SNS COLLEGE OF TECHNOLOGY
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(An Autonomous Institution)

DEPARTMENT OF MECHANICAL ENGINEERING

19 MEB 201 - Fluid Mechanics and Machinery
UNIT -2 Darcy–Weisbach equation **NOTES**

FRICTIONAL LOSS IN PIPE FLOW

When a liquid is flowing through a pipe, the velocity of the liquid layer adjacent to the pipe wall is zero.

The velocity of liquid goes on increasing from the wall and thus velocity gradient and hence shear stress are produced in the whole liquid due to viscosity. This viscous action causes loss of energy which is usually known as Frictional loss.

on the basis of his experiments, William Froude gave the following laws of fluid fraction for turbulent flow.

Frictional resistance for turbulent flow is

(i) Proportional to V^n, where n varies from 1.5 to 2.

(ii) Proportional to the density of fluid

(iii) Proportional to the area of surface in Contact.

(iv) Independent of Pressure

(v) Dependent on the nature of the surface in Contact.

Expression for Loss of Head Due to Friction in pipes:

Consider a uniform horizontal pipe, having steady flow as shown in fig

Let 1-1 and 2-2 are two sections of pipe.

Let P_1 = Pressure intensity at Section 1-1

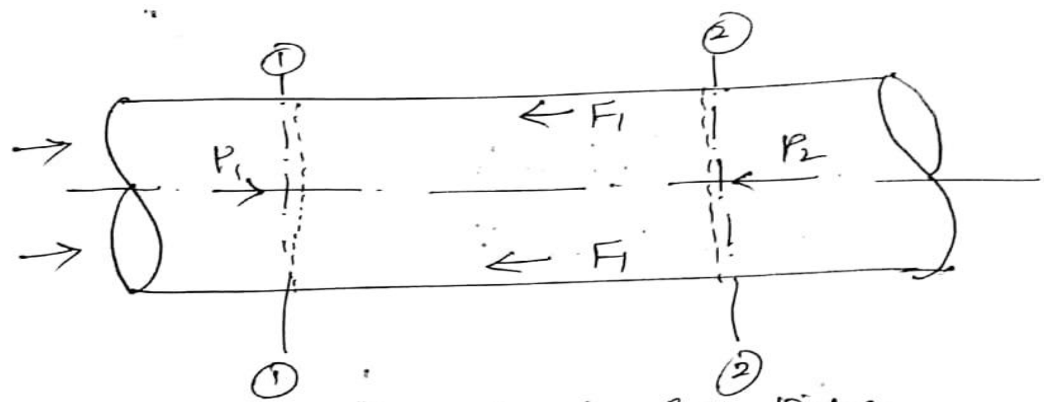
V_1 = Velocity of flow at Section 1-1.

L = Length of the pipe between Section 1-1 and 2-2 d - Diameter of pipe

f' - Frictional resistance per unit wetted area per unit velocity

h_f = Loss of head due to friction

and P_2, V_2 = are values of pressure intensity and velocity at section 2-2



Uniform Horizontal pipe

Applying Bernoulli's equations between section 1-1 and 2-2

Total head at 1-1 = Total head at 2-2 + Loss of head due to friction between 1-1 and 2-2

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + Z_2 + h_f$$

$Z_1 = Z_2$ as pipe is horizontal.

$V_1 = V_2$ as dia of pipe is same at 1-1 and 2-2

$$\frac{P_1}{\rho g} = \frac{P_2}{\rho g} + h_f \quad (\text{or}) \quad h_f = \frac{P_1}{\rho g} - \frac{P_2}{\rho g} \quad \text{—(1)}$$

But h_f is the head lost due to friction and hence intensity of Pressure will be reduced in the direction of flow by frictional resistance

Now Frictional resistance = Frictional resistance per unit wetted area per unit velocity × wetted area × Velocity^2.

$$F_1 = f' . P . L . V^2$$

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

(or)

$$F_1 = f' \times \pi d L \times V^2$$ [∵ wetted area = $\pi d L$, velocity = $V = V_1 = V_2$]

(2) — [∵ πd = Perimeter = P] —(2)

The force acting on the fluid between Sections 1-1 and 2-2 are

1. Pressure force at Section 1-1 = $P_1 \times A$
   where A = Area of pipe
2. Pressure force at Section 2-2 = $P_2 \times A$
3. Frictional force F_1 as shown in figure

Resolving all forces in the horizontal direction we have

$P_1 A - P_2 A - F_1 = 0$ ———— (A)

(or) $(P_1 - P_2)\, A = F_1$

$= f' \times P \times L \times V^2$ | from Eqn (2) $F_1 = f' P L V^2$

$P_1 - P_2 = \dfrac{f' \times P \times L \times V^2}{A}$ Perimeter ←

But from equation (1) $P_1 - P_2 = \rho g\, h_f$

∴ Equating the value of $(P_1 - P_2)$ we get

$$\rho g\, h_f = \frac{f' \times P \times L \times V^2}{A}$$

$$h_f = \frac{f'}{\rho g} \times \frac{P}{A} \times L \times V^2 \text{ —— (3)}$$

In equation (3) $\dfrac{P}{A} = \dfrac{\text{Wetted Perimeter}}{\text{Area}}$

$$= \frac{\pi d}{\frac{\pi}{4} d^2} = \frac{4}{d}$$

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

Frictional resistance $= \dfrac{f'}{\rho g} \times \dfrac{4 L V^2}{d}$ —— (4)

Putting $\dfrac{f'}{\rho} = \dfrac{f}{2}$ where f is known as <u>co-efficient of friction</u>.

Equation (4) becomes as $h_f = \dfrac{4 \cdot f}{2g} \dfrac{L V^2}{d}$

$$h_f = \frac{4f \cdot L \cdot V^2}{d \times 2g} \quad \text{——— (5)}$$

Equation (5) is known as Darcy-weisbach equation. This equation is commonly used for finding loss of head due to friction in pipes.

Sometimes Empirically equation (5) is written as

$$h_f = \frac{f \cdot L \cdot V^2}{d \times 2g} \quad \text{——— (5-1)}$$

Thus f is known as friction factor.