Problems Based on Aerodynamic Forces

Vinayagamurthy

28/03/2023

A flat plate 1.5m x 1.5m moves at 50 km/hour in stationary air of density 1.15 kg/m^3. if the co-efficient of drag and lift are 0.15 and 0.75 respectively, determine:

The lift force,
The drag force
The resultant force, and
The power required to keep the plate in motion

Area of the plate, A = 1.5 x 1.5 = 2.25 m^2

Velocity of the plane, $U = 50 \text{ km/hr} = \dfrac{50 \times 1000}{60 \times 60} m/s = 13.89 \text{m/s}$

Density of air $\rho = 1.15 \text{ kg/m}^3$

Co-efficient of drag $C_D = 0.15$

Co-efficient of lift $C_L = 0.75$

i) **Lift Force (F_L)** Using equation.

$$F_L = C_L A \times \frac{\rho U^2}{2} = 0.75 \times 2.25 \times \frac{1.15 \times 13.89^2}{2} \text{ N=187.20N Ans.}$$

ii) **Drag Force (F_D)** using equation

$$F_D = C_D \times A \times \frac{\rho U^2}{2} = 0.15 \times 2.25 \times \frac{1.15 \times 13.89^2}{2} \text{ N=37.44N Ans.}$$

iii) **Resultant Force (F_R)** Using equation

$$F_R = \sqrt{F_D^2 + F_L^2} = \sqrt{37.44^2 + 187.20^2} \text{ N}$$

$$= \sqrt{1400+35025} = 190.85 \text{ N}$$

iv) **Power Required to keep the Plate in Motion**

$$\text{P=}\frac{\text{Force in the direction of motion } \times \text{Velocity}}{1000} kW$$

$$= \frac{F_D \times U}{1000} = \frac{37.425 \times 13.89}{1000} kW = 0.519 \text{ kW. Ans}$$

A man weighting 90 kgf descends to the ground from an aeroplane with the help of a parachute against the resistance of air. The velocity with which the parachute, which is hemispherical in shape, comes down is 20 m/s. finds the diameter of the parachute. Assume $C_D = 0.5$ and density of air $= 1.25\ kg/m^3$.

Solution, Given:

Weight of man	W = 90 kgf = 90 x 9.81 N = 882.9 N($\therefore$ 1 kgf = 9.81 N)
Velocity of parachute	U = 20 m/s
Co-efficient of drag	C_D = 0.5
Density of air	ρ = 1.25 kg/m^3
Let the dia, of parachute	= D
$\therefore$ Area	$A = \frac{\pi}{4} D^2 m^2$

When the parachute with the man comes down with a uniform velocity, U=20 m/s, the drag resistance will be equal to the weight of man, neglecting the weight parachute. And projected are of the hemispherical parachute will be equal to $\frac{\pi}{4}$ d^2.

$\therefore$ Drag, F_D = 90 kgf = 90 x 9.81 = 882.9 N (using equation)

$$F_D = C_D \times A \times \frac{\rho U^2}{2}$$

$$\therefore\ 882.9 = 0.5 \times \frac{\pi}{4} D^4 \times \frac{1.25 \times 20^2}{2}$$

$$\therefore\ D^2 = \frac{882.9 \times 4 \times 2.0}{0.5 \times \pi \times 1.25 \times 20 \times 20} = 8.9946\ m^2$$

$$D = \sqrt{8.9946} = 2.999\ m.\ \ \text{Ans}$$

A kite 0.8 m x 0.8 m weighing 0.4 kgf (3.924 N) assumes an angle, of 12° to the horizontal. The string attached to the kite makes an angle of 45° to the horizontal. The pull on the string is 2.5 kgf (24.525 N) when the wind is flowing at a speed of 30 km/hour. Find the corresponding co-efficient of drag and lift. Density of air is given as 1.25 kg/m^3