2º TESTE MFI (MA10)
19/12/2014

Ar $(\rho = 1{,}26\ kg\ m^{-3}\ ;\ \nu = 1{,}5\times10^{-5}\ m^2 s^{-1})$

$a = 3{,}8\ cm = 0{,}038\ m$ $\qquad v_0 = 14\ m s^{-1}$

$L = 22\ cm = 0{,}22\ m$ $\qquad N = 400$

a) laminar, $\frac{dp}{dx} = 0 \Rightarrow$ BLASIUS:

$$Re_L = \frac{v_0 . L}{\nu} = \frac{14 . 0{,}22}{1{,}5\times10^{-5}} = 2{,}05\times10^{5} < 5{,}5\times10^{5} \quad \text{(escoamento laminar)}$$

BLASIUS

$$\frac{\delta(x)}{x} = \frac{5{,}0}{\sqrt{Re_x}} \Rightarrow \delta(L) = 2{,}429\times10^{-3}\ m$$

$$\frac{\delta^*(x)}{x} = \frac{1{,}721}{\sqrt{Re_x}} \Rightarrow \delta^*(L) = 8{,}362\times10^{-4}\ m$$

$$\frac{\theta(x)}{x} = \frac{0{,}664}{\sqrt{Re_x}} \Rightarrow \theta(L) = 3{,}226\times10^{-4}\ m$$

b) 1 camada limite

$$C_D = \frac{D}{\frac{1}{2}\rho v_0^2 L . a} = \frac{1{,}33}{\sqrt{Re_L}} \Rightarrow D(L) = \frac{1{,}33}{\sqrt{Re_L}} . \frac{1}{2} . \rho v_0^2 L . a =$$

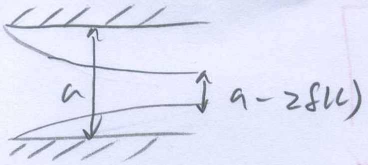
$$= \frac{1{,}33}{\sqrt{0{,}205\times10^6}} . \frac{1}{2} . 1{,}26 . 14^2 . 0{,}22 . 0{,}038$$

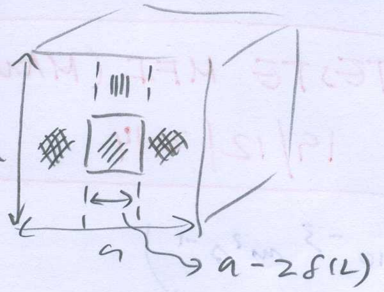
$$= 3{,}036\times10^{-3}\ N$$

Por cada elemento: $4 \times 3{,}036\times10^{-3} = 1{,}22\times10^{-2}\ N$

Por 400 elementos: $D_\nu = 4{,}890\ N$

c)





continuidade:

$$v_0 \cdot a^2 = v_e(L) \cdot \left[a - 2\delta(L)\right]^2 + 2 \cdot v_e(L) \left[\delta(L) - \delta^*(L)\right] \cdot a \; +$$

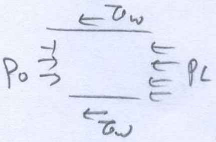
$$+ \; 2 v_e(L) \cdot \left[\delta(L) - \delta^*(L)\right] \cdot \left[a - 2\delta(L)\right]$$

$$v_0 \cdot a^2 = v_e(L) \left[(a - 2\delta(L))^2 + 2a(\delta(L) - \delta^*(L)) + 2(\delta(L) - \delta^*(L)) \times (a - 2\delta(L)) \right]$$

$$14 \cdot 0{,}038^2 = v_e(L) \left[1{,}098 \times 10^{-3} + 0{,}121 \times 10^{-3} + 1{,}0558 \times 10^{-4} \right]$$

$$v_e(L) = 15{,}262 \text{ m s}^{-1}$$

d)



$$\Sigma F_x = \iint u\rho\,(\vec{v}\cdot\vec{n})\,ds \Leftrightarrow$$

$$p_0 \cdot a^2 - p_L \cdot a^2 - D + v_0 \rho(-v_0) \cdot a^2 + \rho\, v_e^2(L) \cdot a^2 + \rho \int u^2(y)\,dy \times \left[2a + 2(a - 2\delta(L))\right] \Leftrightarrow$$

$$\int u^2(y)\,dy = v_e^2 \left[\delta - \delta^* - \theta\right]$$

$$\Delta p \cdot a^2 - D = \rho\left[-v_0^2 \cdot a^2 + v_e^2(L) \cdot a^2 + v_e^2(L)\left[\delta(L) - \delta^*(L) - \theta(L)\right] \cdot \left[2a + 2a - 4\delta(L)\right]\right]$$

$$\Delta p = 92{,}28 \text{ Pa}$$

e)

$$v(y) = -\int_0^y \frac{\partial u}{\partial x} \cdot dy = \int_0^y \left(\frac{dv_e}{dx} - \frac{du}{dx} - \frac{dv_e}{dx}\right) dy = \frac{d}{dx}\int_0^y (v_e - u)\,dy - \int_0^y \frac{dv_e}{dx} \cdot dy$$

$$= v_e \frac{d}{dx}\int_0^y \left(1 - \frac{u}{v_e}\right) dy - \frac{dv_e}{dx} \cdot y$$

$$\frac{d\delta^*}{dx} = 1{,}721 \left(\frac{1{,}5 \times 10^{-5}}{14}\right)^{1/2} \left(\frac{1}{2}\right) x^{-1/2}$$

$$y = \delta: \quad v(y = \delta) = v_e \cdot \frac{d\delta^*}{dx} - \frac{dv_e}{dx} \cdot y$$

BLASIUS $\quad \frac{dv_e}{dx} = 0 \Rightarrow v(\delta) = v_e \cdot \frac{d\delta^*}{dx}$

$$v(\delta) = 14 \cdot 8{,}907 \times 10^{-4} \cdot 0{,}22^{-1/2} =$$

$$= 2{,}658 \times 10^{-2} \text{ m s}^{-1}$$