MTF052 Strömningsmekanik 2014-08-18

$h_1 = h_2 = h_3 = h_4 = h$

jmukt:

$$p_1 + \rho_{H_2O}\, g h + \rho_x\, g h = (3h - h_5)\, g\, \rho_{Hg}$$

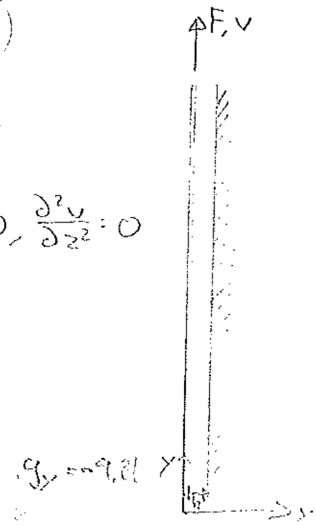
$$\rho_x = \frac{(3h - h_5)\, g\, \rho_{Hg} - \rho_{H_2O}\, g h - p_1}{g h} =$$

tabell: $\left.\begin{array}{l}\rho_{Hg} = 13550\ kg/m^3 \\ \rho_{H_2O} = 998\ kg/m^3\end{array}\right\} \Rightarrow$

$$\rho_x = 1271\ kg/m^3$$

givet: $L = 5\ m$, $b = 1\ m$, $h = 1\ cm$, $F = 850\ N$, oil SAE 50 $\left\{\begin{array}{l}\rho = 902\ kg/m^3 \\ \mu = 0{,}86\ kg/m{\cdot}s \\ \nu = 9{,}534 \cdot 10^{-4}\ m^2/s\end{array}\right.$

sökt: V



$F = -\tau \cdot A = -\tau \cdot 2 \cdot L \cdot b \Rightarrow \tau = \frac{-F}{2 \cdot L \cdot b} = -85\ N/m^2 \quad \left(= \mu \frac{\partial v}{\partial x}\right)$

N.S. i y-riktn. (endast 2-dim strömning)

$$\frac{\partial v}{\partial t} + u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} + w\frac{\partial v}{\partial z} = -\frac{1}{\rho}\frac{\partial p}{\partial y} + g_y + \nu\left(\frac{\partial^2 v}{\partial x^2} + \frac{\partial^2 v}{\partial y^2} + \frac{\partial^2 v}{\partial z^2}\right)$$

stationärt: $\frac{\partial v}{\partial t} = 0$; "lång kanal": $u = 0$, $w = 0$, $\frac{\partial v}{\partial y} = 0$, $\frac{\partial v}{\partial z} = 0$, $\frac{\partial^2 v}{\partial y^2} = 0$, $\frac{\partial^2 v}{\partial z^2} = 0$

försumma trycket: $\frac{\partial p}{\partial y} = 0$

$\Rightarrow \quad 0 = g_y + \nu \frac{\partial^2 v}{\partial x^2} \quad \Rightarrow \quad \frac{\partial^2 v}{\partial x^2} = -\frac{g_y}{\nu}$

integrera:

$$\frac{\partial v}{\partial x} = -\frac{g_y}{\nu} x + C_1 \qquad (1)$$

integrera:

$$v = -\frac{g_y}{\nu}\frac{x^2}{2} + C_1 x + C_2 \qquad (2)$$

R.V. 1: $x = 0 \quad \mu \frac{\partial v}{\partial x} = \tau \Rightarrow \frac{\partial v}{\partial x} = \frac{\tau}{\mu}$

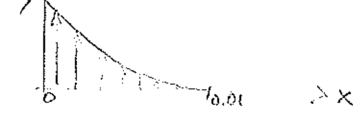
$(1) \Rightarrow \frac{\tau}{\mu} = -\frac{g_y}{\nu} \cdot 0 + C_1 \Rightarrow C_1 = \frac{\tau}{\mu}$

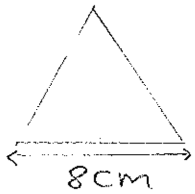
R.V. 2: $x = 0{,}01\ m \quad v = 0$

$(2) \Rightarrow 0 = -\frac{g_y}{\nu}\frac{0{,}01^2}{2} + \frac{\tau}{\mu} \cdot 0{,}01 + C_2 \Rightarrow C_2 = \frac{g_y}{\nu}\frac{0{,}01^2}{2} - \frac{\tau}{\mu} \cdot 0{,}01$

$\Rightarrow v = -\frac{g_y}{\nu}\frac{x^2}{2} + \frac{\tau}{\mu}x + \frac{g_y}{\nu}\frac{0{,}01^2}{2} - \frac{\tau}{\mu}0{,}01 = \frac{g_y}{\nu \cdot 2}(0{,}01^2 - x^2) + \frac{\tau}{\mu}(x - 0{,}01)$

$v(x = 0) = 0{,}47\ m/s$





$\varepsilon = 0{,}30$ mm
$Q = 0{,}02\ m^3/s$
$L = 50$ m
$t = 10°C$

3.68b)

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

$A_1 = A_2 \Rightarrow V_1 = V_2 = V = \frac{Q}{A} = 7{,}2 m/s$
$z_1 = z_2$
$w_s = 0$ (inget tillfört arbete)

$$p_1 - p_2 = \Delta p_f$$

6.10b) $\Delta p_f = f \frac{L}{d} \rho \frac{V^2}{2}$

icke cirkulärt $D_h = \frac{4A}{P} = \frac{8}{\sqrt{3}} \cdot 10^{-2} m$

$$Re_{D_h} = \frac{V \cdot D_h}{\nu} = 2{,}6 \cdot 10^5 > Re_c$$
$\Rightarrow$ turbulent

skrovligt rör $\frac{\varepsilon}{D_h} = 6{,}5 \cdot 10^{-3}$

Moody diagram $\Rightarrow f = 0{,}033$

$$p_1 - p_2 = f \frac{L}{D_h} \rho \frac{V^2}{2} = \underline{\underline{930 kPa}}$$

Givet: $x = 3m$, $y = 0{,}003$ m, $\bar{u} = 3$ m/s
Luft, $t = 20°C$, Tabell 1.4 $\Rightarrow$
$\mu = 18 \cdot 10^{-6}$ kg/ms, $\nu = 15 \cdot 10^{-6} m^2/s$, $\rho = 1{,}2$ kg/m³

Sökt: τ_w, U och δ

Lösning: Laminärt eller turbulent?
Beräkna Re_x baserat på $\bar{u}$

$$Re_x = \frac{\bar{u} x}{\nu} = \frac{3 \cdot 3}{15 \cdot 10^{-6}} = 6 \cdot 10^5 > 5 \cdot 10^5$$

alltså bör Re_x baserat på U vara ändå större
$\Rightarrow$ Sannolikt turbulent

log-lagen: $\frac{\bar{u}}{u^*} = 2{,}44 \ln\left(\frac{u^* y}{\nu}\right) + 4{,}9$

$$\Rightarrow \left(\frac{3}{u^*} - 4{,}9\right) \cdot \frac{1}{2{,}44} \quad \ln \frac{u^* \cdot 0{,}003}{15 \cdot 10^{-6}}$$

Iterera fram u^*

	VL	HL
Gissa $u^* = 0{,}2$ m/s	4,14	3,68
0,22	3,58	3,78
0,213	3,76	3,75

$u^* = 0{,}213$ m/s, kolla $y^+ = \frac{u^* y}{\nu} = 42{,}6$ ∴ log-omr OK

$$\underline{\tau_w = \rho u^{*2} = 0{,}054 \text{ Pa}}$$

(7.44) $\Rightarrow$

$$\underline{U} = \left(\frac{\tau_w x^{1/7}}{0{,}0135 \mu^{1/7} \rho^{6/7}}\right)^{7/13} = \underline{4{,}89 \text{ m/s}}$$

$$Re_x = \frac{4{,}89 \cdot 3}{15 \cdot 10^{-6}} = 9{,}78 \cdot 10^5$$

(7.1) $\Rightarrow$ $\underline{\delta} = \frac{0{,}16 x}{Re_x^{1/7}} = \underline{0{,}067 \text{ m}}$

(giltig för $Re_x > 1 \cdot 10^6$)

$\frac{A_e}{A^*} = 3$

$P_0 = 100$ kPa.

Två områden där vi inte får stöt:

1) Stöt i utloppet (supersoniskt)
↓
Totalt expanderat

2) Ingen strömning (subsoniskt)
↓
Chokat men subsoniskt.

1) $\frac{A_e}{A^*} = \frac{1}{Ma} \frac{(1 + 0{,}2\ Ma^2)^3}{1{,}728}$ ⇒ Ma_e (sup) = 2,6374.
Ma_e (sub) = 0,1975

$\frac{P_0}{P_e} = (1 + 0{,}2\ Ma_e^2)^{3,5}$ ⇒ $P_e = \ldots = 4{,}73$ kPa.

Över stöten

$\frac{P_2}{P_1} = \frac{1}{k+1} \left[2k\, Ma_1^2 - (k-1)\right]$

$P_2 = 37{,}6$ kPa.

⇒ $\underline{0 < P_b = P_e < 37{,}6 \text{ kPa.}}$

2) $Ma_e = 0{,}1975$

⇒ $P_e = 97{,}32$ kPa.

$\underline{97{,}3 < P_b = P_e < 100 \text{ kPa}}$