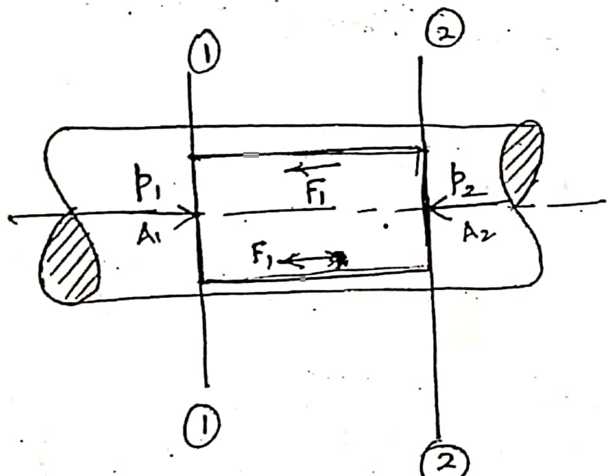
from centre of the pipe. → See pg. No. 32

## Darcy-Weisbach equation:




Uniform horizontal pipe

At ①

$p_1$ - pressure intensity
$V_1$ - velocity

At ②

$p_2$ - presure intensity
$V_2$ - velocity
$f''$ - frictional resistance per unit area per unit velocity
$h_f$ - loss of head due to friction

Applying Bernoulli's equation:

$$\frac{p_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{p_2}{\rho g} + \frac{V_2^2}{2g} + z_2 + h_f$$

As, it is horizontal pipe, $z_1 = z_2$ and assuming $V_1 = V_2$ as dia. of pipe at 1-1 and 2-2.

$$\frac{p_1}{\rho g} = \frac{p_2}{\rho g} + h_f$$

$$h_f = \frac{p_1}{\rho g} - \frac{p_2}{\rho g}$$ ($h_f$ - loss of head due to friction, so, reduction in pressure exists)

Frictional Force = $F_1 = f'' \times \pi d L \times V^2$

Forces acting:

1. pressure force at 1-1 = $p_1 A$
2. pressure force at 2-2 = $p_2 A$
3. frictional force = $F_1 = f'' \times \pi d L \times V^2$

Resolving all forces in the horizontal direction,

$$p_1 A - p_2 A - F_1 = 0$$

$$A(p_1 - p_2) = F_1$$

$$A(p_1 - p_2) = f'' \times \pi d L \times V^2$$

$$p_1 - p_2 = \frac{f'' \times \pi d L \times V^2}{A}$$

$$\rho g h_f = \frac{f'' \times \pi d L \times V^2}{\frac{\pi}{4} d^2}$$

$$h_f = \frac{f''}{\rho g} \times \frac{4}{d} \times L \times V^2$$

Now, let $\frac{f''}{\rho g} = \frac{f'}{2g}$, where $f'$ = co-efficient of friction

$$h_f = \frac{f'}{2g} \times \frac{4}{d} \times L \times V^2$$

$f'$ - co-efficient of friction

$$h_f = \frac{4 f' L V^2}{2gd}$$ → Darcy-Weisbach equation

$\frac{16}{Re}$ (Lam)

$\frac{0.079}{(Re)^{1/4}}$ (Turb)

$$h_f = \frac{f L V^2}{2gd}$$ ← f - friction factor $= \frac{64}{Re}$

~~$f' = 4f$~~ $f = 4f'$

friction factor = 4 times of coefficient of friction ($f = 4f'$)

$\frac{.316}{Re^{1/4}}$ turbulent $= \frac{64}{Re}$ for laminar

(18)

$$= \frac{4 \times 0.0048 \times 1000 \times (1.074)^2}{2 \times 9.81 \times 0.3}$$

$= 163.23\ m$

Power required $= \dfrac{\rho g Q h_f}{1000}$ kW

$S_0 = \dfrac{\rho_0}{\rho_w}$

$\rho_0 = S_0 \times \rho_w = 0.7 \times 1000 = 700$

$$P = \frac{700 \times 9.81 \times 500 \times 10^{-3} \times 163.23}{1000}$$

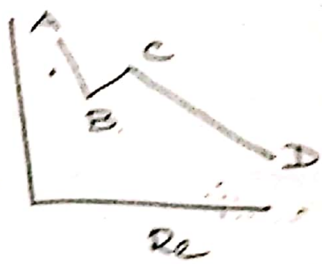
$= 560.45\ kW$

**Friction Factors (f)**

It is a dimensionless term. It depends upon following parameters

(i) Reynold's number

(ii) Relative roughness of pipe surface.




**For laminar flow**

$$f = \frac{64}{Re}$$

**For turbulent flow,**

$$f = \frac{0.316}{(Re)^{\frac{1}{4}}}$$

**Coefficient of Friction: (f')**

Function of Reynolds number.

$f = 4f'$

$$(f') = \frac{16}{Re}$$

$$f = \frac{0.079}{(Re)^{\frac{1}{4}}}$$

## Moody's Diagram:

Moody diagram developed by Prof. Lewis. F. Moody, shows the variation of friction factor f with the governing parameters, viz. the Reynolds number of flow and the relative roughness $\left(\frac{\varepsilon}{D}\right)$; where '$\varepsilon$' – absolute/average roughness and 'D' – diameter of pipe.

Used to determine friction factor for commercial pipes.

→ Please go to page.no. 17.

## Minor losses:

(head)