# 6th Chapter - Flow through pipe

**Pipe:** A pipe is a closed conduit, generally a circular cross-section used to carry water or any other fluid.

## Loss of Energy in pipes:

When a fluid is flowing through a pipe, the fluid experiences some resistance due to which some of the energy of fluid is lost. This loss of energy in classified as:

Energy Losses

1. Major Energy Losses
   - This is due to friction and it is calculated by the following formulae:
     - (a) Darcy-Weisbach formula
     - (b) Chezy's formula

2. Minor energy losses
   - This is due to
     - (a) Sudden expansion of pipe
     - (b) Sudden contraction of pipe
     - (c) Bend in pipe
     - (d) pipe fittings etc.
     - (e) An obstruction in pipe.

(69) Loss of Energy (OR HEAD) Due to friction:

(a) Darcy-Weisbach formula: The loss of head (or energy) in pipes due to friction is calculated from Darcy-Weisbach equation which has been derived and given by

$$h_f = \frac{4 \cdot f \cdot L \cdot V^2}{d \times 2g} \quad \text{---(1)}$$

where $h_f$ = loss of head due to friction.

$f$ = coefficient of friction which is a function of Reynolds number.

$= \frac{16}{Re}$ for $Re < 2000$ (viscous flow)

$= \frac{0.079}{Re^{1/4}}$ for $Re$ varying from 4000 to $10^8$.

$L$ = length of pipe,

$V$ = mean velocity of flow,

$d$ = diameter of pipe.

(b) Chezy's formula for loss of head due to friction in pipes:

The formula is already derived and given by;

$$h_f = \frac{f'}{8g} \times \frac{P}{A} \times L \times V^2 \quad \text{---(2)}$$

where $h_f$ = loss of head due to friction.

$A$ = Area of crossection of pipe.

$V$ = mean velocity of flow

$P$ = wetted perimeter of pipe

$L$ = length of pipe.

(20) ↳ Now the ratio of $\frac{A}{P}\left(=\frac{\text{Area of flow}}{\text{Perimeter(wetted)}}\right)$ is called hydraulic mean depth or hydraulic radius and is denoted by m.

∴ Hydraulic mean depth, $m=\frac{A}{P}=\frac{\frac{\pi}{4}d^2}{\pi d}=\frac{d}{4}$.

Substituting, $\frac{A}{P}=m$ or $\frac{P}{A}=\frac{1}{m}$. in eqⁿ (2), we get;

$$h_f=\frac{f'}{\rho g}\times L\times v^2\times\frac{1}{m}.$$

$$\Rightarrow v^2=h_f\times\frac{\rho g}{f'}\times m\times\frac{1}{L}=\frac{\rho g}{f'}\times m\times\frac{h_f}{L}$$

$$\Rightarrow V=\sqrt{\frac{\rho g}{f'}\times m\times\frac{h_f}{L}}=\sqrt{\frac{\rho g}{f'}}\sqrt{m\cdot\frac{h_f}{L}}. \quad \text{——(3)}.$$

↳ Let $\sqrt{\frac{\rho g}{f'}}=C$, where C is a constant known as Chezy's constant and $\frac{h_f}{L}=i$, where i is loss of head per unit length of pipe.

↳ Substituting the values of $\sqrt{\frac{\rho g}{f'}}$ and $\sqrt{\frac{h_f}{L}}$ is equation (3), we get

$$V=C\sqrt{mi} \quad \text{——(4)}.$$

↳ Equation (4) is known as Chezy's formula. Thus the loss of head due to friction in pipe from Chezy's formula can be obtained if the velocity of flow through pipe and also value to C is known and $m=d/4$.

(71) Hydraulic gradient line: It is defined as the line which gives the sum of pressure head $P/w$ & datum head ($z$) if a flowing fluid in a pipe with respect to the reference line or it is the line which is obtained by joining of the top of all vertical ordinates showing pressure head ($P/w$) of a flowing fluid in a pipe from the centre of the pipe. It is briefly written as H.G.L.

Total Energy line: It is defined as the line which gives the sum of pressure head, datum head and kinetic head of a flowing fluid in a pipe with respect to some reference line or it is the line which is obtained by joining the tops of all vertical ordinates showing the sum of pressure head and kinetic head from the centre of the pipe. It is also written as T.E.L.