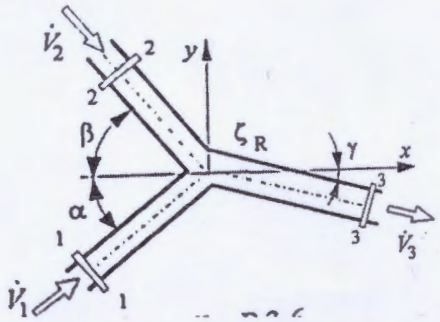
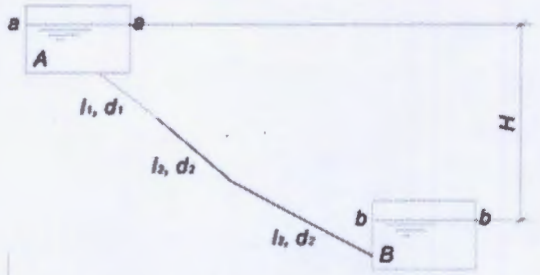
Drugi kolokvijum iz Mehanike fluida

(14.01.2020)

1. **(10p)** U horizontalnu račvu dotiču količine Q_1 i Q_2 a iz nje ističe količina Q_3. Odrediti ugao γ tako da ukupna sila tečnosti nastala usled promjene količine kretanja, ima minimalnu vrijednost. Trenje u račvi zanemariti. Pozbate veličine su: Q_i, d_i (i= 1,2,3), α, β, ρ, p_3.



2. **(9p)** Dva velika otvorena rezervoara su povezana sa tri redno vezane cijevi (dionice) od livenog gvožđa: $l_1 = 300$ m, $d_1 = 200$ mm, $l_2 = 400$ m, $d_2 = 300$ mm, $l_3 = 1200$ m, $d_3 = 450$ mm. Ako je protok vode $Q = 360$ m^3/h, odrediti razliku nivoa voda u rezervoarima. Koeficijent trenja je iti za svaku dionicu λ=0,02.



3. **(8p)** Uz pretpostavku da kod male brzine v tonjenja tijela u mirnom fluidu, ta brzina ne zavisi od gustine fluida, već zavisi od težine G tijela, njegovog prečnika D i dinamičke viskoznosti fluida. Ako je izmjereno da kuglica prečnika D = 2.55 mm tone brzinom 1.2 cm/min u vodi koeficijenta dinamičke viskoznosti 0.001 kg/ms, odrediti kojom brzinom će tonuti kuglica prečnika 5 mm (napravljena od istog materijala kao i kuglica prečnika D) u ulju dinamičke viskoznosti 0.02 kg/ms.
4. **(8p)** Na dionici razvoda komprimovanog vazduha prečnika d, u kojoj je radni pritisak p = 5 bar i temperatura t = 20 °C, vrši se ispitivanje vodom pritiska 1 bar i temperatrure 15 °C. Odrediti brzinu strujanja vode prilikom ispitivanja, ako je brzina strujanja pri eksploataciji 6 m/s. Ako je pri ispitivanju dobijen pad pritiska 0.28 kPa, koliki se pad pritiska može očekivati pri radu instalacije?

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① $\frac{\partial}{\partial t}\int_{V_K}\rho\vec{v}\,dV + \int_{A_K}\rho v(\vec{v}\,d\vec{A}) = \vec{R}$

$-\int_{A_1}\rho v_1(\vec{v}_1 d\vec{A}_1) - \int_{A_2}\rho v_2(\vec{v}_2 d\vec{A}_2) + \int_{A_3}\rho v_3(\vec{v}_3 d\vec{A}_3) = \vec{P}_1 + \vec{P}_2 + \vec{P}_3 + \vec{F}_{LF}$

$\vec{F}_R = F_{FK} + P_{bs}$

$\vec{F}_{FK} = -\vec{F}_{FK}$

$-\rho\vec{v}_1 Q_1 - \rho\vec{v}_2 Q_2 + \rho\vec{v}_3 Q_3 = \vec{P}_{1w} + \vec{P}_{1b} + \vec{P}_{2w} + \vec{P}_{2b} + \vec{P}_{3w} + \vec{P}_{3b} - \vec{F}_{FK} - \vec{P}_{bs}$

$\vec{F}_R = \vec{F}_{FK} = \rho\vec{v}_1 Q_1 + \rho\vec{v}_2 Q_2 - \rho\vec{v}_3 Q_3 + \vec{P}_{1w} + \vec{P}_{2w} + \vec{P}_{3w}$

$F_{Rx} = \rho v_1 Q_1 \cos\alpha + \rho v_2 Q_2 \cos\beta - \rho v_3 Q_3 \cdot \cos\gamma + p_{1w} A_1 \cos\alpha + p_{2w} A_2 \cos\beta - p_{3w} A_3 \cos\gamma$

$F_{Ry} = \rho v_1 Q_1 \sin\alpha - \rho v_2 Q_2 \sin\beta + \rho v_3 Q_3 \sin\gamma + p_{w1} A_1 \sin\alpha - p_{w2} A_2 \sin\beta + p_{w3} A_3 \sin\gamma$

$A_1 = \frac{d_1^2\pi}{4}$; $A_2 = \frac{d_2^2\cdot\pi}{4}$; $A_3 = \frac{d_3^2\pi}{4}$; $v_1 = \frac{Q_1}{A_1}$; $v_2 = \frac{Q_2}{A_2}$; $v_3 = \frac{Q_3}{A_3}$.

5. J. 2-2 3-3

$\frac{p_2}{\rho} + \frac{v_2^2}{2} + g z_2 = \frac{p_3}{\rho} + \frac{v_3^2}{2} + g z_3 \Rightarrow p_2 = p_3 + \frac{\rho}{2}(v_3^2 - v_2^2)$

5. J. 1-1 3-3

$\frac{p_1}{\rho} + \frac{v_1^2}{2} + g z_1 = \frac{p_3}{\rho} + \frac{v_3^2}{2} + g z_3 \Rightarrow p_1 = p_3 + \frac{\rho}{2}(v_3^2 - v_1^2)$

$P_3 = p_{w3} + p_{b3} \Rightarrow p_{w3} = p_3 - p_{b3}$

$p_{w2} = p_2 - p_{b2}$

$p_{w1} = p_1 - p_{b1}$.

~~$F_x = C_1 \cos\gamma + (\rho v_3 Q_3 + p_{w3} A_3)$~~

$C = \rho v_3 Q_3 + p_{w3} A_3$

$F_{Rx} = C_1 - C\cos\gamma$

$F_{Ry} = C_2 + C\sin\gamma$

$C_1 = \rho v_1 Q_1 \cos\alpha + \rho v_2 Q_2 \cos\beta + p_{w1} A_1 \cos\alpha + p_{w2} A_2 \cos\beta$

$C_2 = \rho v_1 Q_1 \sin\alpha - \rho v_2 Q_2 \sin\beta + p_{w1} A_1 \sin\alpha - p_{w2} A_2 \sin\beta$

$F_R = \sqrt{F_{Rx}^2 + F_{Ry}^2}$

$F_R = \sqrt{C_1^2 + C_2^2 + C^2 - 2C_1 C\cos\gamma + 2C_2 C\sin\gamma}$

$\frac{\partial F_R}{\partial\gamma} = 0 \Rightarrow \frac{2C_1 C\sin\gamma + 2C_2 C\cdot\cos\gamma}{2\sqrt{C_1^2 + C_2^2 + C^2 - 2C_1 C\cos\gamma + 2C_2 C\sin\gamma}} = 0$

$\Rightarrow 2C_1 C\sin\gamma + 2C_2 C\cos\gamma = 0$

$2C_1 C\sin\gamma = -2C_2 C\cos\gamma \Rightarrow \operatorname{tg}\gamma = -\frac{C_2}{C_1} \Rightarrow \boxed{\gamma = \operatorname{arctg}\frac{-C_2}{C_1}}$

2. $l_1 = 300\,m$

$d_1 = 200\,mm = 0{,}2\,m$

$l_2 = 400\,m$

$d_2 = 300\,mm = 0{,}3\,m$

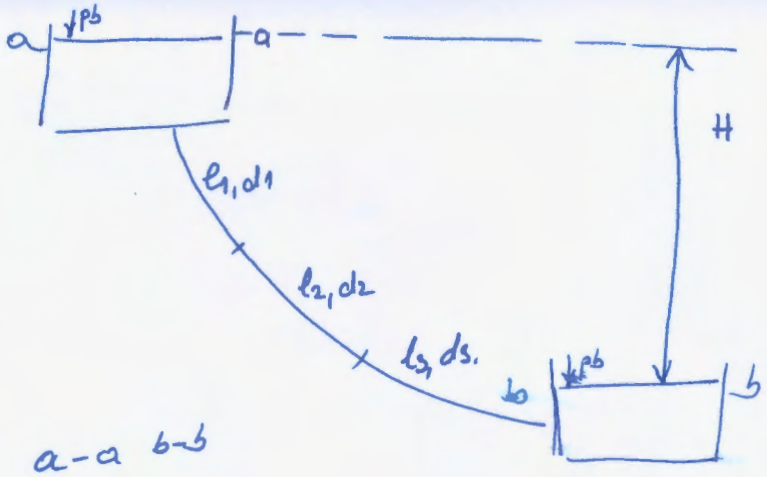
$l_3 = 1200\,m$

$d_3 = 450\,mm = 0{,}45\,m$

$Q = 360\,m^3/h = 0{,}1\,m^3/s$

$\lambda = 0{,}02$

$H = ?$



5. J. a-a b-b

$$\frac{p_a}{\rho g} + \frac{v_a^2}{2} + g z_a = \frac{p_b}{\rho g} + \frac{v_b^2}{2} + g z_b + g h_w \Rightarrow$$

$p_a = p_b \qquad v_a \approx 0$

$p_b = p_b \qquad v_b \approx 0$

$$g(z_a - z_b) = g h_w$$

$$gH = g h_w$$

$$gH = \lambda \cdot \left(\frac{l_1}{d_1} \cdot \frac{v_1^2}{2} + \frac{l_2}{d_2} \frac{v_2^2}{2} + \frac{l_3}{d_3} \cdot \frac{v_3^2}{2} \right)$$

$$v_1 = \frac{Q_1}{A_1} \Rightarrow \frac{4 \cdot Q_1}{d_1^2 \pi} = 3{,}18\,m/s$$

$$v_2 = \frac{Q_2}{A_2} \Rightarrow \frac{4 \cdot Q_2}{d_2^2 \pi} = 1{,}43\,m/s$$

$$v_3 = \frac{Q_3}{A_3} = \frac{4 \cdot Q}{d_3^2 \pi} = 0{,}625\,m/s$$

$$gH = 0{,}02 \cdot \left(\frac{300}{0{,}2} \cdot \frac{(3{,}18)^2}{2} + \frac{400}{0{,}3} \cdot \frac{(1{,}43)^2}{2} + \frac{1200}{0{,}45} \cdot \frac{(0{,}625)^2}{2} \right)$$

$$gH = 189{,}38 \Rightarrow \boxed{H = 19{,}3\,m}$$

маса: G

брзина: v

дужина: D

$v(m/s) = L \cdot T^{-1}$

$G(N) = M \cdot L \cdot T^{-2}$

$D(m) = L$

$\mu(kg/ms) = M \cdot L^{-1} T^{-1}$

$$v = G^x \mu^y D^z$$

$$L \cdot T^{-1} = M^x L^x T^{-2x} M^y L^{-y} T^{-y} L^z$$

$$\left.\begin{aligned} 0 &= x + y \\ 1 &= x - y + z \\ -1 &= -2x - y \end{aligned}\right\}$$

$x = -y$ $\quad \boxed{x = 1}$

$-1 = +2y - y \Rightarrow -1 = y \Rightarrow \boxed{y = -1}$

$1 = 1 + 1 + z \Rightarrow \boxed{z = -1}$

$$v = \frac{G}{\mu \cdot D} \Rightarrow \qquad \Pi = \frac{v \cdot \mu \cdot D}{G}$$

Тежина куглице рачуна се према изразу:

$$G = \frac{D^3 \cdot \pi \cdot \rho}{6} \qquad G_1 = \frac{D_1^3 \cdot \pi \cdot \rho}{6} \Rightarrow \frac{G_1}{G} = \frac{D_1^3}{D}$$

Брзина тонења куглице:

$$v_1 = v \cdot D \cdot \frac{\mu \cdot D_1^3}{(D_1 \cdot \mu) \cdot D^3} \Rightarrow \boxed{v_1 = 4 \cdot 10^{-5} m/s}$$

4)

$Eu_O = Eu_M$

$$\frac{p_O}{\rho_O \cdot v_O} = \frac{p_M}{\rho_M \cdot v_M^2} \Rightarrow v_M = v_O \cdot \sqrt{\frac{p_M}{p_O} \cdot \frac{\rho_O}{\rho_M}} = 6 \cdot \sqrt{\frac{1}{5} \cdot \frac{1{,}22}{1000}} = 0{,}093 \text{ m/s}$$

$$\frac{\Delta p_M}{\Delta p_O} = \frac{\rho_M \cdot v_M^2}{\rho_O \cdot v_O^2} \Rightarrow \Delta p_O = \Delta p_M \cdot \frac{\rho_O \cdot v_O^2}{\rho_M \cdot v_M^2} = 1{,}42 \text{ kPa}$$