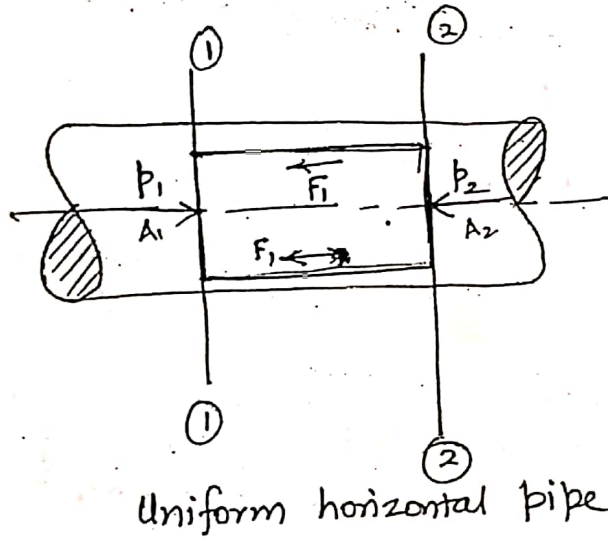


from centre of the pipe. → See pg. No. 32

Darcy-Weisbach equation:



At ①

p_1 - pressure intensity

v_1 - velocity

At ②

p_2 - pressure 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.

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

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

~~$F = f' \times A$~~ Force
 Frictional resistance = $F_1 = f'' \times \pi d L \times v^2$

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,

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

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

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

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

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

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

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

$$h_f = \frac{f'}{2g} \times \frac{4}{d} \times L \times v^2 \quad f' - \text{coefficient of friction}$$

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

Darcy-Weisbach equation $\frac{16 (L v^3)}{2g Re}$
 $\frac{0.079 (L v^3)}{(Re)^{1/4}}$

$$h_f = \frac{f L v^2}{2 g d}$$

f - friction factor = $\frac{64}{Re}$

~~$f' = 4f$~~

$$f = 4f'$$

friction factor = 4 times of coefficient of friction (18)

$\frac{64}{Re}$ for laminar

$$= \frac{4 \times 0.0048 \times 1500 \times (1.014)^2}{2 \times 9.81 \times 0.3}$$

$$= 163.22 \text{ m}$$

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

$$S_0 = \frac{C_0}{C_w}$$

$$C_0 = S_0 \times C_w = 0.7 \times 1000 = 700$$

$$P = \frac{700 \times 9.81 \times 500 \times 10^{-3} \times 163.22}{1000}$$

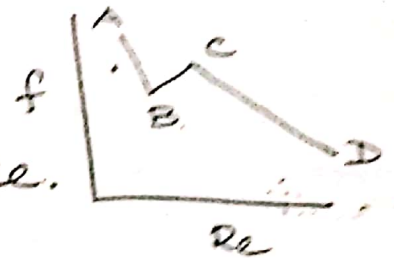
$$= 560.45 \text{ kW}$$

Team 2

Friction Factors (f)

It is a dimensional less 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.

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

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

$f = 4f'$

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 $(\frac{E}{D})$; where 'E' - 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) ...