Two Phase Flows

(Section 8)

Empirical Treatments of Two Phase Flow

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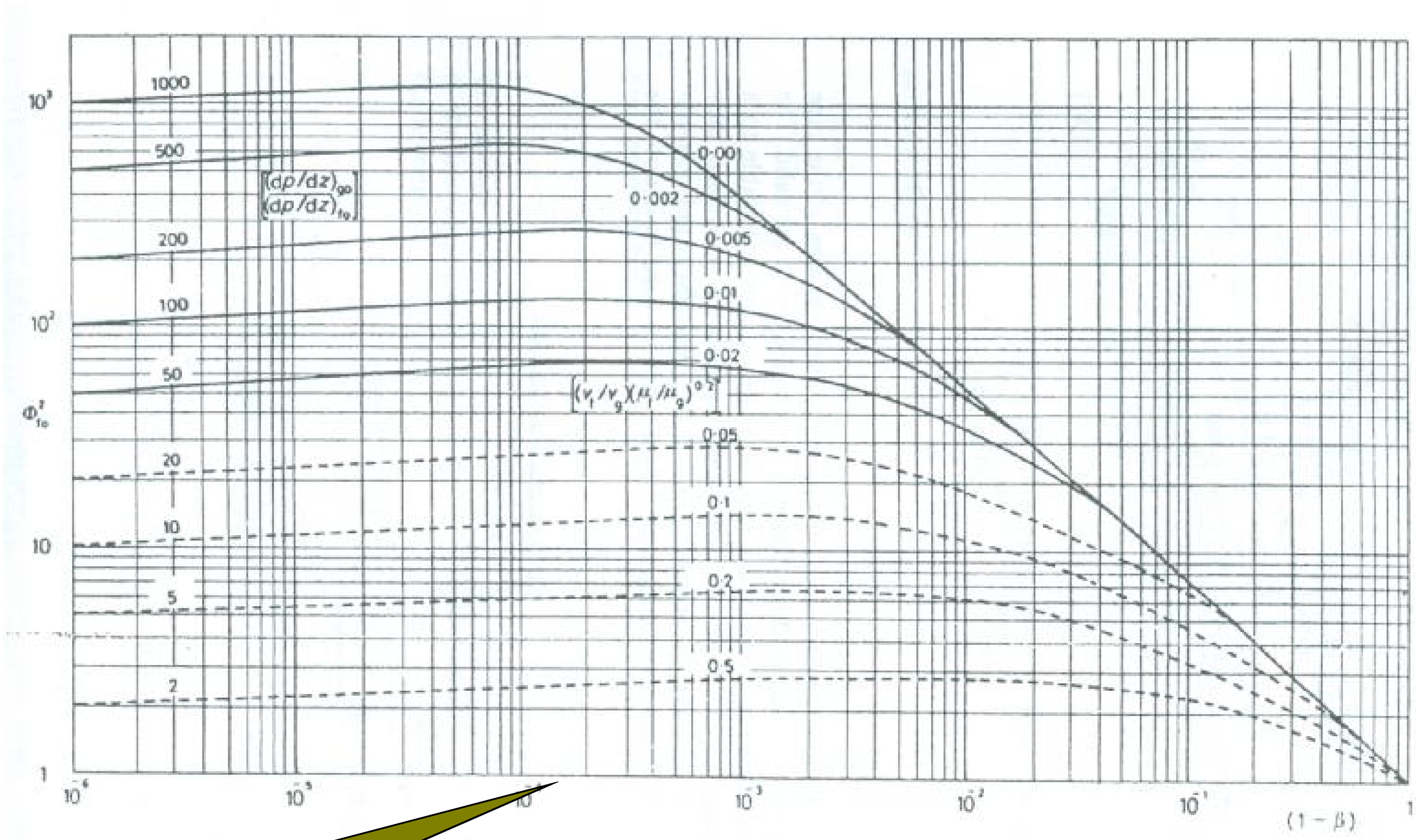
Assignment

Exercise set 3

Chapter 2, Collier and Thome:
Problems 1-6

Due to next Tuesday

Correlation for large bore pipes



Chenoweth and martin (1955)

Pressure loss through sudden Enlargement

Momentum Balance:

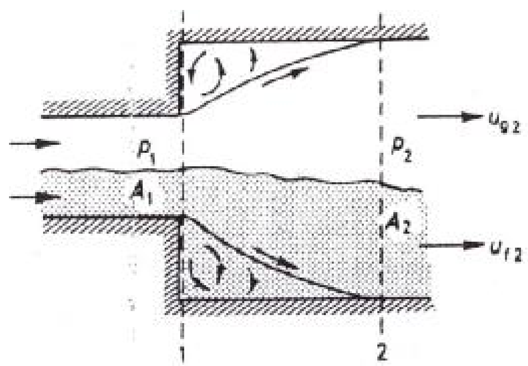
$$p_1A_1 - p_2A_2 = W_g\left(u_{g2} - u_{g1}\right) + W_f\left(u_{f2} - u_{f1}\right)$$

$$s = A_1 / A_2$$

$$p_2 - p_1 = G_1^2 s\, v_f \left[\left\{\frac{(1-x)^2}{1-a_1} + \left(\frac{v_g}{v_f}\right)\frac{x^2}{a_1}\right\} - s\left\{\frac{(1-x)^2}{1-a_2} + \left(\frac{v_g}{v_f}\right)\frac{x^2}{a_2}\right\}\right]$$

$$a_1 = a_2$$

Homogeneous Model Assumption



$$p_2 - p_1 = G_1^2 s\,(1-s)\, v_f \left[1 + \left(\frac{v_{fg}}{v_f}\right)x\right]$$

...

Energy Balance:

$$-(p_2-p_1)\left[W_g v_g+W_f v_f\right]=WdE+\frac{W_g}{2}\left(u_{g2}^2-u_{g2}^2\right)+\frac{W_f}{2}\left(u_{f2}^2-u_{f2}^2\right)$$

$$(p_2-p_1)=-\frac{dE}{\left[xv_g+(1-x)v_f\right]}+\frac{G_1^2\left(1-s^{2}\right)\left[\frac{x^3v_g^2}{a^2}+\frac{(1-x)^3v_f^2}{(1-a)^2}\right]}{2\left[xv_g+(1-x)v_f\right]}$$

Homogeneous Model Assumption

$$\Delta p_f=\frac{G_1^2}{2}\left(1-s^{2}\right)\left[1+\left(\frac{v_{fg}}{v_f}\right)x\right]$$

Static pressure change:

$$(p_2-p_1)=G_1^2 s\,(1-s)\,v_f\,(1-x)^2\left[1+\frac{C}{X}+\frac{1}{X^2}\right]$$

Pressure loss through sudden Contraction

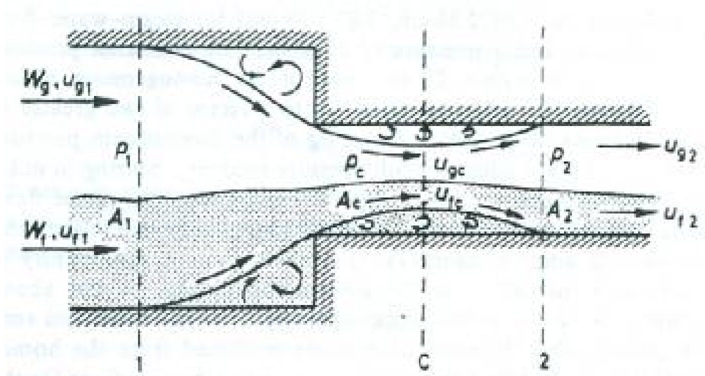
$$\Delta p_f = \left(\frac{G_2}{C_c}\right)^2 (1-C_c)\left[\frac{(1+C_c)\left[\dfrac{x^3 v_g^2}{a^2} + \dfrac{(1-x)^3 v_f^2}{(1-a)^2}\right]}{2\left[x v_g + (1-x) v_f\right]} - C_c\left\{\frac{x^2 v_g}{a} + \frac{(1-x)^2 v_f}{(1-a)}\right\}\right]$$

Homogeneous Model Assumption

$$\Delta p_f = \frac{G_2^2 v_f}{2}\left[\frac{1}{C_c} - 1\right]^2 \left[1 + \left(\frac{v_{fg}}{v_f}\right) x\right]$$

Static pressure change:

$$p_1 - p_2 = \frac{G_2^2 v_f}{2}\left[\left[\frac{1}{C_c} - 1\right]^2 + \left(1 - \frac{1}{s^2}\right)\right]\left[1 + \left(\frac{v_{fg}}{v_f}\right) x\right]$$



Pressure loss through orifice

Assumption:
1. The flow is incompressible
2.Upstream momentum is negligible
3. There is no phase change
4.Shear forces are neglected
5. Void fraction remains constant

$$(p_1 - p_2) A_0 + F = W u_c$$

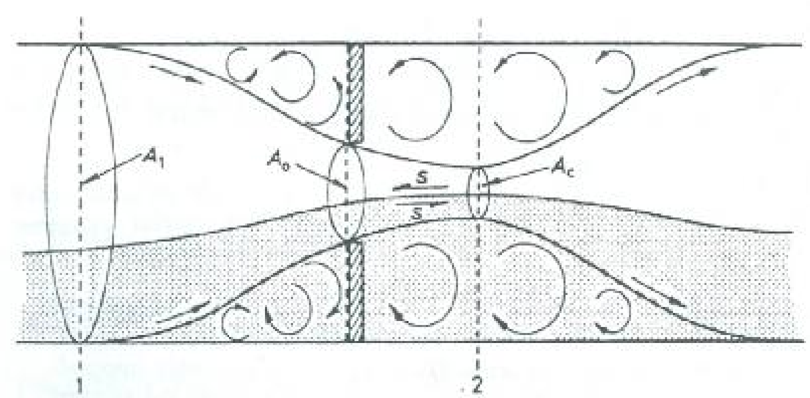
$$F = f \frac{W_f^2 v}{A_0} = \left[\frac{1}{C_D} - \frac{1}{2C_D^2} \right]$$

$$C_D = A_c / A_0$$

$$\Delta p_f = \frac{W_f^2 v}{2A_c^2} = \frac{W^2 (1-x)^2 v_g}{2C_D^2 A_0^2}$$

$$\frac{\Delta p_{TP}}{\Delta p_f} = 1 + C \left(\frac{\Delta p_g}{\Delta p_f} \right)^{0.5} + \frac{\Delta p_g}{\Delta p_f}$$

$$C = Z + \frac{1}{Z} = K \left(\frac{v_g}{v_f} \right)^{-0.5} + \frac{1}{K} \left(\frac{v_g}{v_f} \right)^{0.5}$$



Pressure loss through nozzles and venturis

Chisholm (1967)

$$K = \frac{1}{Z}\left(\frac{v_{gl}}{v_f}\right)^{0.5}\frac{1}{Br^{1/n}}$$

$$B = \left[\left(\frac{n-1}{n}\right)\left(\frac{1-r}{1-r^{n-1/n}}\right)\left(\frac{1}{r^{2/n}}\right)\right]^{0.5}$$

$$\frac{A_{gc}}{A_{fc}} = Z\left(\frac{x}{1-x}\right)\left(\frac{v_{gl}}{v_f}\right)^{0.5}$$

Waston et al (1967)

$$\frac{\Delta p_g}{\Delta p_f} = \frac{1}{X} = \left(\frac{x}{1-x}\right)\left(\frac{v_{gl}}{v_f}\right)^{0.5}$$