MTF052 Strömn. mek 2012-08-24

(2.8)

~~(2.15)~~ $\nabla p = \rho(\mathbf{g} - \mathbf{a}) + \mu \nabla^2 \mathbf{V}$

Ingen relativrörelse mellan elementen

$\nabla p = \rho(\mathbf{g} - \mathbf{a})$

z-axeln uppåt $\Rightarrow \frac{dp}{dz} = \rho(-g - a)$ (1)

$p_2 = 100$ kPa , vi söker p_1

a) $a = 7g$

$(1) \Rightarrow \frac{dp}{dz} = \rho(-8g)$

$p_2 - p_1 = -8\rho g(z_2 - z_1)$

$p_1 = p_2 + 8\rho g(z_2 - z_1) =$

$= 100 \cdot 10^3 + 8 \cdot 1000 \cdot 9{,}81 \cdot 0{,}05 = \underline{\underline{103{,}9 \text{ kPa}}}$

b) $a = -g$

$(1) \Rightarrow \frac{dp}{dz} = \rho \cdot 0$

$\Rightarrow p = \text{konst} \Rightarrow p_1 = p_2 = \underline{\underline{100 \text{ kPa}}}$

c) $V = \text{konst} \Rightarrow a = 0$

$(1) \Rightarrow \frac{dp}{dz} = -\rho g$

$p_1 = p_2 + \rho g(z_2 - z_1) = \underline{\underline{100{,}5 \text{ kPa}}}$

(samma som om muggen stått still, dvs hydrostatiskt, om man bortser från vakeffekter. I verkligheten minska trycket p_2 också pga avlösning)

$\nu_v = 10^{-6}, \nu_L = 15 \cdot 10^{-6}$

dynamisk likformighet

$Re_b = Re_m \Rightarrow C_{D_b} = C_{D_m}$

$\frac{U_b D_b}{\nu_L} = \frac{U_m D_m}{\nu_v}$

$U_m = U_b \frac{D_b}{D_m} \frac{\nu_v}{\nu_L} = 9{,}3 \text{ m/s}$

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

$F_m = \frac{1}{2} \rho_v A_m C_D U_m^2$ (2)

$C_D = \frac{F_m \cdot 2}{\rho_v A_m U_m^2}$ (3)

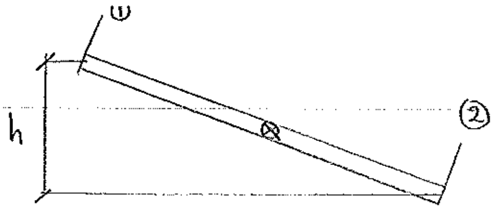
sätt in (3) i (1)

$F_b = \frac{1}{2} \rho_L A_b U_b^2 \frac{F_m \cdot 2}{\rho_v A_m U_m^2} =$

$= \frac{\rho_L}{\rho_v} \frac{A_b}{A_m} \frac{U_b^2}{U_m^2} F_m$

$= \frac{\rho_L}{\rho_v} \left(\frac{D_b}{D_m}\right)^2 \left(\frac{U_b}{U_m}\right)^2 F_m = \underline{\underline{1{,}2 \text{ kN}}}$

Svar: 1,2 kN



Givet: $h = z_1 - z_2 = 12{,}5$ m
$L = 60$ m $\quad p_1 = 420$ kPa $\quad p_2 = 110$ kPa
$d = 0{,}11$ m $\quad Q_A = 240$ m³/h $\quad Q_B = 200$ m³/h
Antag $t = 20°C \Rightarrow \nu = 1{,}0 \cdot 10^{-6}$ m²/s $\quad \rho = 10^3$ kg/m³
Sökt: Ventilens engångsförlustkoeff K.

Lösning. Bestäm först friktionsfaktorn f för fall A
bernoullis utvidgade ekv, (3.68 b):

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

$\rho w_s = 0 \quad V_1 = V_2$

$$\Delta p_f = (420 - 110)\cdot 10^3 + 10^3 \cdot 9{,}81 \cdot 12{,}5 = 433 \cdot 10^3 \text{ Pa}$$

$$\Delta p_{fA} = f \frac{L}{d} \rho \frac{V^2}{2} \qquad (6.30)$$

KE $\Rightarrow V_A = 7{,}0$ m/s $\quad \Rightarrow \quad f_A = 0{,}0324$

$$Re_A = \frac{V_A \cdot d}{\nu} = 7{,}7 \cdot 10^5$$

Moody diagram $\Rightarrow \dfrac{\varepsilon}{d} = 0{,}006$

Beräkna K. $\quad V_B = 5{,}85$ m/s , $Re_B = 6{,}43 \cdot 10^5$

Moody diagram $\Rightarrow$ f ändras försumbart

$\therefore f_B = 0{,}0324$

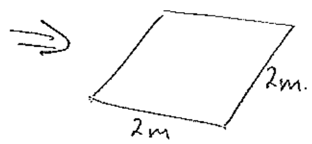
Nu är $\Delta p_{fB} = \Delta p_{fA}$

$$\therefore \Delta p_f = f \frac{L}{d} \rho \frac{V_B^2}{2} + K \rho \frac{V_B^2}{2} = 433 \cdot 10^3 \text{ Pa}$$

Ins ger $K = 7{,}68$

Svar: $K = 7{,}68$

$p = 1$ bar
$T = 20°C$
$U - 3$ m/s
$A - 4$ m²



Luft $\begin{cases} \mu = 18{,}1 \cdot 10^{-6} \text{ Ns/m} \\ \rho = 1{,}189 \text{ kg/m}^3 \end{cases}$

Vatten $\begin{cases} \mu = 1005 \cdot 10^{-6} \text{ Ns/m} \\ \rho = 998 \text{ kg/m}^3 \end{cases}$

Dragkraften
Luft: $\quad D = 2 \cdot \frac{1}{2} C_D \rho U^2 b \cdot L$

$Re_L = \dfrac{\rho U L}{\mu} = 394 \cdot 10^3 \quad \therefore$ Lam.

(7.27) $\quad C_D = \dfrac{1{,}328}{Re_L^{1/2}} = 0{,}00211$

$D = 90{,}5 \cdot 10^{-3}$ N

Vatten:

$Re_L = \dfrac{\rho U L}{\mu} = 5{,}96 \cdot 10^6 \quad \therefore$ Turb

(7.45) $\quad C_D = \dfrac{0{,}031}{Re_L^{1/7}} = 0{,}00334$

$D = 120$ N

Hastighet.
Luft: $\quad y = 0{,}5$ mm $\quad x = 2$ m.

$$y \cdot \left(\frac{U}{\nu x}\right)^{1/2} = 0{,}144$$

Interpolering $\Rightarrow u/U = 0{,}048$

$u = 0{,}143$ m/s.

Vatten:
(7.44) $\quad \tau_w = \dfrac{0{,}0135\, \mu^{1/7} \rho^{6/7} U^{13/7}}{L^{1/7}}$

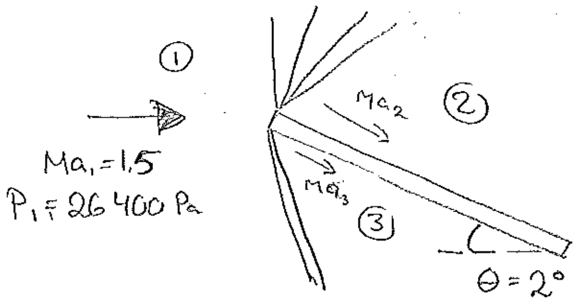
$= 13{,}06$ Pa

$u^* = \sqrt{\dfrac{\tau_w}{\rho}} = 114{,}4 \cdot 10^{-3}$ m/s

$y^+ = \dfrac{y u^* \rho}{\mu} = 56{,}8 \Rightarrow$ log-lag

$\dfrac{u}{u^*} = 2{,}44 \ln y^+ + 5 \quad \Rightarrow u = 1{,}7$ m/s

$m = 6000$ kg
$g = 9{,}81$
$c = 1$m
$k = 1{,}4$



1) Före vingen $\frac{p_0}{p_1} = (1+0{,}2 Ma_1^2)^{3,5} \Rightarrow p_0 = 96915$ Pa

2) Isentropisk expansion.
[B5] $\omega(Ma_1 = 1{,}5) = 11{,}91°$
$2°$ expansion $\Rightarrow \omega(Ma_2) = 13{,}91°$
$\Rightarrow$ {Interpolera} $Ma_2 = 1{,}568$.
$\frac{p_{02}}{p_2} = (1+0{,}2 Ma_2^2)^{3,5}$ $[p_{02} = p_0] \Rightarrow P_2 = \underline{23904 \text{ Pa}}$

3) Sned stöt med avlänkning $\theta = 2°$
(9,86) $\tan\theta = \frac{2(Ma_1^2 \sin^2\beta - 1)}{\tan\beta(Ma_1^2(k+\cos 2\beta)+2)} \Rightarrow \beta = 44{,}1°$

Räkna igenom stöten med (9,83a)

$\frac{p_3}{p_1} = \frac{1}{k+1}\left[2kMa_1^2 \sin^2\beta - (k-1)\right]$
$\Rightarrow P_3 = \underline{29162 \text{ Pa}}$

Planet skall hålla konst. höjd
$(P_3 - P_2)\cdot\cos\theta\cdot c\cdot b = m\cdot g$
$\Rightarrow b = \underline{\underline{11{,}2 \text{ m}}}$