Module 6. Flow Through pipes

Lesson 17
PROBLEMS ON HEAD LOSS

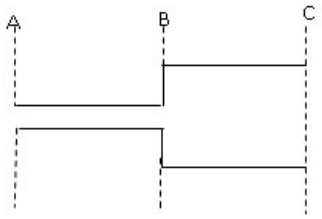
17.1 Numericals

Q 1. Discharge through a pipe line is 0.05 m3/s. The diameter of pipe at section AB is 10 cm which suddenly changes to 15 cm in section BC. The co-efficient of friction is 0.05 for both the pipes; determine the total head loss from A to C.

Solution:

$$Q = 0.05 m^3/s$$

Area	Section	Length	Diameter
$A_1=\frac{\pi}{4}(0.1)^2$	AB	L_1	$D_1 = 0.10$ m
$A_2=\frac{\pi}{4}(0.15)^2$	BC	L_2	$D_1 = 0.15$ m



$$\text{Total loss} = \text{Major loss} + \text{Minor loss}$$

$$V_1 = \frac{Q}{A_1} = 6.369\, m/s,\ V_2 = \frac{Q}{A_2} = 2.831\, m/s$$

$$h_f = \frac{4fLV^2}{2gD};\ h_{se} = \frac{(V_1 - V_2)^2}{2g};\ f = 0.05$$

$$\text{Total head loss (h)} = \frac{4fL_1V_1^2}{2gD} + \frac{(V_1 - V_2)^2}{2g} + \frac{4fL_2V_2^2}{2gD_2}$$

$$h = \frac{4\times0.05\times5\times(6.36)^2}{2\times9.81\times0.1} + \frac{(6.36-2.83)^2}{2\times9.81} + \frac{4\times0.05\times10\times(2.83)^2}{22\times9.81\times0.15}$$

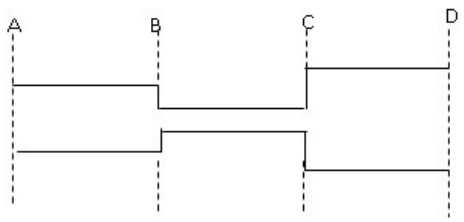
$$= 20.229 + 0.635 + 5.442$$

$$= 26.3066\, m$$

Q 2. Diameter and length of the different sections of a pipe line is given as follows:

Junctions B and C are cases of sudden contraction & enlargement respectively. If the flow rate is 0.01 m3/s, determine total head loss in entire length of pipe. Contraction loss co-efficient is 0.45.

Section	Length	Diameter	Co-efficient of friction
AB	$L_1 = 2.5$	$D_1 = 0.15$ m	0.02
BC	$L_2 = 5$	$D_2 = 0.10$ m	0.02
CD	$L_3 = 2.5$	$D_3 = 0.20$ m	0.02



$A_1=\frac{\pi}{4}(0.15)^2$; $A_2=\frac{\pi}{4}(0.10)^2$ and $A_3=\frac{\pi}{4}(0.20)^2$

$$V_1=\frac{Q}{A_1};V_2=\frac{Q}{A_2};V_3=\frac{Q}{A_3}$$

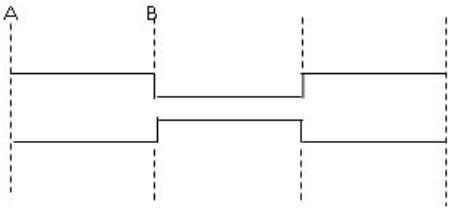
$$\text{Total head loss (h)}=\frac{4fL_1V_1^2}{2gD_1}+K_c\frac{V_2^2}{2g}+\frac{4fL_2V_2^2}{2gD_2}+\frac{(V_2-V_3)^2}{2g}+\frac{4fL_3V_3^2}{2gD_3}$$

$$h=\frac{4\times0.02\times2.5\times(0.56)^2}{2\times9.81\times0.15}+\frac{0.45\times(1.27)^2}{2\times9.81}+\frac{4\times0.02\times5\times(1.27)^2}{2\times9.81\times0.10}+\frac{(1.27)^2}{2\times9.81}$$
$$+\frac{4\times0.02\times2.5\times(0.32)^2}{2\times9.81\times0.20}$$
$$h=0.021+0.036+0.328+0.045+0.005$$
$$h=0.435\,m$$

Q 3. Diameter & length of different sections of pipe line connected to a large tank given as below. There is an abrupt expansion & contraction at junction B & C. Water is discharged directly into open at end of pipe at D. Determine the height of water surface above the discharge point to get a velocity of 2.5 m/s at the end of pipe. Take contraction loss co-efficient as 0.45.

Section	Length	Diameter	Co-efficient of friction
AB	L_1 = 10 m	D_1 = 0.05 m	0.005
BC	L_2 = 20 m	D_2 = 0.10 m	0.005
CD	L_3 = 15 m	D_3 = 0.05 m	0.005

Solution:



Section	Co-efficient	Area	Velocity
AB	0.005	$A_1=\frac{\pi}{4}(D_1)^2$	$V_1=Q/A_1$
BC	0.005	$A_2=\frac{\pi}{4}(D_2)^2$	$V_2=Q/A_2$
CD	0.005	$A_3=\frac{\pi}{4}(D_3)^2$	$V_3=2.5$ m/s

$$Q = V_3A_3 = 2.5^* \frac{\pi}{4}(0.05)^2$$

$$= 4.90 \text{ X } 10^{-3} \text{ m}^3/\text{s}$$

Height of water surface above discharge point = Total head loss.

Total head loss

$$= \frac{0.5V_1^2}{2g} + \frac{4fL_1V_1^2}{2gD_1} + \frac{(V_1 - V_2)^2}{2g} + \frac{4fL_2V_2^2}{2gD_2} + K_C\frac{V_3^2}{2g} + \frac{4fL_3V_3^2}{2gD_3} + \frac{V_3^2}{2g}$$

$$h = \frac{0.5\times(2.5)^2}{2\times9.81} + \frac{4\times0.005\times10\times(2.5)^2}{2\times9.81\times0.05} + \frac{(2.5-0.60)^2}{2\times9.81} + \frac{4\times0.005\times20\times(0.60)^2}{2\times9.81\times0.10}$$

$$+ 0.45\times\frac{(2.5)^2}{2\times9.81} + \frac{4\times0.005\times15\times(2.5)^2}{2\times9.81\times0.05} + \frac{(2.5)^2}{2\times9.81}$$

$$h = 0.159 + 1.274 + 0.184 + 0.073 + 0.143 + 1.911 + 0.318 == 4.062\ m$$

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