FORMULE – TEORIJA LETA II

*** <u>Horizontalni let</u>**

polara aviona: $C_D = C_{D0} + C_{Di} = C_{D0} + \dfrac{C_L^2}{\pi \cdot e \cdot A\mathrm{R}}$; uzgon: $F_L = C_L \dfrac{1}{2}\rho V^2 A$; otpor: $F_D = C_D \dfrac{1}{2}\rho V^2 A$

opće jednadžbe gibanja aviona: $F_T \cdot \cos\alpha_T - F_D - F_G \cdot \sin\theta = m\dfrac{\mathrm{d}V}{\mathrm{d}t}$; $F_L + F_T \cdot \sin\alpha_T - F_G \cdot \cos\theta = m\dfrac{V^2}{r}$

jednadžbe gibanja za hor. let pravocrtnom putanjom stalnom brzinom: $F_T = F_D$; $F_L = F_G$

aspektni odnos: $A\mathrm{R} = \dfrac{b^2}{A}$; brzina leta: $V = \sqrt{\dfrac{2F_G}{C_L \rho A}}$; minimalna brzina: $V_{\min} = \sqrt{\dfrac{2F_G}{C_{L\max}\rho A}}$

potrebni potisak: $F_{TR} = F_D = F_G \dfrac{C_D}{C_L}$; $F_{TR} = \dfrac{1}{2}C_{D0}\rho A V^2 + \dfrac{2F_G^2}{\pi e A\mathrm{R}\rho A}\cdot\dfrac{1}{V^2}$; opterećenje krila: $\dfrac{F_G}{A}$

minimalni potrebni potisak, najbolji dolet: $C_{D0} = C_{Di} = \dfrac{C_L^2}{\pi \cdot e \cdot A\mathrm{R}}$; finesa aviona: $f = \left(\dfrac{C_L}{C_D}\right)_{\max}$

potrebna snaga: $P_R = F_{TR}V$; $P_R = \dfrac{C_D}{C_L^{1,5}}\sqrt{\dfrac{2F_G^3}{\rho A}}$; $P_R = \dfrac{1}{2}C_{D0}\rho A V^3 + \dfrac{2F_G^2}{\pi e A\mathrm{R}\rho A}\cdot\dfrac{1}{V}$

min. potrebna snaga, najveća istrajnost leta: $P_{R\min} = \left(\dfrac{C_D}{C_L^{1,5}}\right)_{\min}\sqrt{\dfrac{2F_G^3}{\rho A}}$; $C_{D0} = \dfrac{1}{3}C_{Di} = \dfrac{C_L^2}{3\pi \cdot e \cdot A\mathrm{R}}$

raspoloživa (korisna) snaga: $P_A = F_{TA}V$; $P_A = \eta P$; (η – stupanj korisnog djelovanja propelera)

maksimalna brzina: $P_A = P_R$; utjecaj visine: $V_h = V_0\sqrt{\dfrac{\rho_0}{\rho_h}}$; $P_{Rh} = P_{R0}\sqrt{\dfrac{\rho_0}{\rho_h}}$; $T_{TRh} = F_{TR0}$

Breguetove formule - propelerski pogon: $R = \dfrac{\eta}{c}\dfrac{C_L}{C_D}\ln\dfrac{m_0}{m_1}$; $E = \dfrac{\eta}{c}\dfrac{C_L^{1,5}}{C_D}\sqrt{2\rho A}\left(\dfrac{1}{\sqrt{F_{G1}}} - \dfrac{1}{\sqrt{F_{G0}}}\right)$

dolet i istrajnost - mlazni pogon: $R = \dfrac{1}{c_t}\dfrac{C_L^{0,5}}{C_D}\sqrt{\dfrac{8}{\rho A}}\left(\sqrt{F_{G0}} - \sqrt{F_{G1}}\right)$; $E = \dfrac{1}{c_t}\dfrac{C_L}{C_D}\ln\dfrac{m_0}{m_1}$

specifična potrošnja goriva: $c = SFC\left[\dfrac{\mathrm{N}}{\mathrm{Ws}}\right]$; $c_t = TSFC\left[\dfrac{\mathrm{N}}{\mathrm{Ns}} = \dfrac{1}{\mathrm{s}}\right]$

*** <u>Penjanje</u>**

brzina uzdizanja: $R/C = V\sin\theta$; $R/C = \dfrac{P_A - P_R}{F_G}$; $(R/C)_{\max} = \dfrac{(P_A - P_R)_{\max}}{F_G}$

kut penjanja: $\sin\theta = \dfrac{R/C}{V}$; $\theta = \arcsin\left(\dfrac{R/C}{V}\right)$; $\theta_{\max} = \arcsin\left(\dfrac{R/C}{V}\right)_{\max}$

vrijeme penjanja: $t = \int_{h_1}^{h_2}\dfrac{\mathrm{d}h}{R/C}$; $t = \dfrac{h_2 - h_1}{(R/C)_{sr}} = \dfrac{\Delta h}{(R/C)_{sr}}$; $(R/C)_{sr} = \dfrac{(R/C)_1 + (R/C)_2}{2}$

apsolutni vrhunac (plafon) leta: $R/C = 0$; praktični vrhunac (plafon) leta: $R/C = 0{,}5$ m/s

*** <u>Spuštanje</u>**

brzina propadanja: $R/D = V\sin\theta$; kut spuštanja: $\tan\theta = \dfrac{F_D}{F_L} = \dfrac{C_D}{C_L}$; $\tan\theta_{\min} = \left(\dfrac{C_D}{C_L}\right)_{\min} = \dfrac{1}{(C_L/C_D)_{\max}}$

*** <u>Polijetanje</u>**

duljina zaleta: $s_{LO} = \dfrac{V_{LO}^2 \cdot m}{2\{F_T - [F_D + \mu(F_G - F_L)]\}_{sr}} = \dfrac{S^2 \cdot F_G^2}{g\rho A C_{L\max}\{F_T - [F_D + \mu(F_G - F_L)]\}_{sr}}$

S - faktor sigurnosti; μ - koeficijent trenja; brzine: $V_{stall} = \sqrt{\dfrac{2F_G}{C_{L\max}\rho A}}$; $V_{LO} = SV_{stall}$; $V_{sr} = 0{,}7V_{LO}$

uzgon: $F_L = C_L\dfrac{1}{2}\rho V_{sr}^2 A$; otpor: $F_D = (C_{D0} + \phi C_{Di})\dfrac{1}{2}\rho V_{sr}^2 A$; utjecaj blizine tla: $\phi = \dfrac{(16h/b)^2}{1 + (16h/b)^2}$

*** <u>Slijetanje</u>**

duljina kočenja: $s_L = \dfrac{V_T^2 \cdot m}{2\left[F_D + \mu\left(F_G - F_L\right)\right]_{sr}} = \dfrac{S^2 \cdot F_G^2}{g\rho A C_{L\max}\left[F_D + \mu\left(F_G - F_L\right)\right]_{sr}}$

duljina kočenja uz revers potiska: $s_L = \dfrac{S^2 \cdot F_G^2}{g\rho A C_{L\max}\left\{F_{TR} + \left[F_D + \mu\left(F_G - F_L\right)\right]\right\}_{sr}}$

S - faktor sigurnosti; μ - koeficijent kočenja; brzine: $V_{stall} = \sqrt{\dfrac{2F_G}{C_{L\max}\rho A}}$; $V_T = SV_{stall}$; $V_{sr} = 0{,}7V_T$

uzgon: $F_L = C_L \dfrac{1}{2}\rho V_{sr}^2 A$; otpor: $F_D = \left(C_{D0} + \phi C_{Di}\right)\dfrac{1}{2}\rho V_{sr}^2 A$; utjecaj blizine tla: $\phi = \dfrac{(16h/b)^2}{1+(16h/b)^2}$

*** <u>Zaokreti</u>**

<u>- u horizontalnoj ravnini:</u>

radijus zaokreta: $R = \dfrac{V^2}{g\sqrt{n^2-1}}$; $R_{\min} = \dfrac{V^2}{g\sqrt{n_{\max}^2-1}}$; kutna brzina: $\varpi = \dfrac{V}{R} = \dfrac{g\sqrt{n^2-1}}{V}$

faktor opterećenja: $n = \dfrac{F_L}{F_G}$; $n = \dfrac{1}{\cos\phi}$; centrifugalna sila: $F_c = \dfrac{mV^2}{R}$

<u>- pull-up manevar:</u> $R = \dfrac{V^2}{g(n-1)}$; $\varpi = \dfrac{g(n-1)}{V}$

<u>- pull-down manevar:</u> $R = \dfrac{V^2}{g(n+1)}$; $\varpi = \dfrac{g(n+1)}{V}$

*** <u>Stabilnost i upravljivost aviona</u>**

položaj težišta: $x_{CG} = \dfrac{\sum M_i}{\sum m_i}$; $M_i = m_i \cdot x_i$; x_i - krak (udaljenost) hvatišta težine do referentne crte

moment oko težišta: $M_{CG} = C_{MCG}\dfrac{1}{2}\rho V^2 Ac$; apsolutni napadni kut: $\alpha_a = \alpha - \alpha_{L0}$; $(\alpha_{L0} < 0)$

koef. momenta oko težišta: $C_{MCG} = C_{MAC} + C_L\left[\dfrac{x_{CG}}{c} - \dfrac{x_{AC}}{c}\right] - V_H C_{LH}$ *

$C_L = a \cdot \alpha_a$; $C_{LH} = a_H \cdot \alpha_H$, $\alpha_H = \alpha_a - i_H - \varepsilon$; $\varepsilon = \varepsilon_0 + \dfrac{\partial\varepsilon}{\partial\alpha}\alpha_a$; volumen. omjer repa: $V_H = \dfrac{l_H \cdot A_H}{c \cdot A}$

uvjeti uzdužne statičke stabilnosti aviona: $C_{M0} > 0$ i $\dfrac{\partial C_{MCG}}{\partial\alpha_a} < 0$

$C_{M0} = C_{MAC} + V_H a_H\left(i_H + \varepsilon_0\right)$; $\dfrac{\partial C_{MCG}}{\partial\alpha_a} = a\left[\dfrac{x_{CG}}{c} - \dfrac{x_{AC}}{c} - V_H\dfrac{a_H}{a}\left(1 - \dfrac{\partial\varepsilon}{\partial\alpha}\right)\right]$

neutralna točka: $\dfrac{\partial C_{MCG}}{\partial\alpha_a} = 0$; $\left(\dfrac{x}{c}\right)_n = \dfrac{x_{AC}}{c} + V_H\dfrac{a_H}{a}\left(1 - \dfrac{\partial\varepsilon}{\partial\alpha}\right)$; statička rezerva: $\left(\dfrac{x}{c}\right)_n - \left(\dfrac{x}{c}\right) = -\dfrac{1}{a}\dfrac{\partial C_{MCG}}{\partial\alpha_a}$

utjecaj otklona elevatora na uzgon horizontalnog repa: $C_{LH} = \dfrac{\partial C_{LH}}{\partial\alpha_H}\alpha_H + \dfrac{\partial C_{LH}}{\partial\delta_e}\delta_e = a_H\alpha_H + \dfrac{\partial C_{LH}}{\partial\delta_e}\delta_e$

$\dfrac{\partial C_{LH}}{\partial\delta_e}$ - djelotvornost elevatora; otklon elevatora za $C_{MCG} = 0$: $\delta_{etrim} = \dfrac{C_{M0} + \left(\partial C_{MCG}/\partial\alpha_a\right)\cdot\alpha_a}{V_H\left(\partial C_{LH}/\partial\delta_e\right)}$