Flow Through Pipes الجريان خلال الانابيب

A pipe is a closed conduit, generally of circular cross section, used to carry water or any other fluid, when the pipe is running full the flow is under pressure. But if the pipe is not running full the flow is not under pressure.

Loss of Head in Pipes فواقد الشحنة في الانابيب

A. Major head loss الفواقد الكبرى

These losses which are due to friction are calculate by:

1. Darcy Formula

$$h_f = \frac{4\,f\,L\,V^2}{2\,D\,g}$$

h_f = Loss of head due to friction.

f = Coefficient of friction.

$f = \frac{0.0791}{Re^{0.25}}$ for $Re > 4000$ to 1000000

$f = \frac{16}{Re}$ for $Re < 2000$

Reynolds Number = $Re = \frac{VD}{\vartheta} = \frac{\rho\,V\,D}{\mu}$

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V = Velocity of flow

D = Diameter of the pipe

ϑ = Kinematic viscosity

L = Length of the pipe

2- Chezy Formula

$$V = c\sqrt{m\,i}$$

V = Mean velocity

C = Chezy constant

m = Hydraulic mean depth or hydraulic radius = $\frac{Area\ of\ flow}{Wetted\ perimeter} = \frac{A}{P}$

i = The loss of head per unit length of pipe = $\frac{h_f}{L}$

Example

In a pipe of diameter $350\ mm$ and length $75\ m$ water is flowing at a velocity of $2.8\ m/s$. Find the head lost due to friction, using:

1. **Darcy Formula**
2. **Chezy Formula**

Assuming kinematic viscosity of water $= 0.012 \times 10^{-4}\ m^2/s$, $c = 55$

1. $h_f = \frac{4\,f\,L\,V^2}{2\,D\,g}$

$$Re = \frac{V\,D}{\vartheta} = \frac{2.8 \times 0.35}{0.012 \times 10^{-4}} = 816700 > 4000$$

$$f = \frac{0.0791}{Re^{0.25}} = \frac{0.0791}{(816700)^{0.25}} = 0.00263$$

$$h_f = \frac{4 \times 0.00263 \times 75 \times (2.8)^2}{2 \times 0.35 \times 9.81} = 0.9\ m$$

. 2. $v = c\sqrt{mi}$

$$m = \frac{A}{P} = \frac{\frac{\pi}{4} D^2}{\pi D} = \frac{D}{4} = \frac{0.35}{4} = 0.0875\ m$$

$$2.8 = 55 \times\times \sqrt{0.0875 \times i} \qquad \rightarrow \qquad i = 0.0296$$

$$i = \frac{h_f}{L}$$

$$h_f = i \times L = 0.0296 \times 75 = 2.22\ m$$

Example

Water flows through a pipe of diameter 300 m with a velocity of 5 m/s. If the coefficient of friction is given by $f = 0.015 + \frac{0.08}{Re^{0.3}}$, find the head lost due to friction for a length of 10 m. Take $\vartheta = 0.01 \times 10^{-4}\ m^2/s$

$$h_f = \frac{4 f L V^2}{2 D g}$$

$$f = 0.015 + \frac{0.08}{Re^{0.3}}$$

$$Re = \frac{V D}{\vartheta} = \frac{5 \times 0.3}{0.01 \times 10^{-4}} = 1.5 \times 10^6$$

$$f = 0.015 + \frac{0.08}{(1.5 \times 10^6)^{0.3}} = 0.0161$$

$$h_f = \frac{4 \times 0.0161 \times 10 \times (5)^2}{2 \times 0.3 \times 9.81} = 2.735\ m$$

Example

A town having a population of 100000 is to be supplied with water from a reservoir 5 km distance and it is stipulated that one half of the daily supply of 150 litters per head should be delivered in 8 hrs. What must be the size of pipe to furnish the supply, if the head available is 12 m, Take $c = 45$ in Chezy formula.

Population $= 100000$

Pipe length $= l = 5\ km = 5000\ m$

Daily supply $= 150\ \ l/head = 0.15\ m^3/head$

Total supply $= 100000 \times 0.15\ \ = 15000\ m^3$

Sine half of this quantity is to be delivered in 8 hrs , therefore

maximum flow:

$$Q = \frac{150000}{2 \times 8 \times 60 \times 60} = 0.26\ m^3/s$$

$$V = c\sqrt{mi}$$

$$head = h_f = 12m \quad , \quad c = 45$$

$$i = \frac{h_f}{L} = \frac{12}{5000} = 0.0024$$

$$m = \frac{A}{P} = \frac{D}{4}$$

$$Q = A \times V = \frac{\pi}{4} \times d^2 \times c\sqrt{mi}$$

$$0.26 = \frac{\pi}{4} \times d^2 \times 45 \times \sqrt{\frac{d}{4} \times 0.0024}$$

$$0.068 = 0.749 \times d^5 \qquad \rightarrow \qquad d = 0.618\ m = 61.8\ cm$$

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