7-36: طبق شکل نموداری که داریم وقتی به مرحله جریان کاملا آشفته‌ی زبر، ضریب اصطکاک فقط به زبری نسبی بستگی دارد.

گزینه اول

$$\frac{1}{\sqrt{f}} = -2\log\left(\frac{\varepsilon/D}{3.7}\right) \rightarrow * \quad \sqrt{f} \text{ نسبت عکس با}$$

7-41: برای جریان آرام و آشفته داریم:

$$\Delta p = \frac{4L}{D}\tau_0 \; ; \; \frac{\Delta p}{L} = \frac{4\tau_0}{D}$$

اگر برای دو شریان جریان، تنش برشی دیواره برابر باشد طبق رابطه بالا نسبت گرادیان فشار برابر $\frac{1}{5}$ خواهد بود.

7-46: سطح دو مخزن با یکی مستقری می‌کنیم:

$$P_1 + \gamma_w h_1 + \gamma_g a - \gamma_w a - \gamma_w h_1 = P_2 \; ; \; \Delta p = (\gamma_g - \gamma_w)a$$

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + Z_1 + h_p = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + Z_2 + h_L \; ; \; \frac{P_1 - P_2}{\gamma} + h_p = 0$$

$$h_p = \frac{P_2 - P_1}{\gamma_w} = \frac{(\gamma_g - \gamma_w)a}{\gamma_w} = (SG-1)a = 12.6a$$

$$\frac{P_A}{\gamma} + \frac{V_A^2}{2g} + Z_A + h_p = \frac{P_B}{\gamma} + \frac{V_B^2}{2g} + Z_B + h_f$$

$$h_f = \frac{8fLQ^2}{g\pi^2 D^5} = \frac{8Q^2}{g\pi^2 D^4} \times 12.6 = h_p \; ; \; a = \frac{8Q^2}{g\pi^2 D^4}$$

7-50:

$$\frac{P_A}{\gamma} + \frac{V_A^2}{2g} + Z_A + h_p = \frac{P_C}{\gamma} + \frac{V_E^2}{2g} + Z_F + h_L$$

$$0 + 0 + 0 + h_p = 0 + \frac{16}{2g} + h + 2\times\frac{16}{2g}\frac{V_C^2}{2g}$$

$$h_p = 5\frac{V_C^2}{2g}$$

$$\Rightarrow h = 1.63\,m$$

گزینه اول

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: 7-55

$$\frac{P_1}{\gamma}+\frac{v_1^2}{2g}+z_1+h_p=\frac{P_2}{\gamma}+\frac{v_2^2}{2g}+z_2+h_f \Rightarrow$$

$$0+0+z_1+0=0+0+0+h_f \Rightarrow 0.7m=\left[\frac{fl}{D}+\sum_{j=1}^{\hat{}} k_j\right]\times\frac{v^2}{2g}$$

به دلیل طول لوله کم است

$$0.7m=\left[\quad +k_F\right]\times\frac{v^2}{2g} \xrightarrow[\text{لوله به 30 شاخه متوازی است}]{\text{به دلیل سرعت}} 0.7m=k_F\frac{v^2}{2g}\rightarrow k_F=\frac{0.7m\times 2g}{v^2}$$

: 7-60

$$\frac{P_1}{\gamma}+\frac{v_1^2}{2g}+\cancel{z_1^{\circ}}=\frac{\cancel{P_2^{\circ}}}{\gamma}+\frac{v_2^2}{2g}+\cancel{z_2^{\circ}}+h_f \Rightarrow P_1=f\frac{l}{D}\frac{\rho v^2}{2}$$

$$\frac{\varepsilon}{D}=\frac{8mm}{4000mm}=0.002 \quad ; \underline{f=0.0235}$$

$$Re=\frac{vD}{\nu}=\frac{(15m/s)(4m)}{(1.46\times10^{-5}m^2/s)}=4.1\times10^6$$

$$P_1=(0.0235)\frac{8cm}{4m}\frac{(1.225kg/m^3)(15m/s)^2}{2}=647.7pa$$

$$\frac{P_3}{\gamma}+\frac{v_3^2}{2g}+\cancel{z_4}=\frac{P_4}{\gamma}+\frac{v_4^2}{2g}+z_4+h_f \rightarrow P_4=-f\frac{l}{D}\frac{\rho v^2}{2}$$

$$P_4=-(0.0235)\frac{8cm}{4m}\frac{1.23kg/m^3\times(15m/s)^2}{2}=-650.4pa$$

$$\Delta P=P_1-P_4=1298pa$$

$$\dot{w}_p=FV=(\Delta PA)V=1298pa\times\left(\frac{\pi}{4}\times16\right)15m/s=245kw$$

: 7-63

$$h_p=\frac{\dot{w}_p}{\gamma Q}=\frac{20kw}{(9.81kN/m^3)(0.14m^3/s)}=14.56m$$

$$\frac{P_A}{\gamma}+\frac{v_A^2}{2g}+z_A+h_p=\frac{P_F}{\gamma}+\frac{v_F^2}{2g}+z_F+h_L=\frac{P_F}{\gamma}+\frac{v^2}{2g}+z_F+f\frac{l}{D}\frac{v^2}{2g}+\left[k_m\frac{v^2}{2g}\right.$$

$$46m+14.56m=\frac{P_F}{9.81kN/m^3}+2m+\left\{1+f\left(\frac{140m}{0.2m}\right)+\left[(0.5)+2(0.9)+1\right]\right\}\frac{(4.46m/s)^2}{2(9.81m/s^2)}$$

$$P_F=9810\left[40.56-1.012(4.3+700f)\right]$$

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$$\frac{\varepsilon}{D} = \frac{(0.045mm)}{(200mm)} = 0.000225$$

$$Re = \frac{VD}{\upsilon} = \frac{(4.46 m/s)(0.2m)}{(1.12\times10^{-6}\ m^2/s)} = 8\times10^5$$

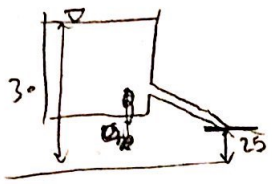
$$\Rightarrow f = 0.0015 \Rightarrow P_F = 251\ kPa$$

$$\frac{V^2}{2g} = \frac{4.46^2\ m^2/s^2}{2\times9.81\ m/s^2} = 1.01m \quad ; \quad \frac{f}{D}\frac{V^2}{2g} = \frac{(0.0015)}{(0.2m)}(1.01m) = 0.0076$$

چون لوله ثابت ⇐ خط شیب انرژی و خط شیب هیدرولیکی با اندازه هد سرعت تفاوت دارند.

مسئله حل شده است

: 7-68



$D = 0.15m \qquad L = 3.0m$

$$\frac{P_1}{\gamma}^{0} + \frac{V_1^2}{2g}^{0} + Z_1 = \frac{P_2}{\gamma}^{0} + \frac{V_2^2}{2g} + Z_2^{25} + h_L$$

$$30 - 25 = \left(1 + K_m + f\frac{L}{D}\right)\frac{V^2}{2g} = \left[1 + K_m + f\frac{30}{0.15}\right]\frac{V^2}{2(9.81 m/s^2)}$$

$$V = \sqrt{\frac{98.1}{1 + K_m + 200f}} \quad ; \quad \text{ورودی} \Rightarrow K_m = 0.5 \quad ; \quad f_{\text{اولیه}} = 0.02$$

$$V = 4.22\ m/s \quad ; \quad \begin{cases} \frac{\varepsilon}{D} = \frac{0.26mm}{150mm} = 0.001 \\ Re = \frac{VD}{\upsilon} = \frac{4.22\times0.15}{1.12\times10^{-6}\ m^2/s} = 5.65\times10^5 \end{cases} \quad ; \quad f = 0.022 \text{ نزدیک}$$

$$V = \sqrt{\frac{98.1}{1.5 + 4.9}} = 4.03 \quad ; \quad Re = \frac{4.03\times0.15}{1.12\times10^{-6}} = 5.4\times10^5 \quad ; \quad f = 0.022 \text{ نزدیک} \quad \text{تکرار} \rightarrow$$

0.0176

$$Q = VA = 4.03\,\pi\times\frac{0.15^2}{4} = 0.071\ (m^3/s)$$

: 7-74

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + Z_2 + h_f \quad ; \quad 120m = 20m + f\frac{1000m}{1m}\frac{V^2}{2(9.81 m/s^2)} \quad ; \quad V = \sqrt{\frac{0.196}{f}}$$

$$V = \sqrt{\frac{0.196}{0.02}} = 3.13\ m/s \quad ; \quad \begin{cases} \frac{\varepsilon}{D} = \frac{0.045mm}{1000mm} = 0.000045 \\ Re = \frac{VD}{\upsilon} = \frac{(3.13 m/s)(1m)}{1.308\times10^{-6}\ m^2/s} = 2.4\times10^6 \end{cases} \quad ; \quad f = 0.0175 \text{ نزدیک}$$

نزدیک اول ← نزدیک دوم ← همین شد

$$V = \sqrt{\frac{0.196}{0.0175}} = 4.13\ m/s \quad ; \quad Q = VA = 4.13\ m/s\left(\frac{\pi}{4}(1m)^2\right) = 3.24\ m^3/s$$

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$\frac{\varepsilon}{D} = \frac{0.26mm}{1000mm} = 0.00026$

$Re = \frac{(3.13\ m/s)(1m)}{1.307 \times 10^{-6}\ m^2/s} = 2.4 \times 10^6$ نزدیک

$f = 0.015 \Rightarrow V = \sqrt{\frac{0.196}{0.015}} = 3.62\frac{m}{s}$ فرض شد

$Q = VA = 2.84\frac{m^3}{s}$

به قسمتی دهم:

$\frac{P_B}{\gamma} + \frac{V_B^2}{2g} + Z_B + h_p = \frac{P_A}{\gamma} + \frac{V_A^2}{2g} + Z_A + h_f$

h_p ثابت می‌ماند $\leftarrow$ 3.5 به 3.24 دبی قسمت دهم از

$h_p = 2085.714$

$h_f = \frac{1000}{1} \times \frac{4.45^2}{2(9.81)} \times 0.02 = 1985.714$

$f \leftarrow \begin{cases} \frac{\varepsilon}{D} = 0.00045 \\ Re = \frac{VD}{\upsilon} = \frac{4.45 \times 1}{1.308 \times 10^{-6}} = 3.4 \times 10^6 \end{cases}$

$Q = VA = V \times \frac{\pi}{4} = 3.5\frac{m^3}{s} \rightarrow V = 4.45\frac{m}{s}$

$\dot{W}_p = \gamma Q h_p = \boxed{7.3 \times 10^6\ W}$

7-79 :

$h_f = 30 = f \times \frac{LQ^2}{0.12.1 \times D^5} \Rightarrow D = \sqrt[5]{\frac{10}{363}} \rightarrow D = 0.223m$ f_1 فرض $= 0.02$

$\Rightarrow \frac{\varepsilon}{D} = 0.0002$, $Re = \frac{VD}{\upsilon} = \frac{\frac{0.1}{\frac{\pi}{4}(0.223)^2} \times 0.223}{10^{-5}} = 5.71 \times 10^5 \Rightarrow f_2 = 0.0148$

$\Rightarrow D = 0.201 \Rightarrow \frac{\varepsilon}{D} = 0.00022$, $Re = \frac{VD}{\upsilon} = 6.33 \times 10^5$ تقریب $\Rightarrow f_3 = 0.0141$ ✓

$\Rightarrow D = \sqrt[5]{\frac{10 \times 0.0141}{363}} = 0.208m \Rightarrow \frac{P_1}{\gamma} + \frac{V_1^2}{2g} + Z_1 + h_p = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + Z_2 + h_L \Rightarrow h_p = 30$

$W_p = \gamma Q h_p \overset{0.93*}{=} 9810 \times 0.1 \times 30 =$

7-84 :

$-\rho V^2 A = \sum_{CV} F_x = -R_x + P_1 A$; $-(1000\ kg/m^3)V^2\left(\frac{\pi D^2}{4}\right) = -R_x + P_1\left(\frac{\pi D^2}{4}\right)$

$D = 0.25m$

$P_3 + \frac{\rho V_3^2}{2} + \gamma Z_3 = P_1 + \frac{\rho V_1^2}{2} + \gamma Z_1$; $(9810\ N/m^3)(25m) = P_1 + \frac{(1000\ kg/m^3)V^2}{2} + 0$

$P_1 = 245250 - 500V^2 \Rightarrow -49.06V^2 = -R_x + 12262.5 - 25V^2 \Rightarrow$

$R_x = 25.1V^2 + 12238.68$

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$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + Z_2 + h_f$ پیوستگی $V^2\left(2.f + 0.0.5\right) = 5.0 \Rightarrow V = \sqrt{\frac{5.0}{2.f + \cdots}}$

$f = 0.02 \Rightarrow$ [redacted] $V = 10.591 \frac{m}{s}$, $\frac{\varepsilon}{D} = 0.0.0.18$, $Re = \frac{VD}{\upsilon} = 0.2353 \times 10^5$

$\Rightarrow f = 0.018 \Rightarrow V = 10.973$, $\frac{\varepsilon}{D} = 0.0.0.18$, $Re = \frac{VD}{\upsilon} = 0.275 \times 10^5$

$\Rightarrow f = 0.018$ ✓ جواب $\rightarrow V = 10.973$ $\begin{cases} P = 59059.5 + 245250 = 186190.5\ Pa \\ R_m = 15050.052\ N \end{cases}$

: 7-93

$h_{LD} = h_{Ld_1} + h_{Ld_2}$; $\frac{8fLQ^2}{g\pi^2 D^5} = \frac{8fL_1Q^2}{g\pi^2 d_1^5} + \frac{8fL_2Q^2}{g\pi^2 d_2^5}$; $\frac{L}{D^5} = \frac{L_1}{d_1^5} + \frac{L}{d_2^5}$

$L = D^5\left(\frac{L_1}{d_1^5} + \frac{L}{d_2^5}\right)$ ✓ گزینه 2

: 7-94

$\Delta H_1 = \Delta H_2 \rightarrow \frac{fL_1Q_1^2}{12.1D^5} = \frac{fL_2Q_2^2}{12.1D^5} \Rightarrow L_1 = 4L_2$

$4Q_1^2 = Q_2^2 \rightarrow \frac{Q_1}{Q_2} = \frac{1}{2} \Rightarrow \frac{Q_{new}}{Q_{old}} = \frac{Q_1 + Q_2}{Q_1} = \frac{2Q_1}{Q_1} = 3$ گزینه 2 ✓

7-97: چون انرژی جریان در نقطه A برابر است با انرژی جریان در نقطه B ، پس هیچ آبی از لوله وارد B می شود ← تمامی آب وارد شده از A با دبی $2\frac{m^3}{s}$ وارد مخزن C می شود ← گزینه 3

: 7-99

$\beta = \frac{d}{D} = \frac{1.5cm}{3cm} = 0.5$ $A_n = \frac{\pi d^2}{4} = 1.767 \times 10^{-4}\ m^2$ $Q = A_n C_n \sqrt{\frac{2(P_1 - P_2)}{\rho(1 - \beta^4)}}$

$Q = (1.767 \times 10^{-4}\ m^2)(0.96)\sqrt{\frac{2(400\ Pa)}{(624.4\ kg/m^3)(1 - 0.5^4)}} = 0.627\ L/s$

$V = \frac{Q}{A} = \frac{0.627 \times 10^{-3}\ m^3/s}{\pi(0.03m)^2/4} = 0.887\ m/s$ $Re = \frac{\rho VD}{\mu} = 9.79 \times 10^4$

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$$C_n = 0.9975 - \frac{6.53(0.5)^{0.5}}{(9.79\times10^{4})^{0.5}} = 0.983 \Rightarrow Q_{New} = 0.624\ L/s \checkmark$$ ناشر

Scanned with CamScanner

مقطع	هد پمپ	EGL		HGL
		قبل از مقطع	بعد از مقطع	
سطح مخزن(A)		٤٦	٤٦	٤٦
ورودی لوله(B)	٠,٥*(١,٠١m)=٠,٥١	٤٦	٤٦-٠,٥١=٤٥,٤٩	٤٤,٤٨
زانویی اولی(C)	٠,٠٧٦*٦٠m=٤,٥٦ ٠,٩*(١,٠١)=٠,٩١	٤٥,٤٩-٤,٥٦=٤٠,٩٣	٤٠,٩٣-٠,٩١=٤٠,٠٢	٣٩,٠١
زانویی دومی(D)	٠,٠٧٦*(٢٠m)=١,٥٢ ٠,٩*(١,٠١m)=٠,٩١	٤٠,٠٢-١,٥٢=٣٨,٥٠	٣٨,٥٠-٠,٩١=٣٧,٥٩	٣٦,٥٨
پمپ(E)	٠,٠٧٦*(٣٠m)=٢,٢٨ ١٤,٥٦m	٣٧,٥٩-٢,٢٨=٣٥,٣١	٣٥,٣١+١٤,٥٦=٤٩,٨٧	٤٨,٨٦
F	٠,٠٧٦*(٣٠m)=٢,٢٨ ١*(١,٠١m)=١,٠١	٤٩,٨٧-٢,٢٨=٤٧,٥٩	٤٧,٥٩-١,٠١=٤٦,٥٨	٤٥,٥٧

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