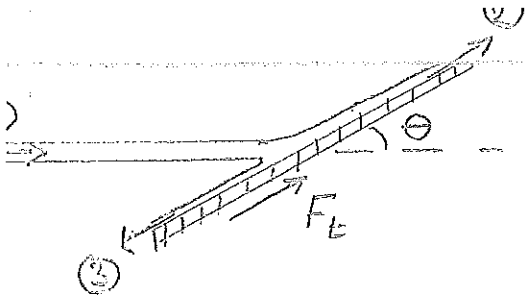


Impulssatsen i tangentiell riktning:

$F_b = 0$

$F_L = \sum((\dot{m}V)_{ut} - (\dot{m}V)_{in})$ (1)

$0 = \rho A_2 V_2^2 - \rho A_3 V_3^2 - \rho A_1 V_1^2 \cos\Theta$ (2)

$\rho V_1 A_1 = \rho V_2 A_2 + \rho V_3 A_3$ (3)

Bernoulli:

$p_1 + \rho V_1^2 = p_2 + \rho V_2^2 = p_3 + \rho V_3^2$ (4)

$\Rightarrow V_1 = V_2 = V_3$ (5)

(5) i (3) $\Rightarrow$

$A_1 = A_2 + A_3 \Rightarrow A_3 = A_1 - A_2$ (6)

(5) & (6) i (2) $\Rightarrow$

$0 = A_2 - (A_1 - A_2) - A_1\cos\Theta$

$2A_2 = A_1(1+\cos\Theta)$

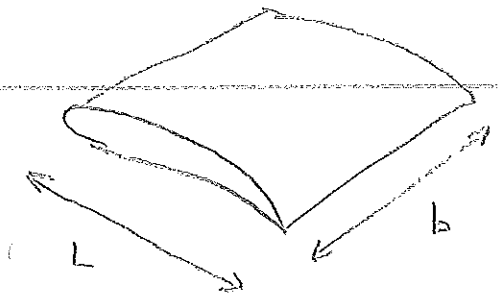
$A_2 = A_1\frac{(1+\cos\Theta)}{2}$ (7)

$Q_2 = A_2 V_2 \overset{(7)}{=} A_1\frac{(1+\cos\Theta)}{2} V_2 =$

$(5) = \underbrace{A_1 V_1}_{Q_1}\frac{(1+\cos\Theta)}{2} =$

$0{,}9\ m^3/s$

$Q_3 = Q_1 - Q_2 = 0{,}1\ m^3/s$



fullskala	modell
$L = 1{,}0$ m	$L = 0{,}3$ m
$U = 25$ m/s	$U = ?$
$t = 20°C$	$t = 30°C$
DRY eller White:	
$\nu = 15{,}2\cdot10^{-6}\ m^2/s$	$\nu = 16{,}2\cdot10^{-6}\ m^2/s$
$\rho = 1{,}189\ kg/m^3$	$\rho = 1{,}151\ kg/m^3$

Sökt $(F_L)_f$

White kap 5

eller

$\Rightarrow F_L = C_L(Re)\cdot A\cdot\frac{\rho U^2}{2}$

Re - likformighetslag. $\Rightarrow (Re)_f = (Re)_m$

$\Rightarrow \left(\frac{UL}{\nu}\right)_f = \left(\frac{UL}{\nu}\right)_m$

$U_m = \frac{(UL/\nu)_f}{(L/\nu)_m} = 88{,}82\ m/s$

Samma Re $\Rightarrow (C_L)_f = (C_L)_m$

$\frac{(F_L)_f}{(F_L)_m} = \frac{(A\rho U^2)_f}{(A\rho U^2)_m} = \frac{(Lb\rho U^2)_f}{(Lb\rho U^2)_m} =$

$= \left[\begin{matrix}\text{Samma skalfaktor}\\ \text{på L och b}\end{matrix}\right] = \frac{(L^2\rho U^2)_f}{(L^2\rho U^2)_m}$

$\Rightarrow (F_L)_f = (F_L)_m\cdot\frac{1{,}0^2\cdot1{,}189\cdot25^2}{0{,}3^2\cdot1{,}151\cdot88{,}82^2}$ (1)

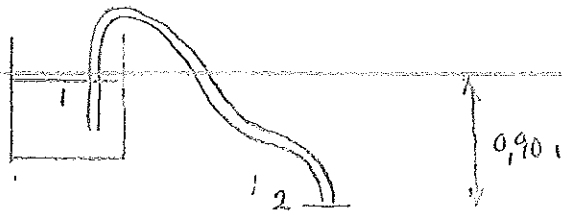
Diagram ger (för $U_m = 88{,}82$ m/s)

$(F_L)_m = 4{,}7\cdot10^3$ N

Eku (1) $\Rightarrow (F_L)_f = 4274$ N

Svar: $4{,}3\cdot10^3$ N

Bernoullis utvidgade (3.68b):



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

$p_1 = p_2$, $V_1 \approx 0$, $z_1 - z_2 = 0{,}9$ $\Rightarrow$

$0{,}9\,\rho g = \rho\frac{V_2^2}{2} + \Delta p_f$ där $\Delta p_f = f\,\rho\frac{V^2}{2}\frac{L}{d}$ (6.10b) (6.65b), $f = f(Re, \frac{\varepsilon}{d})$, $\frac{\varepsilon}{d} = 1{,}25\cdot 10^{-3}$

$\therefore$ $\boxed{0{,}9\,g = \frac{V_2^2}{2}\left(1 + f\frac{L}{d}\right)}$ (1)

$\nu = 1\cdot 10^{-6}\ m^2/s$, $L = 8{,}5\ m$, $d = 0{,}008\ m$

Antag laminärt, (6.66) (16.12) $\Rightarrow$

$f = \frac{64}{Re} \Rightarrow 0{,}9\,g = \frac{V_2^2}{2}\left(1 + \frac{L}{d}\cdot\frac{64\nu}{d\,V_2}\right)$

$\Rightarrow$ $V_2 = 1{,}73\ m/s \Rightarrow Re = 13840 > 2300$

$\therefore$ Turbulent strömning, antagandet var fel.

Använd ekv (6.64a-c) (6.69)

$$\frac{1}{f^{1/2}} \approx -1{,}8\log\left[\frac{6{,}9}{Re_d} + \left(\frac{\varepsilon/d}{3{,}7}\right)^{1{,}11}\right]$$ (2)

Iterera; $Re = 13840$, (2) $\Rightarrow f = 0{,}0285$

Ins i (1) $\Rightarrow V_2 = 0{,}752 \Rightarrow Re = 6017$

(2) $\Rightarrow f = 0{,}0358$, (1) $\Rightarrow V_2 = 0{,}673 \Rightarrow Re = 5381$

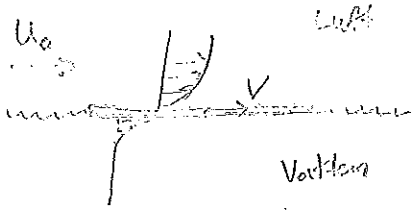
etc $\Rightarrow$ $V_2 = 0{,}66\ m/s$ $Re = \frac{Vd}{\nu} = 5285 > Re_k$

$Q = V_2\frac{\pi d^2}{4} = 3{,}32\cdot 10^{-5}\ m^3/s$

Svar: $Q = 2{,}0$ liter/min

(2) Det går lika bra att använda Moody-diagrammet
ε/d är litet $\Rightarrow$ ≈ slätt rör.

Givet: $L = 2\ m$
$b = 1\ m$
$U_0 = 20\ m/s$
$T = 20°C$
$\varepsilon = 2$ mm



Sök: V, hastigheten på stråken

Lösning:
$\nu_{luft} = 1{,}5\cdot 10^{-5}\ m^2/s$
$\rho_{luft} = 1{,}2\ kg/m^3$
$\nu_{H_2O} = 1{,}005\cdot 10^{-6}\ m^2/s$
$\rho_{H_2O} = 998\ kg/m^3$

$F_{ovan} = F_{under}$

$F_{ovan} = C_D\cdot\frac{\rho_l(U_0 - V)^2}{2}\cdot L\cdot b$

$F_{under} = C_D\cdot\frac{\rho_{H_2O}\cdot V^2}{2}\cdot L\cdot b$

$\Rightarrow C_D\cdot\frac{\rho_l(U_0-V)^2}{2}\cdot 1\cdot 1 = C_D\cdot\frac{\rho_{H_2O}\cdot V^2}{2}\cdot 1\cdot 1$

$\Rightarrow V^2 - \frac{2U_0}{\left(1-\frac{\rho_{H_2O}}{\rho_l}\right)}\cdot V + \frac{U_0^2}{\left(1-\frac{\rho_{H_2O}}{\rho_l}\right)} = 0$

$\Rightarrow V^2 + 0{,}048194\cdot V - 0{,}48157 = 0$

$\Rightarrow$ ~~$V_1 = -0{,}72$~~ $V_2 = 0{,}67\ m/s \Rightarrow$

$Re_{ovan} = \frac{19{,}33\cdot 2}{1{,}5\cdot 10^{-5}} \approx 2{,}6\cdot 10^6$

$Re_{under} = \frac{0{,}67\cdot 2}{1{,}005\cdot 10^{-6}} \approx 1{,}3\cdot 10^6$

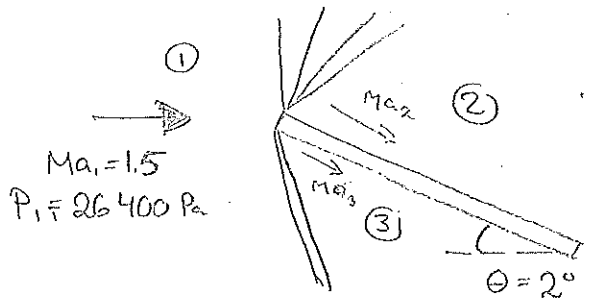
$\frac{L}{\varepsilon} = \frac{2}{0{,}002} = 1000$

{Fig 7.6, anta "fully rough"! ($Re > 10^5$)} $\Rightarrow C_{D,ovan} = C_{D,under}$

"fully rough" antagande ok!

Svar: $V = 0{,}67\ m/s$

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



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

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

3) Snedstöt 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)

$\frac{p_3}{p_1} = \frac{1}{k+1}[2kMa_1^2 \sin^2\beta - (k-1)]$

$\Rightarrow p_3 = \underline{29162 \text{ Pa}}$

Planet skall hålla konst. höjd.

$(p_3 - p_e) \cdot \cos\theta \cdot c \cdot b = m \cdot g$

$\Rightarrow b = 11{,}2$ m