5.6 The advantages and disadvantages of the centrifugal pump

The main advantages are:

(1) It is simple in construction and can, therefore, be made in a wide range of materials.
(2) There is a complete absence of valves.
(3) It operates at high speed (up to 100 Hz) and, therefore, can be coupled directly to an electric motor. In general, the higher the speed the smaller the pump and motor for a given duty.
(4) It gives a steady delivery.
(5) Maintenance costs are lower than for any other type of pump.
(6) No damage is done to the pump if the delivery line becomes blocked, provided it is not ran in this condition for a prolonged period.
(7) It is much smaller than other pumps of equal capacity. It can, therefore, be made into a sealed unit with the driving motor, and immersed in the suction tank.
(8) Liquids containing high proportions of suspended solids are readily handled.

The main disadvantages are:

(1) The single-stage pump will not develop a high pressure. Multistage pumps will develop greater heads but they are very much more expensive and cannot readily be made in corrosion-resistant material because of their greater complexity. It is generally better to use very high speeds in order to reduce the number of stages required.
(2) It operates at a high efficiency over only a limited range of conditions: this applies especially to turbine pumps.
(3) It is not usually self-priming.
(4) If a non-return valve is not incorporated in the delivery or suction line, the liquid will run back into the suction tank as soon as the pump stops.
(5) Very viscous liquids cannot be handled efficiently.

5.7 Priming The Pump

The theoretical head developed by a centrifugal pump depends on *the impeller speed*, *the radius of the impeller*, and *the velocity of the fluid leaving the impeller*. If these factors are constant, the developed head is the same for fluids of all densities and is the same for liquids and gases. A centrifugal pump trying to operate on air, then can neither draw liquid upward from an initially empty suction line nor force liquid a full discharge line. Air can be displaced by priming the pump.

For example, if a pump develops a head of 100 ft and is full of water, the increase in pressure is [100 ft (62.3lb/ft^3) (ft^2 / 144 in^2)] = 43 psi (2.9 atm). If full of air the pressure increase is about 0.05 psi (0.0035 atm).

5.8 **Operating Characteristics**

The operating characteristics of a pump are conveniently shown by plotting the head (h), power (P), efficiency (η), and sometimes required NPSH against the flow (or capacity) (Q) as shown in Figure (5). Theses are known as characteristic curves of the pump. It is important to note that the efficiency reaches a maximum and then falls, whilst the head at first falls slowly with Q but eventually falls off rapidly. The optimum conditions for operation are shown as the duty point, i.e. the point where the head curve cuts the ordinate through the point of maximum efficiency.

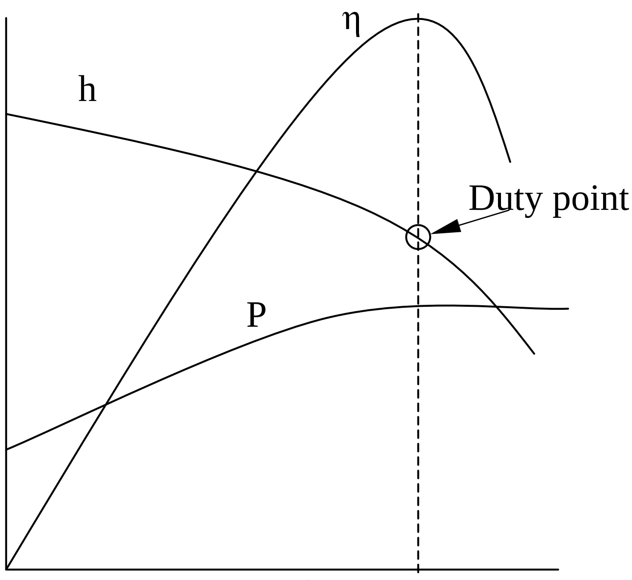

Figure (5) Radial flow pump characteristics

Characteristic curves have a variety of shapes depending on *the geometry of the impeller* and *pump casing*. Pump manufactures normally supply the curves only for operation with water.

In a particular system, a centrifugal pump can only operate at one point on the Δh against Q curve and that is the point where the Δh against Q curve of the pump intersect with the Δh against Q curve of the system as shown in Figure.

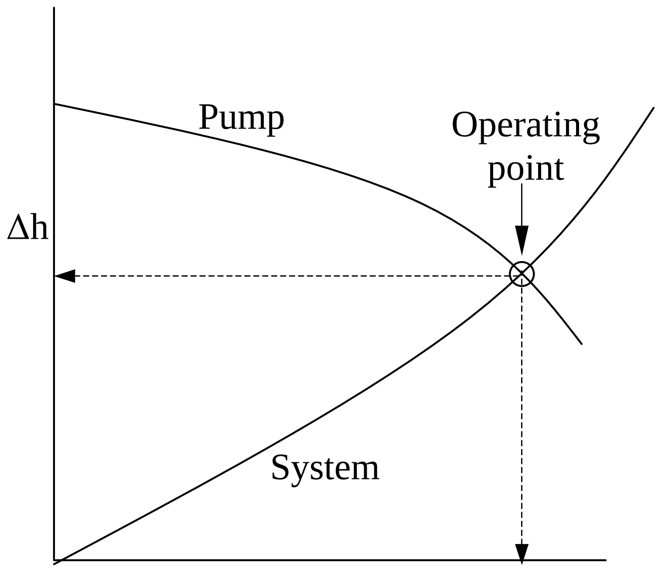

Figure (6) System and pump total head against capacity

The system total head at a particular liquid flow rate

$$\Delta h = (z_d - z_s) + \left(\frac{P_d - P_s}{\rho\, g}\right) + [(h_F)_d + (h_F)_s]$$

where,

$$(h_F)_d = 4 f_d \left[\frac{L}{d} \sum \frac{Le}{d}\right]_d \frac{u_d^2}{2g}$$

$$(h_F)_s = 4 f_s \left[\frac{L}{d} \sum \frac{Le}{d}\right]_s \frac{u_s^2}{2g}$$

For the same pipe <u>type</u> and <u>diameter</u> for suction and discharge lines: -

$$\Delta h = \Delta z + \frac{\Delta P}{\rho\, g} + 4 f \left[\left(\frac{L}{d} + \sum \frac{Le}{d}\right)_d + \left(\frac{L}{d} + \sum \frac{Le}{d}\right)_s\right] \frac{u^2}{2g}$$

but $u = \dfrac{Q}{(\pi / 4\, d^2)}$

$$\Rightarrow \Delta h = \Delta z + \frac{\Delta P}{\rho\, g} + \frac{4 f}{2g} \left[\left(\frac{L}{d} + \sum \frac{Le}{d}\right)_d + \left(\frac{L}{d} + \sum \frac{Le}{d}\right)_s\right] \left(\frac{Q}{(\pi / 4\, d^2)}\right)^2$$