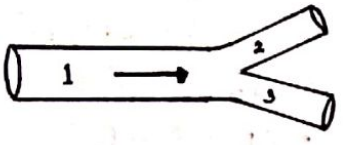
Nurul Dita Ayuningtyas
20/469371/SV/18690
TRPBDS

X	Y	Z
7	1	7

1. Aliran air mengalir dalam pipa 1 dengan jari-jari 7,87 cm, kemudian bercabang menjadi pipa 2 & 3 dengan diameter $D_2 = 0,31\ D_1$ dan $D_3 = 0,5\ D_1$. Kecepatan pipa 2 $0,47\ V_1$. Hitung debit aliran bila Vmax semua pipa tidak diperbolehkan melebihi 5,17 m/s.



- $D_1 = 7,87 \times 2 = 15.74$ cm $= 0.1574$ m
- $D_2 = 0.31 \times 0.1574 = 0.0488$ m $V_2 = 0,47\ V_1$
- $D_3 = 0,5 \times 0.1574 = 0.0787$
- $V_{max} = 5.17$ m/s

- $Q_1 = Q_2 + Q_3$

$A_1 . V_1 = A_2 . V_2 + A_3 + V_3$

$\pi . \frac{d_1^2}{4} . V_1 = \pi . \frac{d_2^2}{4} . V_2 + \pi . \frac{d_3^2}{4} V_3$

$d_1^2 . V_1 = d_2^2 . V_2 + d_3^2 . V_3$

$(0,1574)^2 V_1 = (0,0488)^2 . 0,47\ V_1 + (0,0787)^2 . V_3$

$0.02477476\ V_1 = 0.00119277\ V_1 + 0,00619369\ V_3$

$0,02365548 3 V_1 = 0.00619369\ V_3$

$V_3 = 3,82\ V_1$

- $V_{max} = V_1 + V_2 + V_3$

$5.17 = V_1 + 0.47\ V_1 + 3.82 V_1$

$V_1 = \frac{5.17}{5.29} = 0,977$ m/s

$V_2 = 0.47 \times 0.977 = 0.459$ m/s

$V_3 = 3.82 \times 0.977 = 3.732$ m/s

- $Q_1 = A_1 . V_1$

$= 3,14 \times \frac{(0.1574)^2}{4} \times 0,977$

$= 0.019\ m^3/s$

- $Q_2 = A_2 . V_2$

$= 3,14 \times \frac{(0.0488)^2}{4} \times 0.459$

$= 0,001\ m^3/s$

- $Q_3 = A_3 . V_3$

$= 3,14 \times \frac{(0.0787)^2}{4} \times 3,732$

$= 0,018\ m^3/s$

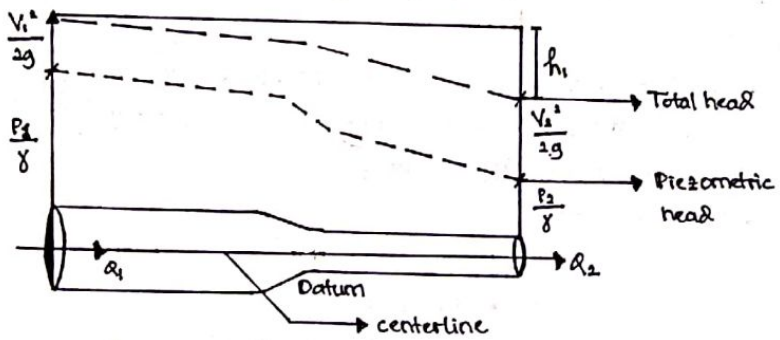
- Cek

$Q_1 = Q_2 + Q_3$

$0.019 = 0.001 + 0.018$

$0.019 = 0.019$ (ok!)

2. Di sebuah Desa di Yogyakarta terdapat pipa yang mengalirkan air secara horizontal dengan panjang 179 m. Pada daerah hulu, pipa tersebut memiliki bagian diameter 24,71 cm, di bagian hilir, diameter mengecil menjadi setengahnya. Pada daerah hulu dan hilir, tekanan masing-masing pipa memiliki perbedaan 2,1 kgf/cm². Estimasi debit aliran yang terjadi.



- panjang pipa = 179 m
- D_1 = 24.71 cm = 0,2471 m
- $D_2 = \frac{1}{2} D_1$
  $= \frac{1}{2}$ 0.2471 = 0.12355 m
- γ_{air} = 1000 kg/m³
- $\Delta P = P_1 - P_2$
  = 2,1 kgf/cm²
  = 21 ton/m²
- Q = ?

- Tinggi tekanan₁ = $\frac{P_1}{\gamma} = \frac{P_1}{1000}$

  Tinggi tekanan₂ = $\frac{P_2}{\gamma} = \frac{P_1 - 21}{1000}$

- $Q_1 = Q_2$

  $A_1 . V_1 = A_2 . V_2$

  $\frac{\pi . (0,2471)^2}{4} V_1 = \frac{\pi (0,12355)^2 . V_2}{4}$

  $V_1 = \frac{0.0153}{0.0610} V_2$

  $V_1 = 0.25 V_2$

- $\frac{P_1}{\gamma} + \frac{V_1^2}{2g} = \frac{P_2}{\gamma} + \frac{V_2^2}{2g}$

  $\frac{P_1}{\gamma} - \frac{P_2}{\gamma} = \frac{V_2^2}{2g} - \frac{V_1^2}{2g}$

  $\frac{21}{1000} = \frac{V_2^2 - (0.25 V_2)^2}{2.10}$

  $0.021 = \frac{V_2^2 - 0.0625 V_2^2}{20}$

  $0.42 = 0.9375 V_2^2$

  $V_2 = \sqrt{\frac{0.42}{0.94}}$

  $= 0.67$ m/s

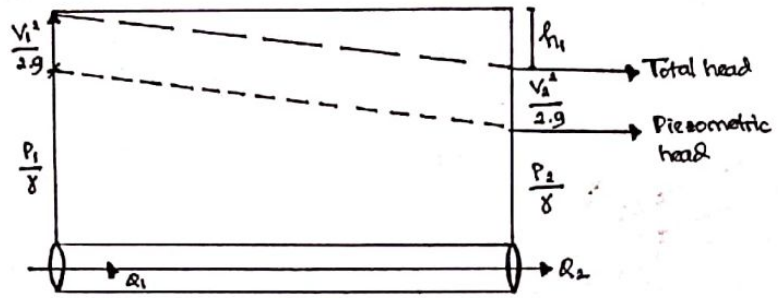
- $V_1 = 0.25 V_2$
  $= 0.25 \times 0.67$
  $= 0.1675$ m/s

- $Q_1 = A_1 . V_1$
  $= 3.14 \times \frac{(0.2471)^2}{4} \times 0.1675$
  $= 0.008$ m³/s

- $Q_2 = A_2 . V_2$
  $= 3.14 \times \frac{(0.12355)^2}{4} \times V_2$
  $= 0.008$ m³/s

- $Q_1 = Q_2$ (OK!)

3. Dengan kasus yang sama dengan nomor 2. Perbedaannya, di hilir tidak ada perubahan diameter pipa. Sehingga, diameternya sama. Bila koefisien gesek aliran yang terjadi adalah $f = 0{,}0377$, tentukan debit aliran



- $Q_1 = Q_2 = 0{,}2471$
- $f = 0.0377$

- $f = \frac{0{,}316}{Re^{0{,}25}}$

$Re^{0{,}25} = \frac{0{,}316}{0{,}0377}$

$Re^{0{,}25} = 8{,}382$

$Re = 4936{,}17$

(aliran turbulen)

- $Q_1 = Q_2$

$A_1 . V_1 = A_2 . V_2$

$\frac{\pi . d_1^2}{4} . V_1 = \frac{\pi . d_2^2}{4} . V_2$

$V_2 = \left(\frac{d_1}{d_2}\right)^2 V_1$

- $\frac{1}{\sqrt{f}} = -2 \log\left(\frac{k}{3{,}7 . d} + \frac{2{,}51}{Re\sqrt{f}}\right)$

$\frac{1}{\sqrt{0{,}0377}} = -2 \log\left(\frac{k}{3{,}7 \times 0{,}2471} + \frac{2{,}51}{4936{,}17\sqrt{0{,}0377}}\right)$

$5{,}155 = -2 \log\left(\frac{k}{0{,}914} + \frac{2{,}51}{957.6}\right)$ ← di misalkan x

- $K = \frac{V_2^2}{2g} . \frac{L}{d} . f$

$27{,}31 = \frac{V_2^2}{2 . 10} . \frac{179}{0.2471} . 0.0377$

$V_2^2 = \frac{27{,}31 . 20}{27{,}31}$

$V_2 = \sqrt{20} = 4{,}47\ m/s$

$5{,}155 = -2 \log x$

$x = 10^{(5{,}155/2)}$

$x = 378{,}007$

$\left(\frac{k}{0{,}914} + \frac{2{,}51}{957{,}6}\right) = 378{,}007$

$\frac{k}{0{,}914} = 378{,}007 - 0{,}0026$

$k = 378{,}004 \times 0{,}914$

$= 345{,}5$

- $Q_1 = Q_2 = A_2 . V_2$

$= 3{,}14 \frac{(0{,}2471)^2}{4} . 4{,}47$

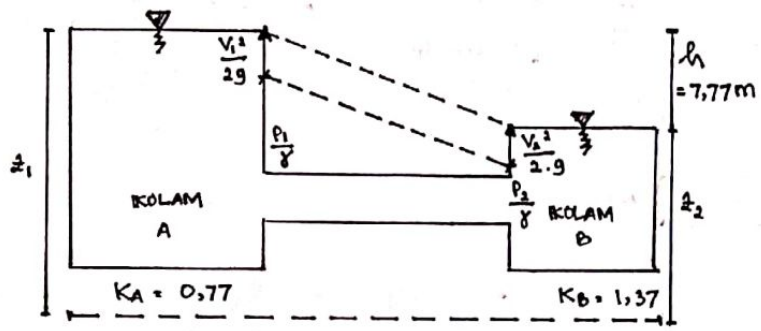
$= 0{,}214\ m^3/s$

- $K = f . \frac{L}{d}$

$= \frac{0{,}0377 . 179}{0{,}2471}$

$= 27{,}31$

4. Dengan kasus yang sama dengan nomor 3. Bedanya, pipa mengalir melalui kolam A dan B dengan pipa tersebut. Elevasi perbedaan kolam di hulu dan hilir adalah 7,77 m. Bila koefisien kehilangan teraga akibat perubahan penampang pada sambungan antara pipa dan kolam A dan B adalah $K_A = 0{,}77$, $K_B = 1{,}37$. Estimasi debit aliran.



1. $\frac{P_1}{\gamma} + \frac{V_1^2}{2.g} + z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + \Sigma h + \Sigma h_f$

$$h + h_f = \left(z_1 + \frac{P_1}{\gamma} + \frac{V_1^2}{2.g} \right) - \left(z_2 + \frac{P_2}{\gamma} + \frac{V_2^2}{2.g} \right)$$

$$= \left(z_1 + \frac{P_1}{\gamma} \right) - \left(z_2 + \frac{P_2}{\gamma} \right)$$

$h_{ab} + h_{fi} = H$

$$K_a \cdot \frac{V_1^2}{2g} + K_b \cdot \frac{V_2^2}{2g} + f_1 \cdot \frac{L_1}{d_1} \cdot \frac{V_1^2}{2g} = H \quad \text{.... (Persamaan I)}$$

2. $Q_1 = Q_2$

$A_1 \cdot V_1 = A_2 \cdot V_2$

$V_2 = \frac{A_1 \cdot V_1}{A_2}$

$V_2 = \frac{\frac{1}{4}\pi \cdot d_1^2 \cdot V_1}{\frac{1}{4}\pi \cdot d_2^2}$

$V_2 = \frac{d_1^2}{d_2^2} V_1$ .... (persamaan II)

3. Subtitusi (II) ke (I)

$$\left(K_a + K_b \left(\frac{d_1}{d_2} \right)^4 + f_1 \frac{L_1}{d_1} \right) \frac{V_1^2}{2.g} = 7{,}77$$

$$\left(0{,}77 + 1{,}37\,(1) + 0{,}0377 \frac{179}{0{,}2471} \right) \frac{V_1^2}{20} = 7{,}77$$

$(0{,}77 + 1{,}37 + 27{,}31)\, V_1^2 = 155{,}4$

$V_1^2 = 5{,}276$

$V_1 = 2{,}3 \text{ m/s}$

4. Jika f_2 diperhitungkan

$$K_A \frac{V_1^2}{2.g} + K_D \left(\frac{d_1}{d_2} \right)^4 \cdot \frac{V_1^2}{2.g} + f_1 \frac{L_1}{d_1} \cdot \frac{V_1^2}{2.g} + f_2 \cdot \frac{L_2}{d_2} \cdot \frac{V_2^2}{2.g} = H$$

$$\left(K_A + K_D \left(\frac{d_1}{d_2} \right)^4 + f_1 \cdot \frac{L_1}{d_1} + f_2 \frac{L_2}{d_2} \left(\frac{d_1}{d_2} \right)^4 \right) \frac{V^2}{2.g} = H$$

$(0{,}77 + 1{,}37 + 27{,}31 + 27{,}31)\, V_1^2 = 7{,}77 \times 20$

$V_1^2 = 2{,}7378$

$V_1 = 1{,}65 \text{ m/s}$

$V_2 = \left(\frac{d_1}{d_2} \right)^2 V_1$

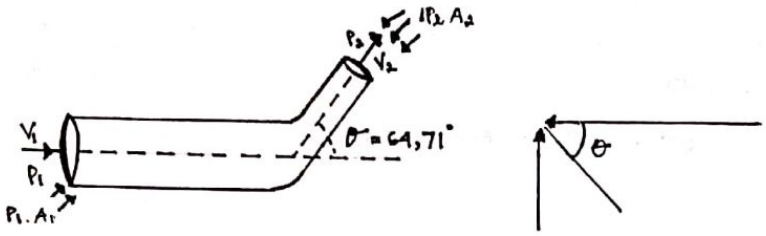
$V_2 = V_1$

5. $Q = A \cdot V$

$= 3.14 \times \frac{(0{,}2471)^2}{4} \cdot 1{,}65$

$= 0{,}079 \text{ m}^3/\text{s}$

5. Dengan kasus yang sama dengan nomor 2, bedanya airnya mengalir pada pipa yang membelok dari diameter besar ke diameter kecil dengan sudut belokan 64,71. Panjang pipa diabaikan. Estimasi kecepatan dengan kasus tersebut, kemudian prediksi gaya untuk menahan pipa bila tekanan yang terjadi mengalami kenaikan 14,17 % dari tekanan studi kasus awal.



- $P_1 . A_1 - P_2 . A_2 \cos\theta - R_x = \rho Q (V_2 \cos\theta - V_1)$

  arah x → $R_x = P_1 . A_1 - P_2 . A_2 \cos\theta - \rho Q (V_2 \cos\theta - V_1)$

  arah y → $R_y = R_y - W - P_2 . A_2 \sin\theta = \rho Q V_2 \sin\theta$

  $R_y = W + P_2 . A_2 \sin\theta + \rho Q V_2 \sin\theta$

- $Q_1 = Q_2$

  $A_1 . V_1 = A_2 . V_2$

  $V_2 = \frac{A_1}{A_2} . V_1$

  $V_2 = \frac{0,0479 . 0.1675}{0,012}$

  $= 0,668 \text{ m/s}$

- $Q_1 = A_1 . V_1$

  $= 0,0479 . 0,1675$

  $= 0,008$

- $\frac{z_1}{} + \frac{P_1}{\gamma} + \frac{V_1^2}{2.g} = \frac{z_2}{} + \frac{P_2}{\gamma} + \frac{V_2^2}{2.g}$

  $\frac{P_1}{1000} + \frac{(0,1675)^2}{20} = \frac{P_2}{1000} + \frac{(0,668)^2}{20}$

  $\frac{P_1}{1000} - \frac{P_2}{1000} = \frac{0,668 - 0,1675}{20}$

  $P_1 - P_2 = \frac{0.5005}{20} . 1000$

  $P_1 - P_2 = 25,025 \text{ N/m}^3$

- Jika P_1 adalah P awal pada no. 2, maka :

  $P_1 = 8,375 \text{ N/m}$

  $P_2 = 25,025 - 8,375 = 16,65 \text{ N/m}$

  Terjadi kenaikan 14,17 %

  $P_1 = 8,375 + 8,375 \times 14,17\ \%$

  $= 8,375 + 1,19 = 9,56 \text{ N/m}^3$

  $P_2 = 8,375 + 8,375 \times 14,17$

  $= 9,56 \text{ N/m}^3$

catatan

$P_1 = P_1 + 14,17 P_1$

$P_2 = P_2 + 14,17$

$\frac{P_1}{\gamma} + \frac{V_1^2}{2.g} = 0$

$\frac{P_1}{1000} + \frac{0,1675}{20} = 0$

$P_1 = 8,375 \text{ N/m}$

$\Rightarrow R_x = P_1 . A_1 - P_2 . A_2 \cos\theta - \rho Q (V_2 \cos\theta - V_1)$

$= 9{,}96 . 0{,}0479 - 9{,}96 . 0{,}012 . \cos 64.71 - \frac{1000}{10} \times 0{,}008 (0{,}668 \cos 64{,}71 - 0{,}1675)$

$= 0{,}477 - 0{,}036 - 0{,}026$

$= 0{,}415\ N$

$\Rightarrow R_z = \boxed{W} + P_2 . A_2 . \sin\theta + \rho Q V_2 \sin\theta$

$= 9{,}96 . 0{,}012 . \sin 64.71 + \frac{1000}{10} \times 0{,}008 (0{,}668 \sin 64{,}71)$

$= 0{,}1135 + 0{,}5092$

$= 0{,}623\ N$

$\Rightarrow R = \sqrt{R_x^2 + R_z^2}$

$= \sqrt{0{,}415^2 + 0{,}623^2}$

$= \sqrt{0{,}17 + 0{,}388}$

$= \sqrt{0{,}56}$

$= 0{,}748\ N$