impulssatsen i x-led:

$$\Sigma F = \int_{CS} V\rho(V\cdot n)\,dA =$$

(inga tryckkrafter $p_1 = p_2$)

$$-\dot{m}V_1 + \int_{CS2} \rho V^2\,dA =$$

$$-\rho V_1^2 2h\,dz + \rho\,dz\,2\int_0^h u^2\,dy =$$

$$= -2\rho V_1^2 h\,dz + 2\rho\,dz\int_0^h (17+10y)^2\,dy$$

$$= -2\rho V_1^2 h\,dz +$$

$$+ 2\rho\,dz\int_0^h (289 + 100y^2 + 340y)\,dy$$

$$= -2\rho V_1^2 h\,dz +$$

$$+ 2\rho\,dz\left[289y + \frac{100y^3}{3} + \frac{340y^2}{2}\right]_0^h =$$

$$= -2\rho V_1^2 h\,dz +$$

$$2\rho\,dz\left(289h + \frac{100}{3}h^3 + 170h^2\right)$$

$$\frac{F}{dz} = -2\rho V_1^2 h +$$

$$+ 2\rho\left(289h + \frac{100}{3}h^3 + 170h^2\right)$$

$$= -41{,}04 \text{ N/m}$$

F är kraften på kontrollvolym
Kraften på kroppen $F_D = -F$

$$F_D = 41 \text{ N/m}$$

Re-likformighetslag $\Rightarrow$

$Re_m = Re_b \Rightarrow (C_{Dm} = C_{Db} = C_D)$

$$\frac{U_m D_m}{\nu_m} = \frac{U_b D_b}{\nu_b} \quad (\nu_m = \nu_b)$$

$$U_m = U_b \frac{D_b}{D_m} = 5U_b \quad (1)$$

$$F_m = \frac{1}{2} C_D \rho U_m^2 A_m \Rightarrow$$

$$C_D = \frac{2F_m}{\rho U_m^2 A_m} \quad (2)$$

$$F_b = \frac{1}{2} C_D \rho U_b^2 A_b = ((1)\ \&\ (2)) =$$

$$= \frac{1}{2}\,\frac{2F_m}{\rho (5U_b)^2 A_m}\,\rho U_b^2 A_b =$$

$$= (A_b = (D_b)^2 = (5D_m)^2) =$$

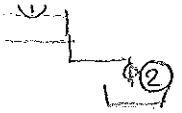
$$= \frac{F_m}{25 D_m^2}\,25 D_m^2 = F_m$$

dus $F_b = F_m = \underline{300 \text{ N}}$

Effekten:

$$P = F_b \cdot U_b = \underline{3{,}3 \text{ kW}}$$

5.68b $w_s = 0$



$$p_1 + \rho g z_1 + \frac{1}{2}\rho V_1^2 = p_2 + \rho g z_2 + \frac{1}{2}\rho V_2^2 + \Delta p_f$$

$p_1 = p_2 = p_{atm}$ $V_1 = 0$

$$\frac{1}{2}\rho V_2^2 + \Delta p_f = \rho g (z_1 - z_2) \quad (1)$$

(6.100b)

$$\Delta p_f = f\frac{\rho V^2}{2}\frac{\Delta L}{D} + (K_1 + K_2 + K_3)\frac{\rho V^2}{2} \quad (2)$$

(2) i (1) $\Rightarrow$

$$\frac{1}{2}\rho V_2^2 + f\frac{\rho V_2^2}{2}\frac{\Delta L}{D} + K\ (K_2 + K_3)\frac{\rho V_2^2}{2} = \rho g (z_1 - z_2)$$

$$\frac{1}{2}\rho V_2^2 \left(1 + f\frac{\Delta L}{D} + \underbrace{\frac{K_1 + K_2 + K_3}{2,46}}\right) = \rho g \underbrace{(z_1 - z_2)}_{h + L_1 + L_3 = 4}$$

$$V_2 = \sqrt{\frac{89}{3,46 + f\frac{\Delta L}{D}}} \quad (3)$$

f fås ur Moodydiag. $\frac{\varepsilon}{d} = 0,002$

$\nu = 10^{-6}$

gissa $V_2 = 1$ m/s $\Rightarrow$ Re = 100000 $\Rightarrow$

$f = 0,0255$ (3) $\Rightarrow V_2 = 3,97$ m/s

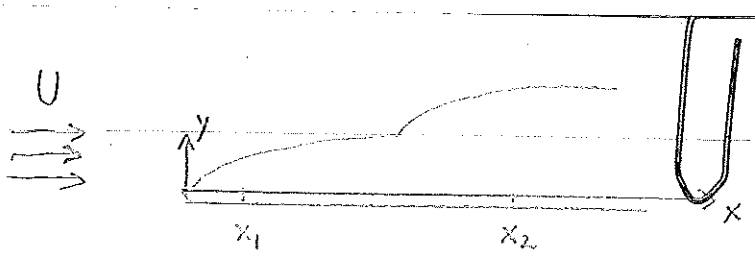
gissa $V_2 = 3,97 \Rightarrow$ Re = 397000

$\Leftrightarrow f = 0,024$ (3) $\Rightarrow V_2 = 4,0$ m/s OK

$$Q = V_2 \cdot A = V_2 \frac{\pi D^2}{4} = 3,14 \cdot 10^{-2}\ m^3/s$$

$$t = \frac{Vol}{Q} = \frac{1}{3,14 \cdot 10^{-2}} = \underline{32\ s}$$

Svar: 32 s



Givet: $U = 50$ m/s

$u(x_1, y_1) = u(x_2, y_2) = 42$ m/s

$x_1 = 0,05$ m $\quad x_2 = 2,5$ m

$t = 20°C$, $p = 100$ kPa $\Rightarrow$ $\nu = 15,2 \cdot 10^{-6}\ m^2/s$, $\rho = 1,189\ kg/m^3$

Sökt: y_1 och y_2

Lösning:

a) $x = x_1$

$$Re_{x_1} = \frac{U x_1}{\nu} = 1,64 \cdot 10^5 < Re_{x_{kr}} \Rightarrow \text{lam.}$$

$$\frac{u}{U} = \frac{42}{50} = 0,84 \quad \text{Tab. 7.1} \Rightarrow \eta = 2,96$$

$$y = \frac{\eta}{\sqrt{\frac{U}{\nu x}}} = 3,65 \cdot 10^{-4}\ m$$

b) $x = x_2$ $\quad Re_{x_2} = 8,224 \cdot 10^6 > Re_{x_{kr}} = 5 \cdot 10^5$

$\therefore$ turb gs. Antag omslag redan i framkanten

(7.43) $\Rightarrow$

$$\tau_w = 0,135 \frac{\rho U^2}{\sqrt[7]{Re_x}} = 4,127\ Pa$$

$$u^* = \sqrt{\frac{\tau_w}{\rho}} = 1,863\ m/s$$

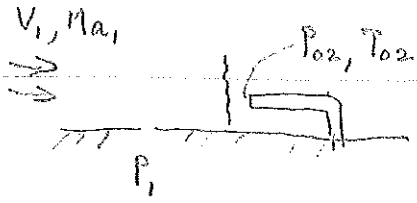
Antag log-områ: $\frac{u}{u^*} = 2,44 \ln \frac{u^* y}{\nu} + 4,9$

$$\Rightarrow y = \frac{\nu}{u^*} e^{\left(\frac{u}{u^*} - 4,9\right)/2,44} = 0,0112\ m$$

Kontroll:

$\frac{u^* y}{\nu} = 1382$, log-lagen kan anses gälla

Svar: a) $y = 0,37$ mm b) $y = 11,2$ mm



Givet: $p_1 = 35$ kPa

$T_{02} = 340°C = 613$ K

$p_{02} = 260$ kPa

Sökt: Ma_1, V_1

Gissa $Ma_1 = 2{,}0$ Tabell B1 $\Rightarrow \frac{p_1}{p_{01}} = 0{,}1278$

$\Rightarrow p_{01} = 273\,865$ Pa

$Ma_1 = 2{,}0$, Tabell B2 $\Rightarrow \frac{p_{02}}{p_{01}} = 0{,}7209 \Rightarrow p_{02} = 197\,430$ Pa

För lågt.

Gissa $Ma_1 = 2{,}3$ B1 $\Rightarrow \frac{p_1}{p_{01}} = 0{,}08 \Rightarrow p_{01} = 437\,500$

$Ma_1 = 2{,}3$ B2 $\Rightarrow \frac{p_{02}}{p_{01}} = 0{,}5833 \Rightarrow$

$\Rightarrow p_{02} = 255\,193 \approx 260$ kPa, OK

(noggrannare itereering $\Rightarrow Ma_1 = 2{,}29$)

$Ma_1 = 2{,}3$ B1 $\Rightarrow \frac{T_1}{T_{01}} = 0{,}4859 \Rightarrow$

$T_{01} = T_{02}$ (adiabatiskt)

$\therefore T_1 = 0{,}4859 \cdot 613 = 298$ K

$V_1 = Ma_1 a_1 = 2{,}3\sqrt{\kappa R T_1} =$

$= 2{,}3\sqrt{1{,}4 \cdot 287 \cdot 298} = 796$ m/s

Svar: $Ma_1 = 2{,}3$ $V_1 = 796$ m/s