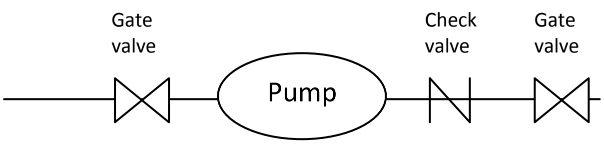
CHAPTER 7

PUMPING

- Transport of water from low sources to elevated tanks or from low sources to directly consumers is accomplished by the help of pumps.
- In the design of pumping stations stand-by units must be provided (therefore, water supply is not affected in case of breakdown or during repair.
- The number of units in operation will depend on the particular situation and operational conditions. For example, if Q_max_hourly need is 200,000 m^3/d, it is not logical to place a pump having capacity of 200,000 m^3/d. Q_min, Qave, Q_max_daily should be considered for pump selection. Thus, selection of pumps having different flowrates is logical.
- The pump house should be as close to the intake point as possible so that the length of suction pipe is short.
- In pumping works, various types of fittings like gate valves, check valves, water meters, and electrical control equipment are used.



This configuration must be installed if the pump is below the level of water.

PUMPS USED IN PUBLIC WATER SUPPLY SYSTEMS

There are usually two type of pumps are used in public water supply systems. There are

- Reciprocating pumps
- Centrifugal pumps

<u>Reciprocating pumps [1]:</u>

This pump consists of a mechanical device that moves a plunger back and forth in a closely fitted cylinder. The plunger is driven by the power source, and the power motion is converted from a rotating action to a reciprocating motion by the combined work of a speed reducer, crank, and a connecting rod. The cylinder, composed of a cylinder wall, plunger, and check valve, should be located near or below the static water level to eliminate the need for priming. The pumping action begins when the water enters the cylinder through a check valve. When the piston moves, the check valve closes, and in so doing forces the water through a check valve in the plunger. With each subsequent stroke, the water is forced toward the surface through the discharge pipe.

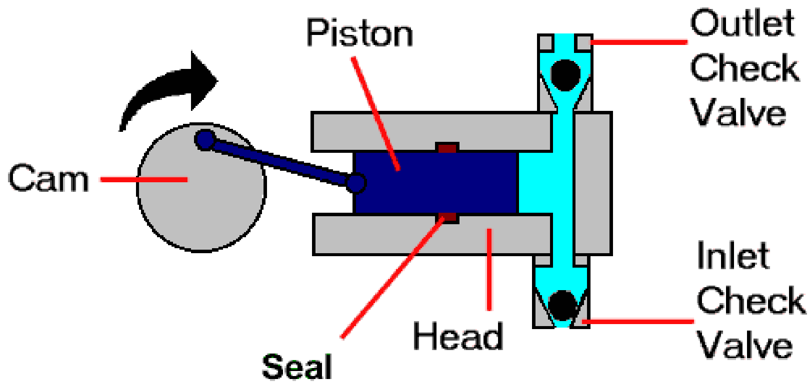


Figure 1: Sketch of a reciprocating pump [2].

<u>Centrifugal pumps [1]:</u>

Centrifugal pumps are pumps containing a rotating impeller mounted on a shaft turned by the power source. The rotating impeller increases the velocity of the water and discharges it into a surrounding casing shaped to slow down the flow of water and convert the velocity to pressure. This decrease of the flow further increases the pressure.

Each impeller and matching casing is called a stage. The number of stages necessary for a particular installation will be determined by the pressure needed for the operation of the water system, and the height the water must be raised from the surface of the water source.

When the pressure is more than can be practicably or economically furnished by a single stage, additional stages are used. A pump with more than one stage is called a multistage pump. In a multistage pump, water passes through each stage in succession, with an increase in pressure at each stage. Multistage pumps commonly used in individual water systems are of the turbine and submersible types.

The vertical-drive turbine pump consists of one or more stages with the pumping unit located below the drawdown level of the water source. A vertical shaft connects the pumping assembly to a drive mechanism located above the pumping assembly. The discharge casing, pump housing, and inlet screen are suspended from the pump base at the ground surface. The weight of the rotating portion of the pump is usually suspended by a thrust bearing located in the pump head. The intermediate pump bearings may be lubricated by either oil or water. From a sanitary point of view, lubrication of pump bearings by water is always preferable, since lubricating oil may leak and contaminate the water.

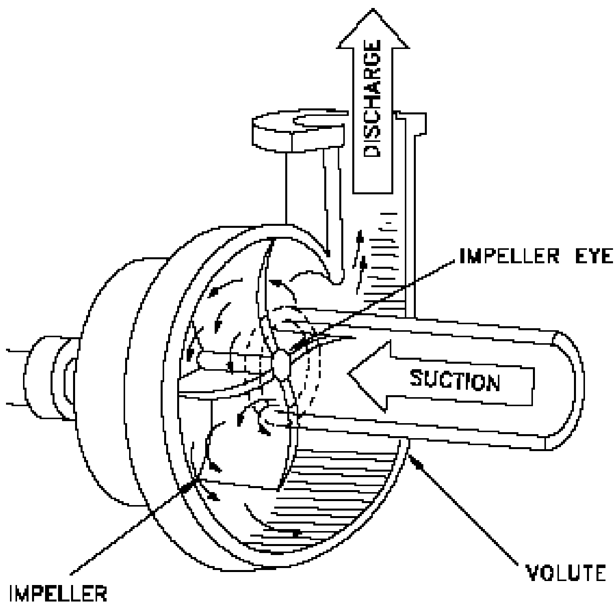


Figure 2: Sketch of a centrifugal pump [3].

Submersible pumps [1]:

They are a special type of centrifugal pumps. When a centrifugal pump is driven by a closely coupled electric motor constructed for submerged operation as a single unit, it is called a submersible pump. The electrical wiring to the submersible motor must be waterproof. The electrical control should be properly grounded to minimize the possibility of shorting and thus damaging the entire unit. The pump and motor assembly are supported by the discharge pipe; therefore, the pipe should be of such size that there is no possibility of breakage.

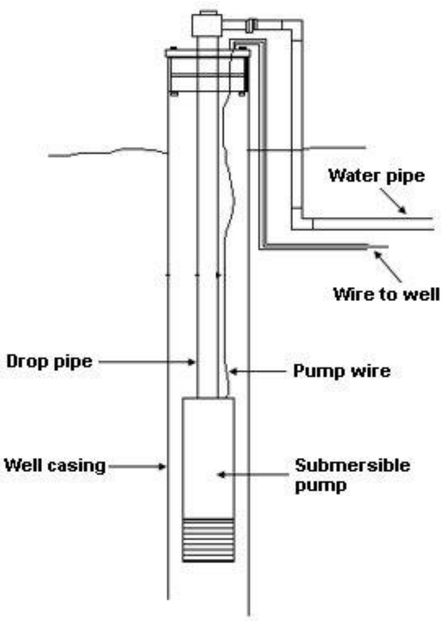


Figure 3: Sketch of a centrifugal pump [4].

PUMP SELECTION [1]

The type of pump selected for a particular installation should be determined on the basis of the following fundamental considerations.

1. Yield of the well or water source.

2. Daily needs and instantaneous demand of the users.

3. The “usable water” in the pressure or storage tank.

4. Size and alignment of the well casing.

5. Total operating head pressure of the pump at normal delivery rates, including lift and all friction losses.

6. Difference in elevation between ground level and water level in the well during pumping.

7. Availability of power.

8. Ease of maintenance and availability of replacement parts.

9. First cost and economy of operation.

10. Reliability of pumping equipment.

System Curve and Pump Performance Curve

To select a proper pump for a particular application it is necessary to utilize the system curve and the pump performance curve [5].

<u>The System Curve</u>

A fluid flow system can in general be characterized with the System Curve

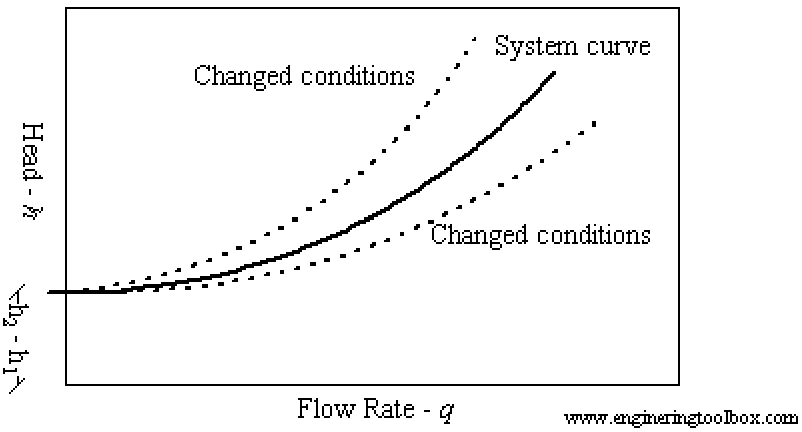


Figure 4: System curve [5].

The system head visualized in the System Curve is a function of the elevation - the static head in the system, and the major and minor losses and can be expressed as:

h = dh + hl   (1)

where

h = system head

dh = h2 - h1 = elevation (static) head - difference between inlet and outlet of the system

hl = head loss

A generic expression of head loss is:

hl = k q2   (2)

where

q = flow rate

k = constant describing the total system characteristics - including all major and minor losses

Increasing the constant - k - by closing some valves, reducing the pipe size or similar - will increase the head loss and move the system curve upwards. The starting point for the curve - at no flow, will be the same [5].

Pump Performance Curve

The pump characteristic is normally described graphically by the manufacturer as a pump performance curve. The pump curve describes the relation between flowrate and head for the actual pump. Other important information for proper pump selection is also included - efficiency curves, NPSH curve, pump curves for several impeller diameters and different speeds, and power consumption [5].

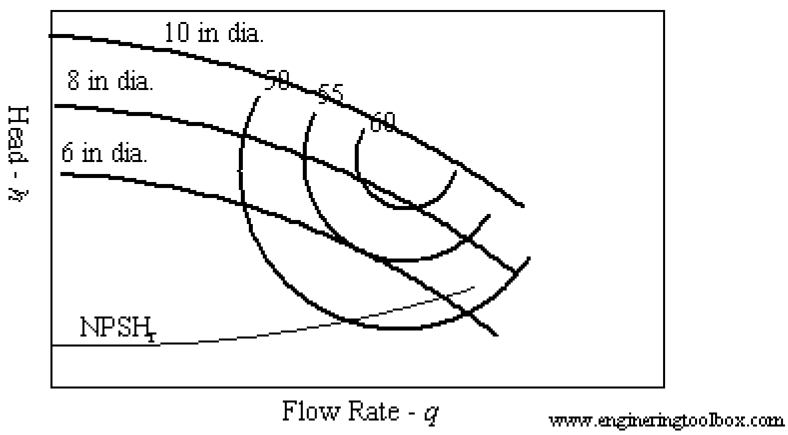


Figure 5: Pump curve [5].

Increasing the impeller diameter or speed increases the head and flow rate capacity - and the pump curve moves upwards.

The head capacity can be increased by connecting two or more *pumps in series*, or the flow rate capacity can be increased by connecting two or more *pumps in parallel*.

Selection of Pump

A pump can be selected by combining the System Curve and the Pump Curve:

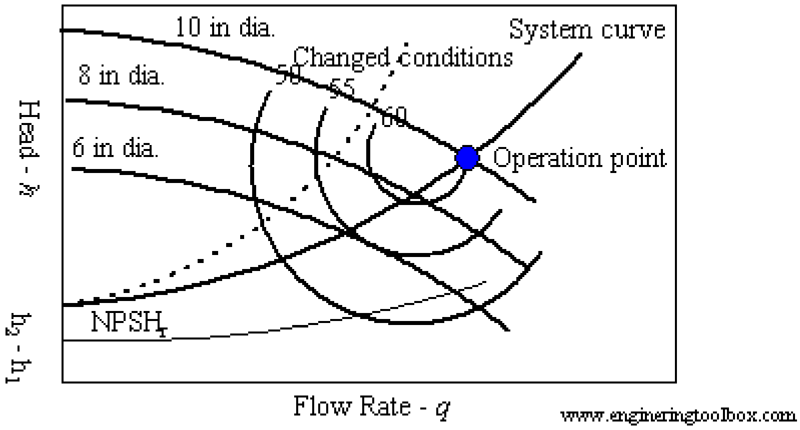


Figure 6: Pump selection curve [5].

The operating point is where the system curve and the actual pump curve intersect [5].

Best Efficiency Point - BEP

The best operating conditions will in general be close to the best efficiency point - BEP [5].

Pumps in Parallel or Series

Pumps can be arranged in serial or parallel to provide additional head or flow rate capacity [5].

Pumps in Serial - Heads Added

When two (or more) pumps are arranged in serial, their resulting pump performance curve is obtained by adding their heads at same flow rate as indicated in the figure below.

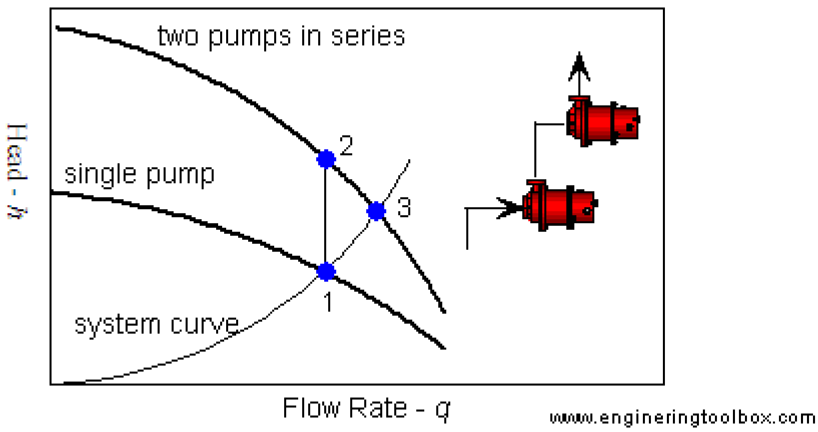


Figure 7: Pumps in series [5].

Centrifugal pump in series are used to overcome larger system head loss than one pump can handle alone. For two identical pumps in series the head will be twice the head of a single pump at the same flow rate. With constant flowrate the combined head moves from 1 to 2. In practice the combined head and flow rated moved along the system curve to 3.

If one of the pumps stops, the operation point moves along the system resistance curve from point 1 to point 2 - head and flow rate are decreased.

Series operation of single stage pumps is seldom encountered - more often multistage centrifugal pumps are used.

<u>Pumps in Parallel - Flow Rate Added</u>

When two or more pumps are arranged in parallel their resulting performance curve is obtained by adding their flowrates at the same head as indicated in the figure below.

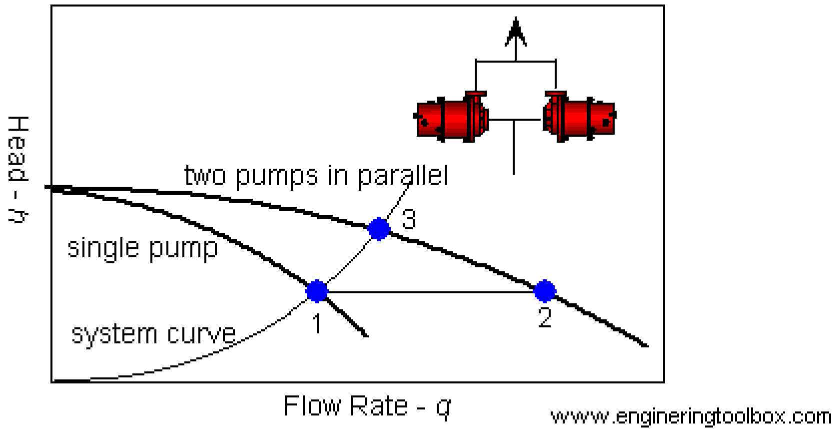


Figure 8: Pumps in parallel [5].

Centrifugal pumps in parallel are used to overcome larger volume flows than one pump can handle alone. For two identical pumps in parallel the flowrate will double (moving from 1 to 2) compared to a single pump if head is kept constant. In practice the combined head and volume flow moves along the system curve as indicated from 1 to 3.

If one of the pumps in parallel or series stops, the operation point moves along the system resistance curve from point 3 to point 1 - the head and flow rate are decreased.

Net Positive Suction Head (NPSH):

It represents the pressure drop between the eye of the pump and the tip of the impeller vanes. With the value of NPSH given, the maximum pump elevation above the water supply reservoir can be easily determined [6].

Cavitation of Water Pumps:

Whenever a pump is positioned above the water supply reservoir, the water in the suction line is under pressure lower than atmospheric. The phenomenon of cavitation becomes a potential danger whenever the water pressure at any location in the pumping system drops substantially below atmospheric pressure. The value of Hs (suction head) must be kept within a limit so that the pressure at every location in the pump is always above the vapor pressure of water, otherwise the water will be vaporized and cavitation will occur. The vaporized water forms small vapor bubbles in the flow. These bubbles collapse when they reach the region of higher pressure in the pump. Violent vibrations may result from the collapse of vapor bubbles in water. Successive bubble breakup with considerable impact force may cause high local stresses on the metal surface of the vane blades and the housing. These stresses cause surface pitting and will rapidly damage the pump.

To prevent cavitation, the pump should be installed at an elevation so that the total suction head is less than the difference between the atmospheric head and the vapor pressure head [6].

References:

[1] Standard Handbook of Environmental Engineering, Corbitt R.A., 2nd edition, McGraw-Hill

[2] http://www.ustudy.in/node/538

[3] http://netpumps.com/centrifugal.html

[4] http://www.cleanwaterstore.com/shock-chlorinate-sanitize-wells.html

[5] http://www.engineeringtoolbox.com/pump-system-curves-d_635.html

[6] Fundamentals of Hydraulic Engineering Systems, Hwang N.H.C., Houghtalen R.J., Third Edition, Prentice Hall, New Jersey.