AE234 Quiz 3 Soham S Phanse 19D170030.

Q1. diameter = 3m input power = 746 kW.

$M_{tip} \leq 0.8$.

1. At SSL, $\rho_{air} = 1.225 \ kg/m^3$ $T = 298 \ K$ and

Static ↗ $P = 100 \ kPa$

speed of sound

$\therefore \cancel{M_{tip}} \ a = \sqrt{\gamma RT} = \sqrt{1.4 \times 287.1 \times 298} = 346.089 \ m/s$

$\therefore M_{tip} \leq 0.8 \quad \therefore V_{tip} \leq 0.8 \, a = 0.8 \times 346.089 \ m/s$

$\therefore V_{tip} \leq 276.8712 \ m/s$ But $V_{tip} = \Omega R \ m/s$. (since $V_0=0$)

$\therefore \Omega \leq \dfrac{276.8712 \ m/s}{1.5 \ m} = 184.5808 \ \dfrac{rad}{s}$

Now, Input power to propellor. P = Thrust to vehicle + Induced power to flow

$\therefore P = T V_1$

$\therefore 746 \times 10^3 = T V_1 = T(V_0 + w) = 2\rho A_d w (V_0 + w)^2$

at $\boxed{V_0 = 0}$ as static operation,

$\dfrac{746 \times 10^3}{2\rho A_d} = w^3 \qquad \therefore w = (43076.494)^{1/3}$

$w = 35.054 \ m/s$.

Here $A_d = \pi R^2$
$= 2.25 \times \pi$

$\therefore V_0 = 0 \ m/s$

$\therefore V_1 = V_2 = 35.054 \ m/s$

$\boxed{V_e = 70.1094 \ m/s}$, speed of exit stream

also thrust
$= \dfrac{74\cancel{8} \times 10^3}{w}$

$\therefore \boxed{\begin{aligned} Thrust &= 21281.45147 \ N \\ &= 21.281 \ kN \end{aligned}}$

and $\Omega \leq 184.58 \ \dfrac{rad}{s}$ & 1 rev = 2π rad
1 s = $\dfrac{1}{60}$ min

$\leq 184.58 \ \dfrac{\frac{1}{2\pi}}{\frac{1}{60}} \ \dfrac{rev}{min} \Rightarrow \boxed{\Omega \leq 1762.609 \ rpm}$

1. $M = 0.2$ SSL $\therefore a = 346.089$ m/s

$\therefore V_{vehicle} = V_0 = 69.2178$ m/s.

$\therefore$ Power $= 746 \times 10^3 = T(V_0 + w)$.

$$= 2\rho A_d (w)(V_0 + w)^2$$

$\therefore w(69.2178 + w)^2 = 43076.494.$

$\therefore$ By solving the cubic equation, we get

$w = 7.348$ m/s.

$\therefore$ Now. $V_0 = 69.2178$ m/s.

$V_1 = V_2 = 76.5658$ m/s

$V_e = V_0 + 2w = 83.9138$ m/s.

$\therefore$ Thrust $= \frac{Power}{V_1}$

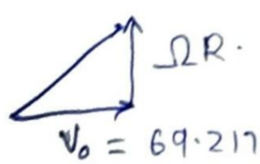
$$= \frac{746 \times 1000}{76.5658}$$

$\therefore$ Thrust $= 9743.253$ N

Now the ~~relative velocity~~

b) $\boxed{\text{Thrust} = 9.743 \text{ kN}}$

Now the relative velocity perceived by the tip is.



$\therefore |V_{res}| = \sqrt{V_0^2 + \Omega^2 R^2}$

$\therefore$ But $M_{tip} \leq 0.8$

$\therefore V_{result, tip} \leq 276.8712$

$\therefore V_0^2 + 2.25\,\Omega^2 \leq 76657.66139.$

$$\therefore \Omega^2 \leq \frac{76657.66139 - (69.2178)^2}{2.25} = 31940.69225$$

a) $\boxed{\Omega \leq 178.719 \frac{rad}{s} = 1706.646 \text{ rpm}}$ ← permitted rpm

$\therefore$ c) $r_{hub} = 20\%\, r_{tip} = 0.3$ m.

$\therefore$ we know ~~ϕ~~ $\tan\phi = \left(\frac{V_a}{\Omega R}\right)$ taking $\Omega = 178.719$ rad/s

which is the upper limit and $V_a = 69.2178$ m/s we have

$$\phi = \tan^{-1}\left(\frac{69.2178}{178.719 \times r}\right) = \tan^{-1}\left(\frac{0.3872}{r}\right)$$

$\therefore$ at $r = 0.1R = 0.15$m $\quad \phi = 68.823^\circ$

@ hub $r = 0.2R = 0.3$m $\quad \phi = 52.231^\circ$

@ $r = 0.3R = 0.45$m $\quad \phi = 40.71^\circ$

P.TO

(a) $r = 0.4R = 0.6\,m$ $\quad \phi = 32.8355^\circ$

$r = 0.5R = 0.75\,m$ $\quad \phi = 27.305^\circ$

$r = 0.6R = 0.9\,m$ $\quad \phi = 23.278^\circ$

$r = 0.7R = 1.05\,m$ $\quad \phi = 20.242^\circ$

$r = 0.8R = 1.2\,m$ $\quad \phi = 17.883^\circ$

$r = 0.9R = 1.35\,m$ $\quad \phi = 16.003^\circ$

$r = R = 1.5\,m$ $\quad \phi = 14.473^\circ$

also ef These are the range of values taken by the parameter ϕ. we can also find the optimum values if we have other parameters like C_L, C_D etc.