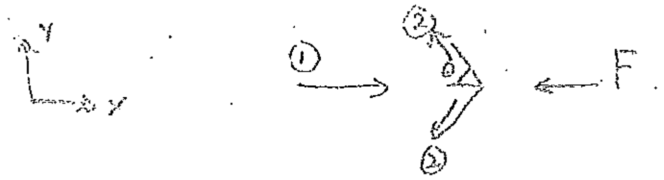
MTF052 Strömningsmek 19/10 -11

$\rho = 1000\ kg/m^3$ $V_1 = 10\ m/s$ $d = 0{,}05\ m$

Impulssatsen: $\mathbf{F} = \dot{m}(\mathbf{V}_2 - \mathbf{V}_1)$



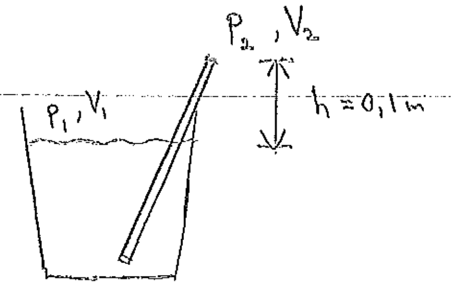
x-led $\quad -F = \dot{m}\left(-u\cos\theta - u\right)$

$$F = \dot{m}u(\cos\theta + 1) = \rho A u^2(\cos\theta + 1) =$$

$$= \rho\frac{\pi d^2}{4}u^2(\cos\theta + 1)$$

a) $\quad F = 1000\frac{\pi \cdot 0{,}05^2}{4} \cdot 10^2(\cos 60° + 1) = 294{,}5\ N$

b) $\quad F = \frac{294{,}5}{1{,}5} = 196{,}3\ N$



$\nu_v = 1{,}307 \cdot 10^{-6}\ m^2/s$

$\rho_v = 1000\ kg/m^3$

$K = 0{,}4$

B: utvidgade (3.72b) [(3.68b)]

$$p_1 + \cancel{\rho\frac{V_1^2}{2}} + \rho g z_1 = p_2 + \rho\frac{V_2^2}{2} + \rho g z_2 + \Delta p_f + \underbrace{\rho w_s}_{0}$$

ingen arbete mellan 1 o 2

$V_1 \approx 0$, $V_2 = V$, $z_2 - z_1 = h = 0{,}1\ m$

$$P_1 - P_2 = 0{,}1\rho g + \rho\frac{V^2}{2} + \Delta p_f \qquad (1)$$

6.79b) $\quad \Delta p_f = \rho\frac{V^2}{2}\left(f\frac{L}{d} + K\right)$

$$\Rightarrow P_1 - P_2 = 0{,}1\rho g + \rho\frac{V^2}{2}\left(1 + f\frac{L}{d} + K\right) \qquad (2)$$

Helt: $\quad P = F \cdot V = (P_1 - P_2)\underbrace{AV} = \Delta p\, Q \qquad (3)$

Fall ①

$$V_1^{①} = \frac{Q}{A^{①}} = \frac{Q}{4\pi r_1^2} = 1{,}43\ m/s$$

$$Re^{①} = \frac{V^{①}d^{①}}{\nu} = 2192 \quad \text{laminärt}$$

$$f^{①} = \frac{64}{Re^{①}} = 0{,}029$$

Fall ② $\quad V^{②} = \frac{Q}{A^{②}} = \frac{Q}{\pi r_2^2} = 1{,}43\ m/s$

$$Re^{②} = \frac{V^{②}d^{②}}{\nu} = 4400 \quad \text{turbulent}$$

Moody $\Rightarrow f^{②} = 0{,}0385$

Ändring i effekt: $(P^{②} - P^{①})/P^{①} =$

$$= Q(\Delta p^{②} - \Delta p^{①})/Q\Delta p^{①} = \begin{bmatrix}\text{Ny:l} \\ (2)\end{bmatrix} =$$

$$= (\Delta p_f^{②} - \Delta p_f^{①})/\Delta p^{①} = \frac{\rho\frac{V^2}{2}L\left(\frac{f^{②}}{d^{②}} - \frac{f^{①}}{d^{①}}\right)}{0{,}1\rho g + \rho\frac{V^2}{2}\left(1 + f^{①}\frac{L}{d^{①}} + K\right)} =$$

$$= -19\ \%$$

$d = 40$ mm $\quad m = 2{,}7$ g $\quad D_0 = 0{,}2$ m $\quad U_0 = 20$ m/s $\quad \rho = 1{,}189$ kg/m³ $\quad \theta = 5°$

$\nu = 15{,}2 \cdot 10^{-6}$ m²/s

$$F_D = F_g \Rightarrow C_D \frac{\rho U^2}{2} \cdot \frac{\pi d^2}{4} = mg \qquad (1)$$

KE: $$U_z A_z = U_0 A_0 \Rightarrow U_z = \frac{U_0 A_0}{A_z} = \frac{U_0 D_0^2}{D_z^2} \qquad (2)$$

$$\Delta r = z \tan\theta \Rightarrow D_z = D_0 + \Delta D = D_0 + 2\Delta r = D_0 + 2z\tan\theta \quad (3)$$

$$\left.\begin{array}{l}\text{Antag } C_D = 0{,}5 \\ U = U_0\end{array}\right\} \Rightarrow F_D = 0{,}5 \cdot \frac{1{,}189}{2} \cdot 20^2 \cdot \pi \cdot \frac{0{,}040^2}{4} \approx 0{,}149 \text{ N} > F_g$$

$$F_g = 0{,}0027 \cdot 9{,}81 = 0{,}026 \text{ N}$$

$U = 8{,}3$ m/s $\Rightarrow F_D = 0{,}026$ N, balans

$$\Rightarrow Re = \frac{8{,}3 \cdot 0{,}04}{15{,}2 \cdot 10^{-6}} = 21842 \Rightarrow C_D \text{ OK}$$ enl Fig 5.3 eller Fig 7.16b i White

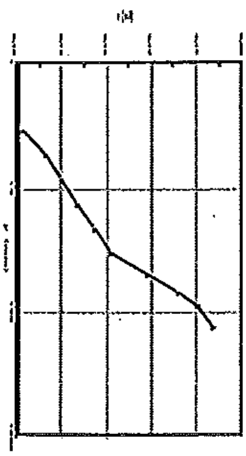
$$(2) \Rightarrow D_z = \sqrt{\frac{U_0}{U_z}}\, D_0 = \sqrt{\frac{20}{8{,}3}} \cdot 0{,}2 = 0{,}310 \text{ m}$$

$$(3) \Rightarrow z = \frac{D_z - D_0}{2\tan\theta} = \frac{0{,}310 - 0{,}2}{2\tan 5°} = 0{,}631 \text{ m}$$

<u>Svar: 0,63 m</u>

Givet: $\nu(20°C) = 1{,}004 \cdot 10\text{-}6$ m²/s $\quad \rho(20°C) = 998{,}2$ kg/m³

<u>Lösning</u>: Ritas hastighetsprofilen som funktion av log(y) fås.



Punkterna 2-6 ligger på en rät linje, log-linjen. På denna gäller (6.21):

$$\frac{\overline{u}}{u^*} = \frac{1}{\kappa}\ln\frac{yu^*}{\nu} + B$$

med k = 0,41 och B = 5,0. Vi väljer punkten 3 och finner

$$\frac{0{,}1195}{u^*} = \frac{1}{0{,}41}\ln\frac{0{,}00858u^*}{1{,}004 \cdot 10^{-6}} + 5$$

Passningsräkning ger: u* = 0,007834 m/s

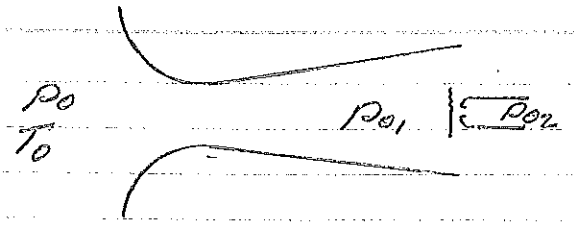
Väggskjuvspänningen fås nu som (6.18) $\qquad \tau_w = \rho u^{*2} = \mathbf{61{,}3\ \ mPa}$

Beräkna dimensionslöst avstånd från väggen för punkten y = 0,1 mm $\Rightarrow$

$$y^+ = \frac{yu^*}{\nu} = \frac{0{,}0001 \cdot 0{,}007834}{1{,}004 \cdot 10^{-6}} = 0{,}780$$

Punkten ligger alltså i det visкösa underskiktet, där det gäller (6.22):

$$u = u^* y^+ = \mathbf{6{,}11\ \ mm/s}$$



Givet: $p_0 = 3{,}0$ MPa
$T_0 = 25°C = 298$ K
$p_{02} = 1{,}2$ MPa

Sökt: M_1, T_1

Lösning: Strömningen isentropisk ⇒ $p_{01} = p_0$
— " — adiabatisk ⇒ $T_{01} = T_{02} = T_0$

$$\frac{p_{02}}{p_{01}} = \frac{1.2}{3.0} = 0.40$$

Tabell B2 ger $M_1 = 2{,}77$
Tabell B1 ger $T_1/T_{01} = 0{,}395 \Rightarrow T_1 = 298 \cdot 0.395 = 118$

Svar: $M_1 = 2{,}77$; $T_1 = 118$ K