Rešenja: Zadatak br. 1

① $p + \frac{1}{2}\rho \cdot V^2 = p + \rho g \cdot \Delta h$

$\Delta p = \frac{1}{2}\rho \cdot V^2$ - dinamički pritisak

a) I - način

$h = 0 \rightarrow \rho_n = 1,225 \left[kg/m^3\right]$ $\quad V_e = 97,2 \left[m/s\right]$

$V_i = V_e = 350 \cdot \frac{1000}{3600} = 97,2 \left[m/s\right]$

$\Delta p = \frac{1}{2} \cdot \rho_n \cdot V_i^2 = \frac{1}{2} \cdot 1,225 \cdot 97,2^2 = 5789,2 \left[Pa\right]$

za $h = 5000 \left[m\right] \rightarrow$

$\rho_{H=5000} = \rho_n \left(1 - 2,256 \cdot 10^{-5} \cdot H_g\right)^{4,256} = 1,225 \left(1 - 2,256 \cdot 10^{-5} \cdot 5000\right)^{4,256}$

$\rho_{amb} = \rho_{H=5000} = 0,7361 \left[kg/m^3\right]$

$\Delta p = \frac{1}{2} \cdot \rho_{amb} \cdot V_s^2 \Rightarrow V_s = \sqrt{\frac{2\Delta p}{\rho_{amb}}} = \sqrt{\frac{2 \cdot 5789,2}{0,7361}}$

$\boxed{V_s = 125,4 \left[m/s\right]}$

II način:

$\rho_n \cdot V_e^2 = \rho_{H=5000} \cdot V_s^2 \Rightarrow V_s = V_e \sqrt{\frac{\rho_n}{\rho_{amb}}} = 97,2 \cdot \sqrt{\frac{1,225}{0,7361}}$

$\boxed{V_s = 125,4 \left[m/s\right]}$

b) $Ma = \frac{V}{a}$ ; $\kappa = 1,4$ ; $R = 287,053 \left[J/kgK\right]$

$a = \sqrt{\kappa \cdot R \cdot T} = \sqrt{\kappa \cdot \frac{p_{amb}}{\rho_{amb}}} = \sqrt{1,4 \cdot \frac{54.015,42}{0,7361}} = 320,519 \left(m/s\right) \Rightarrow Ma = \frac{125,4}{320,519}$

$\boxed{Ma = 0,391}$

$p_{amb} = p_n \left(1 - 2,256 \cdot 10^{-5} \cdot H_g\right)^{5,256} = 101325 \cdot \left(1 - 2,256 \cdot 10^{-5} \cdot 5000\right)^{5,256}$

$\boxed{p_{amb} = 54.015,42 \left[Pa\right]}$

## Zadatak br. 2

Rješenje:

$V = 180\ [km/h] = \frac{180}{3,6} = 50\ [m/s]$ — slika napodele pridružena u praktikumu

$\Delta p_g = -100\ [mm]H_2O \rightarrow \Delta p_g = \rho_v \cdot g \cdot h = 1000 \cdot 9,81 \cdot (-0,1) = -981\ [Pa]$

$\Delta p_d = 50\ [mm]H_2O \rightarrow \Delta p_d = \rho_v \cdot g \cdot h = 1000 \cdot 9,81 \cdot 0,05 = 490,5\ [Pa]$

za $h = 0\ [m]$ $\longrightarrow$ iz tablica za St. atmosferu $\rightarrow \rho_n = 1,225\ [kg/m^3]$

a) Aerodinamička sila po jedinici raspona krila

$F_1 = \Delta \bar{p}_1 \cdot \frac{l}{2} \cdot 1 = -981 \cdot 0,5 = -490,5\ [N]$ ; $\Delta \bar{p}_1 = \Delta p_g = -981\ [Pa]$

$F_2 = \Delta \bar{p}_2 \cdot \frac{l}{2} \cdot 1 = -490,5 \cdot 0,5 = -245,25\ [N]$ ; $\Delta \bar{p}_2 = \frac{\Delta p_g}{2} = \frac{-981}{2} = -490,5\ [Pa]$

$F_3 = \Delta \bar{p}_3 \cdot \frac{l}{2} \cdot 1 = 245,25 \cdot 0,5 = 122,625\ [N]$

$F_4 = \Delta \bar{p}_4 \cdot \frac{l}{2} \cdot 1 = 245,25 \cdot 0,5 = 122,625\ [N]$

aerodinamička sila po jedinici raspona krila:

$F_z = |F_1| + |F_2| + F_3 + F_4 = 490,5 + 245,25 + 122,625 + 122,625 \Rightarrow \boxed{F_z = 981\ [N]}$

b) aerodinamički koeficijent uzgona:

$R_z = F_z = \frac{1}{2} \rho_n \cdot V^2 \cdot S_{kr} \cdot C_z \Rightarrow C_z = \frac{2 \cdot R_z}{\rho_n \cdot V^2 \cdot S_{kr}} = \frac{2 \cdot 9,81}{1,225 \cdot 50^2 \cdot 1 \cdot 1} \Rightarrow \boxed{C_z = 0,641}$

c) moment oko napadne ivice aeroprofila

$M_0 = -|F_1| \cdot x_1 - |F_2| \cdot x_2 - F_3 \cdot x_3 - F_4 \cdot x_4 \Rightarrow$

$M_0 = -|F_1| \cdot \frac{l}{4} - |F_2| \cdot \left(\frac{l}{2} + \frac{1}{3} \cdot \frac{l}{2}\right) - F_3 \cdot \left(\frac{2}{3} \cdot \frac{l}{2}\right) - F_4 \left(\frac{l}{2} + \frac{1}{3} \cdot \frac{l}{2}\right)$

$M_0 = -|F_1| \cdot \frac{l}{4} - |F_2| \cdot \frac{2}{3} l - F_3 \cdot \frac{1}{3} l - F_4 \cdot \frac{2}{3} l$

$M_0 = -490 \cdot \frac{1}{4} - 245,25 \cdot \frac{2}{3} - 122,625 \cdot \frac{1}{3} - 122,625 \cdot \frac{2}{3} \Rightarrow \boxed{M_0 = -408,75\ [Nm]}$

d) Centar potiska

$M_0 = -R_z \cdot x_{cp} \Rightarrow x_{cp} = \frac{-M_0}{R_z} = \frac{408,75}{981} = \boxed{x_{cp} = 0,4167\ [m]}$

$\bar{x}_{cp} = \frac{x_{cp}}{l} = \frac{0,4167}{1} \Rightarrow \bar{x}_{cp} = 0,4167 \Rightarrow \boxed{x_{cp} = 41,67\ \%}$

# 13. Zadatak

## Rešenje:

NACA $CS_2$-415 ; $V = 150 \left[m/s\right]$ ; $\mu = 1{,}7894 \cdot 10^{-5} \left(Pa\,s\right)$ ; $b = 1 (m)$ ; $l = 1 (m)$

a) <u>napadni ugao nultog uzgona</u>

Iz dijagrama napadni ugao - koef. uzgona za dati profil.

$$\Rightarrow \boxed{\alpha_{z_0} = -2{,}5^\circ}$$

$$\text{za } Re = \frac{\rho_n \cdot V \cdot l}{\mu} = \frac{1{,}225 \cdot 150 \cdot 1}{1{,}7894 \cdot 10^{-5}} \Rightarrow \boxed{Re = 10{,}269 \cdot 10^6}$$

b) Sile uzgona i otpora pri napadnom uglu $\alpha = 6^\circ$

$$R_z = \frac{1}{2} \rho_n \cdot V^2 \cdot S_{xr} \cdot C_z = \frac{1}{2} \cdot 1{,}225 \cdot 150^2 \cdot 1 \cdot 1 \cdot 0{,}9 \Rightarrow \boxed{R_z = 12.403{,}125 \left[N\right]}$$

Iz dijagrama $(\alpha - C_z)$ za $\alpha = 6^\circ \Rightarrow C_z = 0{,}9$ ; $C_x = 0{,}0088$

$$R_x = \frac{1}{2} \cdot \rho_n \cdot V^2 \cdot S_{xr} \cdot C_x = \frac{1}{2} \cdot 1{,}225 \cdot 150^2 \cdot 1 \cdot 1 \cdot 0{,}0088 \Rightarrow \boxed{R_x = 121{,}3 \left[N\right]}$$

c) Kritični napadni ugao i odgovarajuće brzine Re brojevima

$$Re = \frac{\rho \cdot V \cdot l}{\mu} \Rightarrow V = \frac{\mu \cdot Re}{\rho \cdot l} = \frac{1{,}7894 \cdot 10^{-5} \cdot Re}{1{,}225 \cdot 1} = 1{,}4607 \cdot 10^{-5} \cdot Re$$

| Re | V [m/s] | $\alpha_{kr}$ [°] |
|---|---|---|
| $3 \cdot 10^6$ | 93, 82 | 16 |
| $6 \cdot 10^6$ | 87, 64 | 17,5 |
| $9 \cdot 10^6$ | 131,47 | 17 |