$W := 900kgf$ $Xcg := 0.3 \cdot Cma$ $CD0 := 0.03$ $etot := 0.8$ $\rho := 1.225 \frac{kg}{m^3}$

ALA

$b := 10m$ $Cr := 1.6m$ $\lambda := 0.5$ $\varepsilon_r := 0deg$ $\varepsilon_t := -3deg$

$\alpha_{0L2dwt} := -2.5deg$ $\alpha_{0L2dwr} := -1.0deg$ $iw := 3deg$

$CL\alpha w_{2dt} := 0.105deg^{-1}$ $CL\alpha w_{2dr} := 0.11deg^{-1}$ $ew := 0.9$

$Cm02dt := -0.093$ $Cm02dr := -0.08$ $Xacw := 0.25 \cdot Cma$ $\Lambda := 15deg$

FLAP

$\eta_{if} := 0.2$ $\eta_{ff} := 0.6$ $\Delta\alpha 0 := -2deg$ $\Delta cm0 := -0.1$

FUSOLIERA

$Cm0_f := -0.05$ $Cm\alpha_f := 0.0035deg^{-1}$ $C_{N\beta f} := -0.0035deg^{-1}$

PIANO ORIZZONTALE

$CL\alpha h_{2d} := 0.11deg^{-1}$ $bh := 2.5m$ $Sh := 2.5m^2$ $eh := 0.9$

$\eta h := 1$ $\tau e := 0.35$ $ih := -2deg$ $Xach := 5m$ $Ch\alpha := -0.0080deg^{-1}$ $Ch\delta e := -0.013deg^{-1}$

1) Calcolare il δe di equilibrio, la posizione del punto neutro,la potenza necessaria ed il carico agente sul piano orizzontale di coda, a comandi bloccati considerando una velocità di volo di $V := 150 \frac{km}{hr}$

2) Calcolare l'assetto e la velocità necessaria, posizione del punto neutro e potenza necessaria all'equilibrio a comandi liberi.

SOLUZIONE

$W = 900\,kgf \Rightarrow W = 8825.985\ N$

$V = 150\,\frac{km}{hr} \Rightarrow V = 41.667\ \frac{m}{s}$

PARAMETRI ALA

$$Cma := \frac{2\cdot\left(\lambda^2 + \lambda + 1\right)\cdot Cr}{3(\lambda + 1)} \qquad S := \frac{(Cr + \lambda\cdot Cr)\cdot b}{2}$$

$$AR := \frac{b^2}{S}$$

$$Ct := \lambda\cdot Cr \qquad C(y) := \frac{Ct - Cr}{\frac{b}{2}}\cdot y + Cr \qquad \varepsilon(y) := \frac{\varepsilon_t}{\frac{b}{2}}\cdot y$$

$$\alpha_{0L2d}(y) := \frac{\alpha_{0L2dwt} - \alpha_{0L2dwr}}{\frac{b}{2}}\cdot y + \alpha_{0L2dwr}$$

$$\alpha_{0L3Dw} := \frac{2}{S}\cdot\int_0^{\frac{b}{2}} \left(\alpha_{0L2d}(y) - \varepsilon(y)\right)\cdot C(y)\,dy$$

$$Cm02d(y) := \frac{Cm02dt - Cm02dr}{\frac{b}{2}}\cdot y + Cm02dr$$

$$xacr := 0.25\cdot Cr \qquad xact := 0.25\cdot Ct + \tan(\Lambda)\cdot\frac{b}{2} \qquad xac(y) := xacr + \frac{xact - xacr}{\frac{b}{2}}\cdot y$$

$$Cm_{acw3D} := \frac{2}{S\cdot Cma}\cdot\int_0^{\frac{b}{2}} Cm02d(y)\cdot C(y)^2\,dy - \frac{2\cdot\pi}{S\cdot Cma}\cdot\int_0^{\frac{b}{2}} \left(\alpha_{0L3Dw} + \varepsilon(y) - \alpha_{0L2d}(y)\right)\cdot C(y)\cdot xac$$

$$Claw(y) := \frac{CL\alpha w_{2dt} - CL\alpha w_{2dr}}{\frac{b}{2}}\cdot y + CL\alpha w_{2dr}$$

$$CL\alpha w_{2d} := \frac{2}{S}\cdot\int_0^{\frac{b}{2}} (Claw(y))\cdot C(y)\,dy$$

$$CL\alpha w := \frac{CL\alpha w_{2d}}{1 + \frac{CL\alpha w_{2d}}{\pi AR \cdot ew}}$$

$$ARh := \frac{bh^2}{Sh} \qquad CL\alpha h := \frac{CL\alpha h_{2d}}{1 + \frac{CL\alpha h_{2d}}{\pi \cdot ARh \cdot eh}}$$

$$Xcg := 0.3 \cdot Cma \qquad Xacw := 0.25 \cdot Cma \qquad X_{acwb} := Xacw - \frac{Cm\alpha_f}{CL\alpha w} \cdot Cma$$

$$lh := Xach - (Xcg - Xacw) \; * \qquad d\varepsilon d\alpha := \frac{2CL\alpha w}{\pi \cdot AR \cdot ew}$$

$$CL0_w := CL\alpha w \cdot \left(iw - \alpha_{0L3Dw}\right) \qquad \varepsilon 0 := \frac{2CL0_w}{\pi \cdot AR \cdot ew}$$

$$Cm\alpha := CL\alpha w \cdot \frac{Xcg - X_{acwb}}{Cma} - CL\alpha h \cdot (1 - d\varepsilon d\alpha) \cdot \left(\frac{lh}{Cma} \cdot \frac{Sh}{S} \cdot \eta h\right)$$

$$Cm0 := Cm_{acw3D} + Cm0_f + CL0_w \cdot \frac{Xcg - X_{acwb}}{Cma} + CL\alpha h \cdot (\varepsilon 0) \cdot \frac{lh}{Cma} \cdot \frac{Sh}{S} \cdot \eta h$$

$$Cmih := -CL\alpha h \cdot \left(\frac{lh}{Cma} \cdot \frac{Sh}{S} \cdot \eta h\right)$$

$$Cm\delta e := -CL\alpha h \cdot \left(\frac{lh}{Cma} \cdot \frac{Sh}{S} \cdot \eta h \cdot \tau e\right)$$

delta e comandi bloccati

$$CL := \frac{W}{\frac{1}{2} \cdot \rho \cdot V^2 \cdot S} \qquad \alpha := \frac{CL - CL0_w}{CL\alpha w} \qquad \alpha = 4.766 \text{ deg}$$

$$\delta e := \frac{-(Cm0 + Cm\alpha \cdot \alpha + Cmih \cdot ih)}{Cm\delta e} \qquad \delta e = -2.223 \text{ deg}$$

$$X_N := \frac{Xcg}{Cma} - \frac{Cm\alpha}{CL\alpha w} \qquad X_N = 0.538 \qquad \alpha h := \alpha - \varepsilon 0 - d\varepsilon d\alpha \cdot \alpha + ih + \tau e \cdot \delta e \qquad \alpha h = -1.376 \text{ deg}$$

$$Lh := 0.5 \cdot V^2 \cdot \rho \cdot CL\alpha h \cdot \alpha h \cdot Sh \qquad \alpha h = -1.376 \text{ deg} \qquad Lh = -21.687 \text{ kgf}$$

$CD := CD0 + \frac{CL^2}{\pi AR \cdot etot}$ $\quad T := \frac{1}{2}\cdot\rho\cdot V^2\cdot S\cdot CD$ $\quad P := T\cdot V$ $\quad P = 28.095\,kW$

$T = 68.758\,kgf$

CM a CL=0

Calcoliamo il CM a CL=0 anche se non richiesto

$ih1 := ih - iw + \alpha_{0L3Dw}$

$Cm0cl0 := Cm0_f + Cm_{acw3D} - CL\alpha h\cdot\frac{lh}{Cma}\cdot\frac{Sh}{S}\cdot\eta h\cdot(ih1 + \tau e\cdot\delta e)$

$Cm0cl0 = 0.165$

Troviamo il risultato per comandi liberi

$\alpha t(\alpha) := \alpha - \varepsilon 0 - d\varepsilon d\alpha\cdot\alpha + ih$ $\quad \delta e(\alpha) := \frac{-Ch\alpha\cdot\alpha t(\alpha)}{Ch\delta e}$

$Cm(\alpha) := (Cm0 + Cm\alpha\cdot\alpha + Cmih\cdot ih + Cm\delta e\cdot\delta e(\alpha))$

$\alpha eq = 1.714\,deg$

$CLeq := CL0_w + CL\alpha w\cdot\alpha eq$ $\quad Veq := \sqrt{\frac{2}{\rho}\cdot\frac{W}{S}\cdot\frac{1}{CLeq}}$

$\delta e(\alpha eq) = 1.466\,deg$ $\quad Veq = 190.01\,\frac{km}{hr}$

$F := 1 - \tau e\cdot\frac{Ch\alpha}{Ch\delta e}$ $\quad XN := \frac{X_{acwb}}{Cma} + F\cdot lh\cdot\frac{Sh}{S\cdot Cma}\cdot\frac{CL\alpha h}{CL\alpha w}\cdot(1 - d\varepsilon d\alpha)$ $\quad XN = 0.467$

$F = 0.785$ $\quad CD := CD0 + \frac{CLeq^2}{\pi AR\cdot etot}$ $\quad T := \frac{1}{2}\cdot\rho\cdot Veq^2\cdot S\cdot CD$ $\quad P := T\cdot V$

$P = 33.163\,kW$ $\quad T = 81.161\,kgf$ $\quad V = 150\,\frac{km}{hr}$

$Lh := 0.5\cdot Veq^2\cdot\rho\cdot CL\alpha h\cdot(\alpha t(\alpha eq) + \tau e\cdot\delta e(\alpha eq))\cdot Sh$ $\quad Lh = -47.276\,kgf$

Flap

$$Sf := 2\cdot\left(\int_{\eta_{if}\cdot\frac{b}{2}}^{\eta_{ff}\cdot\frac{b}{2}} C(y)\,dy\right)$$

$$\alpha_{0Lflap} := \alpha_{0L3Dw} + \frac{Sf}{S}\cdot\Delta\alpha 0 \qquad \alpha_{0Lflap} = -1.187\,deg$$

$$Cmaf := \frac{2}{S}\cdot\left(\int_{\eta_{if}\cdot\frac{b}{2}}^{\eta_{ff}\cdot\frac{b}{2}} C(y)^2\,dy\right)$$

$$Cmwflap1 := \frac{2}{S\cdot Cma}\cdot\int_0^{\frac{b}{2}} Cm02d(y)\cdot C(y)^2\,dy + \frac{Cmaf}{Cma}\cdot\Delta cm0$$

$$Cmwflap2 := -\frac{2\cdot\pi}{S\cdot Cma}\cdot\int_0^{\frac{b}{2}} \left(\alpha_{0L3Dw} + \varepsilon(y) - \alpha_{0L2d}(y)\right)\cdot C(y)\cdot xac(y)\,dy + \frac{2\cdot\pi\,\Delta\alpha 0}{S\cdot Cma}\cdot\int_{\eta_{if}\cdot\frac{b}{2}}^{\eta_{ff}\cdot\frac{b}{2}} C(y)\cdot x$$

$$Cmwflap1 + Cmwflap2 = -0.155$$