans, Blowers, and Turbo-Compressors

Fans

Fans, Blowers, and Turbo-Compressors

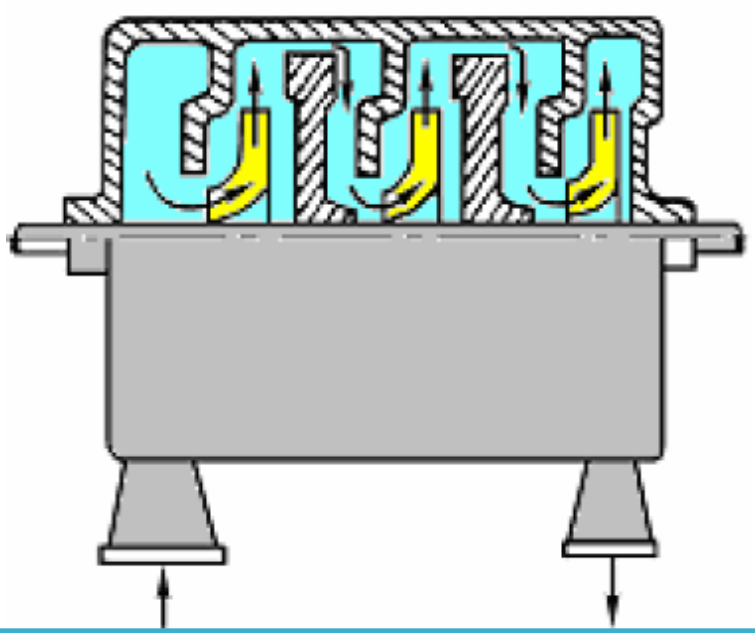
Blowers

Usually used when large capacity is required. It is also used to circulate gases. The pressure is slightly increased but not more than 2 kp/cm^2. The blowers could be axial or mixed flow. If the pressure increment is not sensible, the problem could be treated as incompressible flow problem. The blowers have other names according to the service in which it operates. For example, in gas service blower used to remove gasses from a coke oven is known as an exhauster.

Fans, Blowers, and Turbo-Compressors

Turbo-compressors:

Usually used when a compressed gas is required, the exhaust pressure is not less than 2 kp/cm^2. Centrifugal compressors, Figure 7.2, are used when high pressure is used and relatively low volumetric flow is required.



Three-stages turbo-compressor

Fans, Blowers, and Turbo-Compressors

Turbo-compressors:

Head and Power:

$$\eta_{poly} = \frac{W.D_{poly}}{W.D_{real}}$$

$$\eta_{poly} = \frac{(k-1)/k}{(n-1)/n}$$

The polytropic head: $$H_{poly} = \frac{R.T_1}{m}\left[\left(\frac{P_2}{P_1}\right)^{m} - 1\right]$$

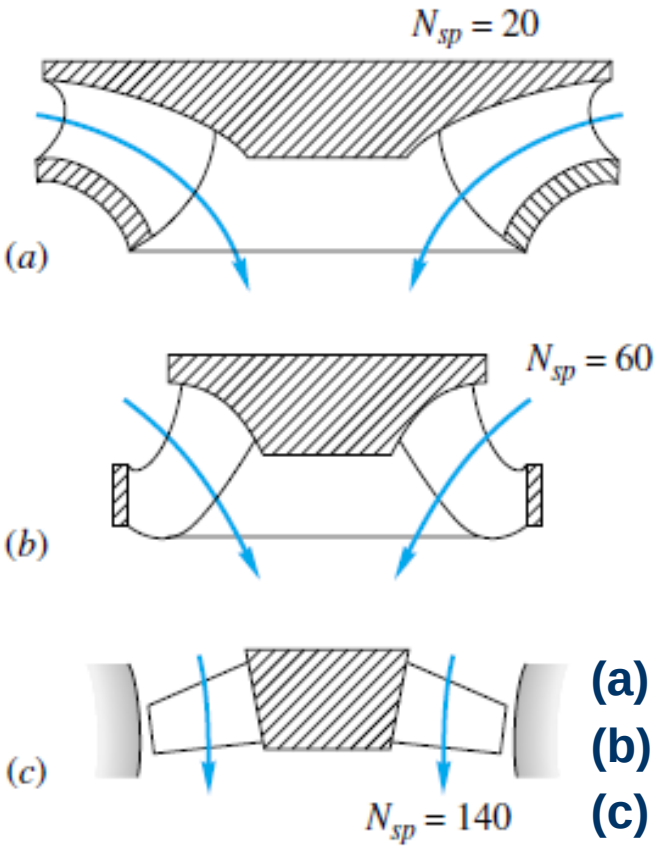
where $$m = \frac{k-1}{k\,\eta_p} \qquad (k = 1.4 \text{ for air})$$

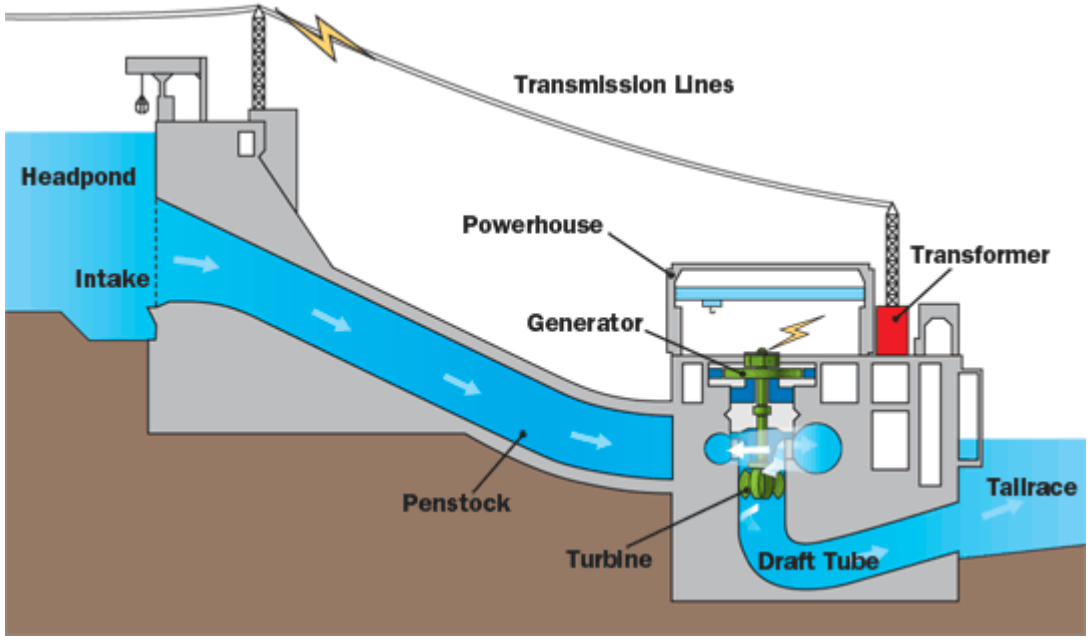
Power $$P = \frac{\gamma Q H}{Const.\eta_{pol}}$$ which usually called the gas h.p.

η_{pol} : the polytropic efficiency, sometimes called the hydraulic efficiency.

Hydraulic Turbines

Reaction Turbines:

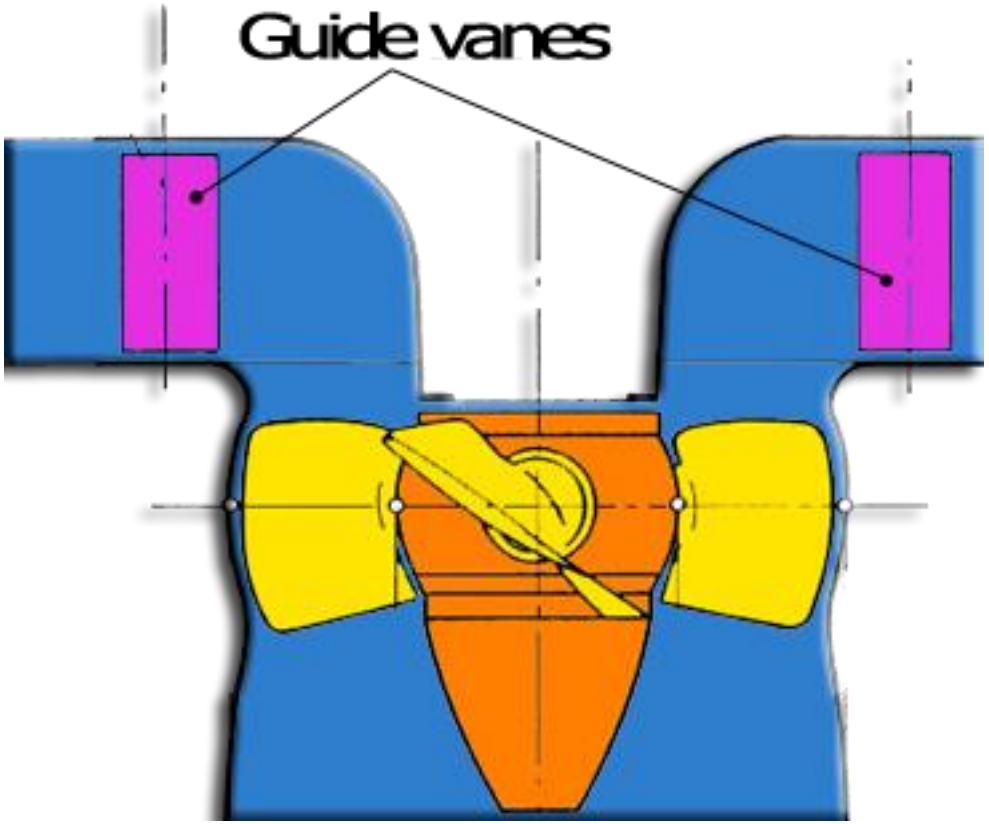


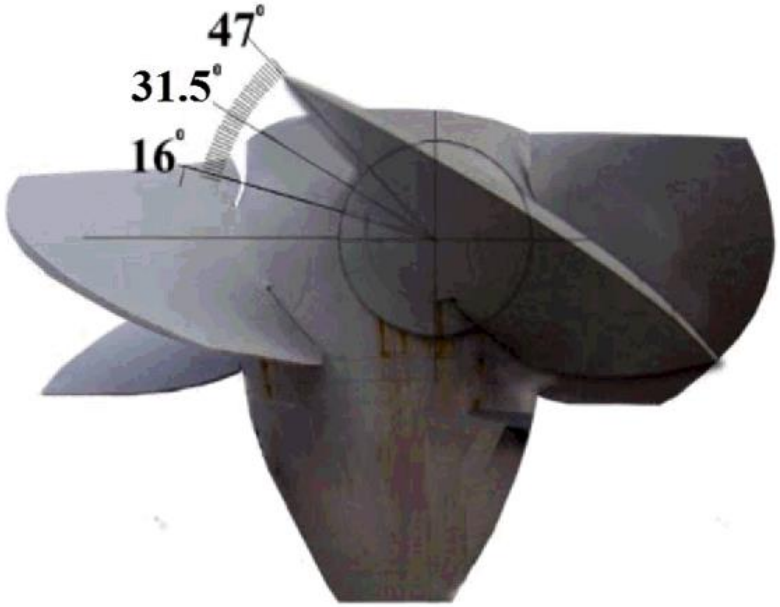


(a) Francis, radial type;
(b) Francis mixed-flow;
(c) propeller axial-flow.

Hydraulic Turbines

Reaction Turbines:





Hydraulic Turbines

Reaction Turbines:

1. ***Radial***: (Francis), low specific speed, usually used for medium and high head installations.
2. ***Mixed***: (Francis), medium specific speed, usually used for medium head installations.
3. ***Axial***: high specific speed, usually used for low head installations (Aswan Dam).

Hydraulic Turbines

Axial Flow Reaction Turbines

Propeller Turbine. Axial Turbine

The blades are fixed on the rotor and the number of the blades is from 3 to 8. In the simplest form of axial flow propeller turbine, the blades are cast integrally with the hub. The propeller turbine is used in the measurement of the flow, especially in petroleum industry to measure the flow rate.

Kaplan Turbine

Although the propeller turbine is almost adequate for high flow and low head operation, it has one quite serious disadvantage is its part load efficiency is unsatisfactory. In Kaplan turbine, this problem is overcome by using movable blades, so that their angles of inclination may be adjusted while the turbine is in motion in such a way that the turbine can operate continuously at its maximum efficiency.

Hydraulic Turbines

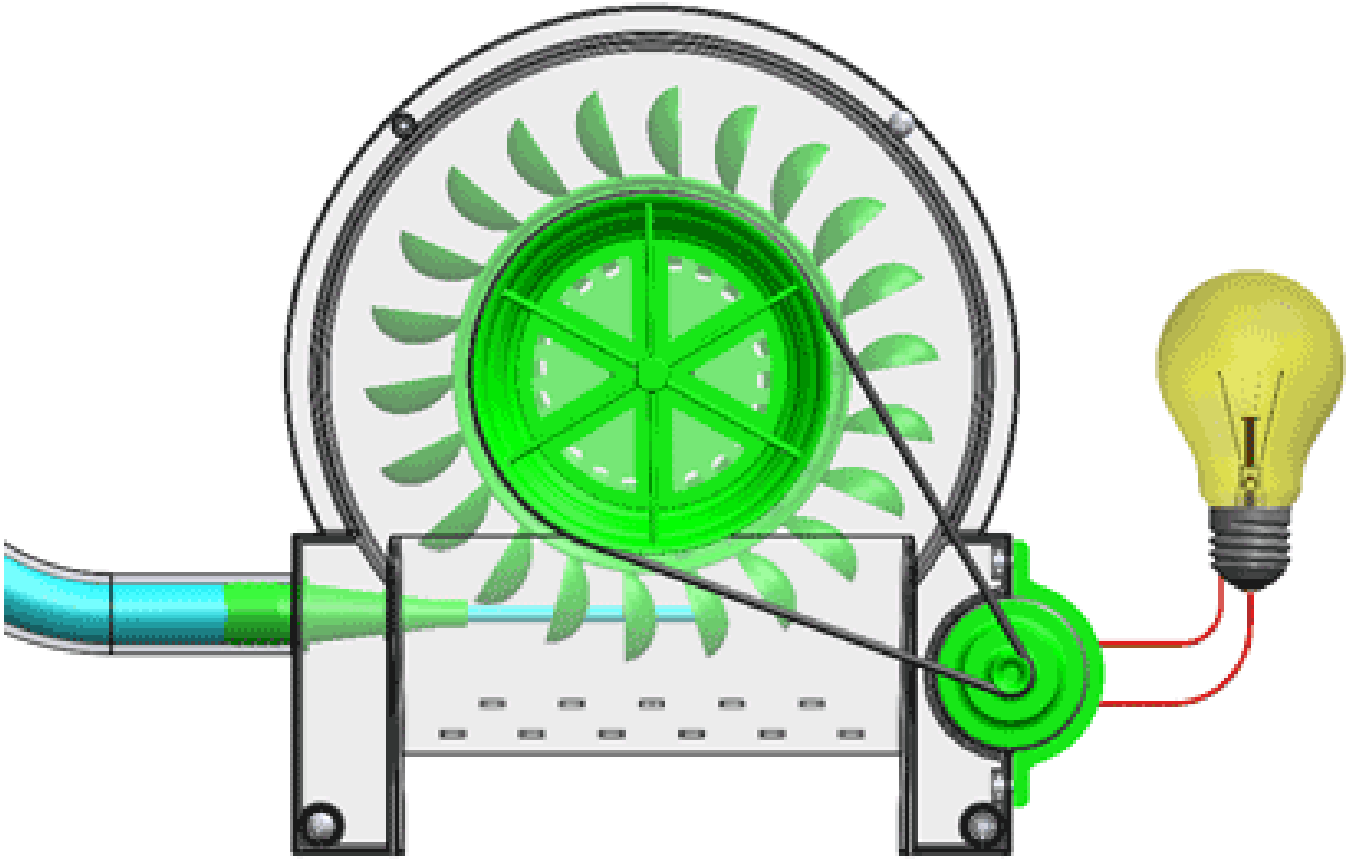
Impulse Turbines (Pelton Wheel)

By definition, the *impulse turbine* is a machine in which the total drop in pressure of the fluid takes place in one or more stationary nozzles and there is no change in the pressure of fluid as it flows through the rotating wheel.

Many designs has existed but only one has been currently used named by man who designed it first in California at 1810 Mr. A. Pelton. Usually, Pelton Wheel is used for high head about more than 300 m.

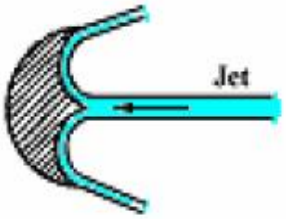
Hydraulic Turbines

Impulse Turbines (Pelton Wheel)

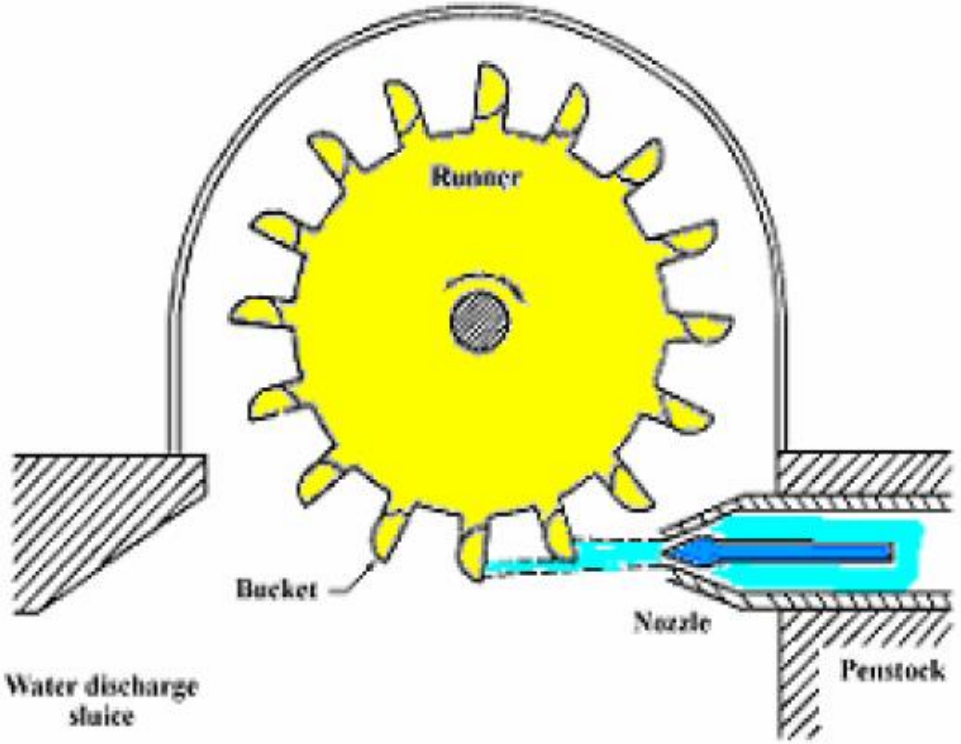


Hydraulic Turbines

View of bucket



Water flow passing bucket section

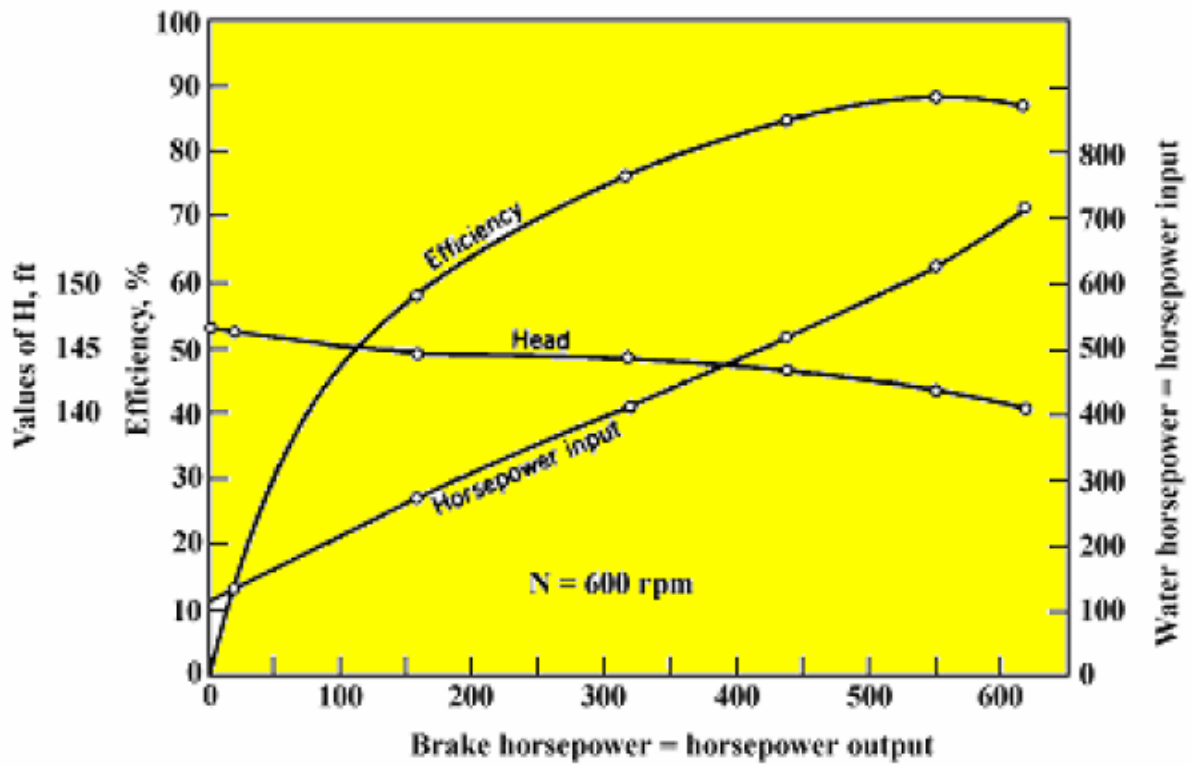


Water discharge sluice

Hydraulic Turbines

Reaction Turbines:

Francis Turbine Performance:




QUIZ

Quiz

Test results on a single stage single suction centrifugal mixed flow type pump operating at 375 rpm designed to deliver 2.4 m^3/min of water are given in curve form as follows:

Flow (m^3/min)	0	4	8	12	16	20	24	28	34
Head (m)	12	11.3	10.6	9.9	9.1	8.2	7.2	5.9	4.9
η (%)	0	23	45	62	75.5	84	88	85	81

a. Plot these curves and draw the BHP curve.

b. On the same sheet, draw the same three curves in dotted lines if the liquid pumped has a specific gravity of 0.9 but otherwise the same as water, give a brief discussion of your reason for each curve.