Flow of Fluid in Pipe

Flow of oil or gas in pipe can be either vertical(such as in tubing) or horizontal (such as in flow pipe on surface) or inclined .Flow of fluid(oil or gas) in pipe exhibited pressure loss .This pressure loss depend on many parameters such as type of flow(laminar or turbulent),fluid properties,pipe diameter,and flow rate.Calculation of pressure loss of fluid flow in pipe can be done by pressure gradient equation as follows:

Total pressure loss=pressure loss due to elevation+pressure loss due to friction+pressure loss due to acceleration

$$\left(\frac{dp}{dl}\right)t = \left(\frac{dp}{dl}\right)elevation + \left(\frac{dp}{dl}\right)friction + \left(\frac{dp}{dl}\right)acceleration$$

$$\left(\frac{dp}{dl}\right) t = \frac{g}{gc}\rho\sin\Theta + \frac{f\ \rho v^2}{2\ g\ c\ D} + \frac{\rho v\ dv}{gc\ D\ dl} \qquad \text{----------(1)}$$

Where $\left(\frac{dp}{dl}\right)elevation = \frac{g}{gc}\rho\sin\Theta$

$$\left(\frac{dp}{dl}\right)friction = \frac{f\rho v^2}{2gc\ D}$$

$$\left(\frac{dp}{dl}\right)acceleration = \frac{\rho v\ dv}{gc\ D\ dl}$$

Where P =pressure,lb/ft^2

L=pipe length,ft

G=Gravitional acceleration,Ft/sec^2

Gc=32.17 ft-lbm/lbf-sec^2

P=fluid density,lb/ft^3

Θ= angle from horizontal direction,deg

F=moody friction factor,from figure or equation

V=fluid velocity,ft/sec

D=pipe diameter,ft

** for horizontal incompressible(liquid)fluid flow in pipe of constant diameter:

$\left(\frac{dp}{dl}\right) elevation = \left(\frac{dp}{dl}\right) acceleration = o$ and equation (1) become

$\left(\frac{dp}{dl}\right) t = \frac{f\rho v^2}{2gc\ D}$ ----------(2) by integrating equation (2) we obtaind

$\Delta p = p1 - p2 = \frac{f\ \rho\ v^2\ \Delta l}{2\ gc\ D}$ ----------(3) Darcy-Wesibach equation

** Flow regiems can be determined by calculation Reynolds Number(NRe) as follows:

$NRe = \frac{1488\ \rho\ v\ D}{\mu}$

P=liquid density,lb/ft^3 ⋮ v=liquid velocity,ft/sec; D=pipe diameter,ft:μ= liquid viscosity,cp

If NRe<2100 flow is laminar and friction factor can be determined as follows:$f = \frac{64}{NRe}$

If NRe>2100 flow is turbulent and friction factor can be determined by Jain equation as follows:

$$\frac{1}{\sqrt{f}} = 1.14 - 2log\left(\frac{\varepsilon}{D} + \frac{21.25}{NRe^{0.9}}\right)$$

Where : D=inside diameter of pipe,in

Ɛ = pipe roughness , in

Example 1.1

An oil which has a viscosity of 50 cp (0.05 kg/m-sec) and a density of 50 lb_m/ft^3 (801.3 kg/m^3) flows in a 1 in. (25.4 mm) diameter pipe at the rate of 0.07 ft^3/sec (0.00198 m^3/sec). Determine the pressure drop which will occur over a 100 ft (30.48 m) section of the pipe.

Solution:

$$v = q/A = 0.07/[\pi/(4 \times 12^2)] = 12.84 \text{ ft/sec}$$

$$N_{Re} = \rho v d/\mu = (50)(12.84)(0.0833)/50/1488 = 1593$$

Flow is laminar, since $N_{Re} < 2000$

Therefore $f = 64/N_{Re} = 64/1593 = 0.04$

$$\Delta p = f \rho v^2 \Delta L/2g_c \, d = (0.04)(50)(12.84)^2(100)/(2)(32.2)(0.0833)$$

$$= 6171 \text{ lbf/ft}^2$$

$$= 42.85 \text{ psi } (295.45 \text{ k Pa})$$

Note : Moody friction can be determined from moody diagram as shown bleow :-

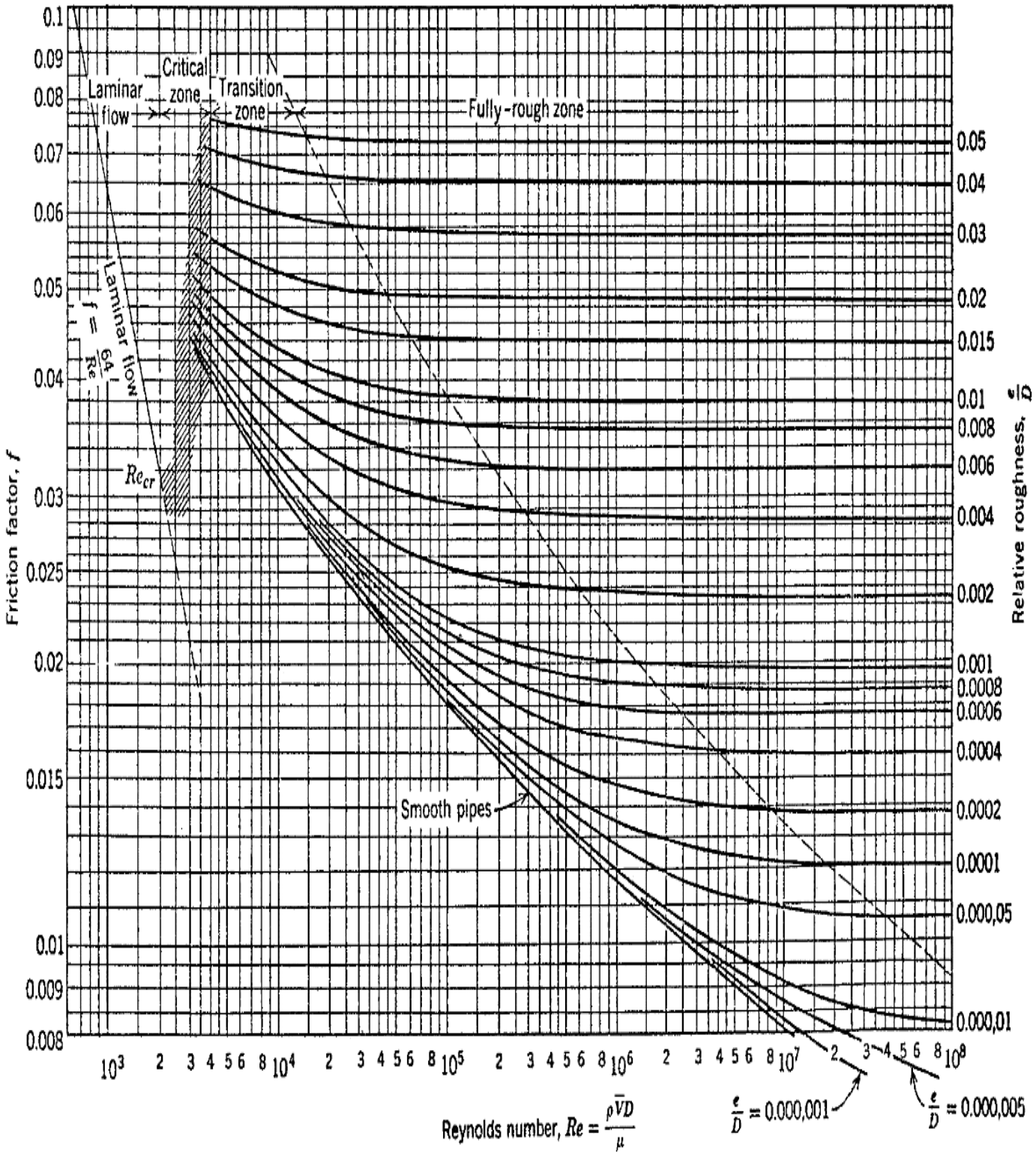

Fig. 1-4 Moody Diagram