

1.8) The engine of a small jet aircraft develops a thrust of 18 kN when the aircraft is flying at a speed of 900 km/h at an altitude where the ambient pressure is 50 kPa. The air flow rate through the engine is 75 kg/s and the engine uses fuel at a rate of 3 kg/s. The pressure on the engine discharge plane is 55 kPa and the area of the engine exit is 0.2 m². Find the jet efflux velocity.

Solution:

Given:

Thrust=18 kN, fuel rate=3 kg/s

Inlet $\rightarrow V_1 = 900 \text{ km/h} = 900/3.6 = 250 \text{ m/s}$, $p_1 = 50 \text{ kPa}$, $\dot{m}_1 = 75 \text{ kg/s}$.

Outlet $\rightarrow p_2 = 55 \text{ kPa}$, $A_{\text{exit}} = 0.2 \text{ m}^2$, $V_2 = ? \text{ m/s}$.

The schematic diagram of the problem description is shown in Fig. 1.

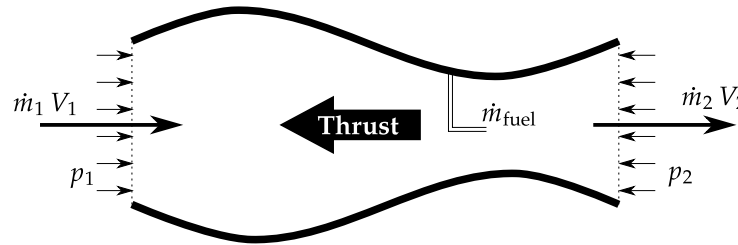


Fig. 1: Schematic diagram for problem description

Using the mass conservation equation,

$$\dot{m}_2 = \dot{m}_1 + \dot{m}_{\text{fuel}}$$

$$\dot{m}_2 = 75 + 3 = 78 \text{ kg/s}$$

Using the conservation of momentum along horizontal direction,

$$\begin{aligned} \text{Thrust} &= \text{rate of momentum exiting} - \text{rate of momentum entering} \\ &\quad + \text{pressure force at exit} - \text{pressure force at inlet} \end{aligned}$$

$$\text{Thrust} = \dot{m}_2 V_2 - \dot{m}_1 V_1 + (p_2 - p_1) A_{\text{exit}}$$

$$18 \times 10^3 = 78 \times V_2 - 75 \times 250 + (55 \times 10^3 - 50 \times 10^3) \times 0.2$$

$$V_2 = \frac{18 \times 10^3 + 75 \times 250 - (55 \times 10^3 - 50 \times 10^3) \times 0.2}{78}$$

$$\boxed{V_2 = 458.3333 \text{ m/s}}.$$