Christopher King

Applied Fluid Mechanics
Homework 05

Christopher King

2018141521058

Applied Fluid Mechanics

Class Section 01

04/20/2021

Problem 9.68

9.68 A fishing net is made of 0.75 mm diameter nylon thread assembled in a rectangular pattern. The horizontal and vertical distances between adjacent thread centerlines are 1 cm. Estimate the drag on a 2 m × 12 m section of this net when it is dragged (perpendicular to the flow) through 15°C water at 6 knots. What is the power required to maintain this motion?

Solution:

$$C_D = \frac{F_D}{\frac{1}{2}\rho V^2 A}$$

$$Re_D = \frac{VD}{\nu}$$
$$= \frac{16 \times (0.5144444\ \ \text{m/s}) \times (0.75\ \ \text{mm})}{(1.01 \times 10^{-6}\ \ \text{m}^2/\text{s})}$$
$$= 6112.2$$

From Figure 9.13, I can know that $C_D = 0.8$ when $Re_D = 6112.2$.

Therefore, the drag on a $2\ \text{m} \times 12\ \text{m}$ section of this net when it is dragged is equal to

$$F_D = C_D \cdot \frac{1}{2}\rho V^2 A$$
$$= 0.8 \times \frac{1}{2} \times (999\ \ \text{kg/m}^3)$$
$$\times [16$$
$$\times (0.5144444\ \ \text{m/s})]^2$$
$$\times (4800\ \ \text{m}) \times (0.75\ \ \text{mm})$$
$$= 97.46\ \ \text{kN}$$

The power required to maintain this motion is equal to

$$P = F_D V = (97.46\ \ \text{kN}) \times 16$$
$$\times (0.5144444\ \ \text{m/s})$$
$$= 802.13\ \ \text{kW}$$

Problem 9.81

9.81 An F–4 aircraft is slowed after landing by dual parachutes deployed from the rear. Each parachute is 3.7 m in diameter. The F–4 weighs 142,400 N and lands at 160 m/s. Estimate the time and distance required to decelerate the aircraft to 100 m/s, assuming that the brakes are not used and the drag of the aircraft is negligible.

Solution:

$$\sum F_x = ma = m\frac{dV}{dt} = -2F_D = -C_D\rho V^2 A$$

$$-\frac{C_D\rho A}{m}\int_0^t dt = \int_{V_i}^{V_f}\frac{dV}{V^2}$$

$$t = \frac{W}{C_D\rho g A}\left[\frac{1}{V_f} - \frac{1}{V_i}\right]$$

$$= \frac{(142{,}400\ \ \text{N})}{(1.42) \times (1.21\ \ \text{kg/m}^3) \times (9.81\ \ \text{m/s}^2) \times \frac{\pi \times (3.7\ \ \text{m})}{4}}$$
$$\times \left[\frac{1}{(100\ \ \text{m/s})} - \frac{1}{(160\ \ \text{m/s})}\right] = 2.95\ \ \text{s}$$

$$\sum F_x = ma = mV\frac{dV}{dx} = -2F_D$$
$$= -C_D\rho V^2 A$$

$$-\frac{C_D \rho A}{m}\int_0^x dx = \int_{V_i}^{V_f}\frac{dV}{V}$$

$$x = -\frac{W}{C_D \rho g A}\ln\frac{V_f}{V_i}$$

$$= -\frac{(142{,}400 \ \ \mathrm{N})}{(1.42)\times(1.21 \ \ \mathrm{kg/m^3})\times(9.81 \ \ \mathrm{m/s^2})\times}$$

$$\times \ln\frac{(100 \ \ \mathrm{m/s})}{(160 \ \ \mathrm{m/s})} = 369.30 \ \ \mathrm{m}$$

Problem 9.116

9.116 An aircraft is in level flight at 225 km/h through air at standard conditions. The lift coefficient at this speed is 0.45 and the drag coefficient is 0.065. The mass of the aircraft is 900 kg. Calculate the effective lift area for the craft, and the required engine thrust and power.

Solution:

$$\sum F_y = 0 = F_L - mg$$

$$C_L = \frac{F_L}{\frac{1}{2}\rho A V^2}$$

$$F_L = mg = C_L \cdot \frac{1}{2}\rho A V^2$$

$$A = \frac{2mg}{C_L \rho V^2}$$

$$= \frac{2\times(900 \ \ \mathrm{kg})\times(9.81 \ \ \mathrm{m/s^2})}{(0.45)\times(1.21 \ \ \mathrm{kg/m^3})\times\left(\frac{225}{3.6} \ \ \mathrm{m/s}\right)^2}$$

$$= 8.302 \ \ \mathrm{m}$$

$$\sum F_x = 0 = T - F_D$$

$$C_D = \frac{F_D}{\frac{1}{2}\rho A V^2}$$

$$T = F_L\frac{C_D}{C_L} = (900 \ \ \mathrm{kg})\times(9.81 \ \ \mathrm{m/s^2})$$

$$\times\frac{0.065}{0.45} = 1275.3 \ \ \mathrm{N}$$

$$P = Tv = (1275.3 \ \ \mathrm{N})\times\left(\frac{225}{3.6} \ \ \mathrm{m/s}\right)$$

$$= 79.7 \ \ \mathrm{kW}$$

Problem 9.122

9.122 Assume that the Boeing 727 aircraft has wings with NACA 23012 section, planform area of 150 m^2, double-slotted flaps, and effective aspect ratio of 6.5. If the aircraft flies at 77.2 m/s in standard air at 778,750 N gross weight, estimate the thrust required to maintain level flight.

Solution:

$$\sum F_y = 0 = F_L - W$$

$$C_L = \frac{W}{\frac{1}{2}\rho A V^2}$$

$$= \frac{(778{,}750 \ \ \mathrm{N})}{\frac{1}{2}\times(1.21 \ \ \mathrm{kg/m^3})\times(150 \ \ \mathrm{m^2})\times(77.2 \ \ \mathrm{m/s})^2}$$

$$= 1.44$$

From Figure 9.23, I can know that for doubled slotted flaps, when $C_L = 1.44$, $C_{D,0} = 0.04$.

Using Equation 9.43, I can get that

$$C_D = C_{D,0} + \frac{C_L^2}{\pi AR} = 0.04 + \frac{1.44^2}{\pi\times 6.5}$$
$$= 0.1415$$

$$T = F_L\frac{C_D}{C_L} = (778{,}750 \ \ \mathrm{N})\times\frac{0.1415}{1.44}$$
$$= 76544 \ \ \mathrm{N}$$

Christopher King