Module-4

Lecture-20

Maneuvering Flight: Stick Fixed Maneuvering point

Stick fixed maneuvering point

Stick fixed maneuvering point is the $c.g.$ location at which $d\delta e/dn = 0$

$$\frac{d\delta e}{dn} = -\frac{1}{V^2}\left[\frac{1.1gl_t}{\tau}\left(1+\frac{k'}{n^2}\right)+\left\{\frac{\frac{2W}{S}}{\rho C_{m_{\delta e}}}\left[\frac{dC_m}{dC_L}\right]_{fix}\right\}\right]$$

$$\frac{d\delta e}{dn} = -\frac{1}{V^2}\frac{2\left(\frac{W}{S}\right)}{\rho C_{m_{\delta e}}}\left[\frac{1.1gl_t\rho C_{m_{\delta e}}}{2\tau\left(\frac{W}{S}\right)}\left(1+\frac{k'}{n^2}\right)+\bar{x}_{cg}-\bar{n}_o\right] \tag{1}$$

$$\bar{x}_{cg}-\bar{n}_o = -\frac{1.1gl_t\rho C_{m_{\delta e}}}{2\tau\left(\frac{W}{S}\right)}\left(1+\frac{k'}{n^2}\right) \tag{2}$$

Pull-up; $k' = 0$

$$\bar{x}_{cg}-\bar{n}_o = -\frac{1.1gl_t\rho C_{m_{\delta e}}}{2\tau\left(\frac{W}{S}\right)}$$

$$\bar{x}_{cg} = \bar{n}_m$$

so Equation 2 becomes,

$$\bar{n}_0 = \bar{n}_m + \frac{1.1gl_t\rho C_{m_{\delta e}}}{2\tau\left(\frac{W}{S}\right)}\left(1+\frac{k'}{n^2}\right) \tag{3}$$

Put Equation 3 in 1 to get;

$$\frac{d\delta e}{dn} = -\frac{1}{V^2}\frac{2\left(\frac{W}{S}\right)}{\rho C_{m_{\delta e}}}\left[\frac{1.1gl_t\rho C_{m_{\delta e}}}{2\tau\left(\frac{W}{S}\right)}\left(1+\frac{k'}{n^2}\right)+\bar{x}_{cg}-\bar{n}_m-\frac{1.1gl_t\rho C_{m_{\delta e}}}{2\tau\left(\frac{W}{S}\right)}\left(1+\frac{k'}{n^2}\right)\right]$$

$$\frac{d\delta e}{dn} = -\frac{1}{V^2}\frac{2\left(\frac{W}{S}\right)}{\rho C_{m_{\delta e}}}\left(\bar{x}_{cg}-\bar{n}_m\right)$$

We know that stick fixed neutral point is that $c.g.$ location at which $d\delta e/dn = 0$, equivalently at $\bar{x}_{cg} = \bar{n}_m$; $d\delta e/dn = 0$

Stick fixed maneuvering point - a closer look

$$\frac{d\delta e}{dn} = -\frac{1}{V^2}\frac{2\left(\frac{W}{S}\right)}{\rho C_{m_{\delta e}}}\left(\bar{x}_{cg} - \bar{n}_m\right)$$

$\bar{n}_m - \bar{x}_{cg}$ is called maneuvering margin

The significant points to be made about the above equation are:

- *The derivative $d\delta e/dn$ varies with maneuver margin.*
- *For more forward c.g. location, more elevator will be required to obtain the limit load factor. Therefore, as the c.g. moves forward, more elevator deflection is necessary to obtain a given load factor.*
- *The lower positive speed (higher the C_L) more elevator will be necessary to set the limit load factor. Thus, at low speeds more elevator deflection is necessary to obtain a desired load factor than is required to obtain at a higher speed.*
- *The derivative $d\delta e/dn$ should be linear with respect to c.g. at a constant C_L.*