

1.5) Two jets of air, each having the same mass flow rate, are thoroughly mixed and then discharged into a large chamber. One jet has a temperature of  $120^\circ\text{C}$  and a velocity of  $100\text{ m/s}$ , whereas the other has a temperature of  $-50^\circ\text{C}$  and a velocity of  $300\text{ m/s}$ . Assuming that the process is steady and adiabatic, find the temperature of the air in the large chamber.

**Solution:**

A schematic diagram of the configuration is shown in Fig. 1.

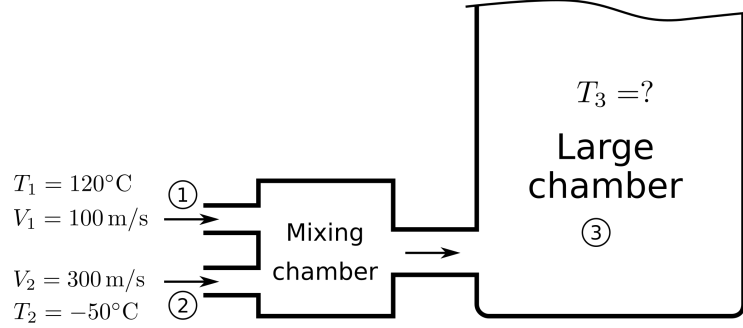


Fig. 1: Schematic diagram for problem description

Given:  $T_1 = 120^\circ\text{C} = 393\text{ K}$ ,  $V_1 = 100\text{ m/s}$ ,  $T_2 = -50^\circ\text{C} = 223\text{ K}$ ,  $V_2 = 300\text{ m/s}$ .  
 The mass flow rate is same through the two inlets, therefore,

$$\dot{m}_1 = \dot{m}_2 = \dot{m}$$

$$\dot{m}_3 = \dot{m}_1 + \dot{m}_2 = 2\dot{m}$$

Applying the conservation of energy equation (without heat and work),

$$\left(\dot{m}_1 c_p T_1 + \dot{m}_1 \frac{V_1^2}{2}\right) + \left(\dot{m}_2 c_p T_2 + \dot{m}_2 \frac{V_2^2}{2}\right) = \left(\dot{m}_3 c_p T_3 + \dot{m}_3 \frac{V_3^2}{2}\right)$$

$$\left(\dot{m} c_p T_1 + \dot{m} \frac{V_1^2}{2}\right) + \left(\dot{m} c_p T_2 + \dot{m} \frac{V_2^2}{2}\right) = \left(2\dot{m} c_p T_3 + 2\dot{m} \frac{V_3^2}{2}\right)$$

$$\left(c_p T_1 + \frac{V_1^2}{2}\right) + \left(c_p T_2 + \frac{V_2^2}{2}\right) = \left(2c_p T_3 + 2\frac{V_3^2}{2}\right)$$

$$T_3 = \frac{c_p T_1 + \frac{V_1^2}{2} + c_p T_2 + \frac{V_2^2}{2} - V_3^2}{2c_p}$$

Assuming  $c_p = 1005\text{ J/kg-K}$  for air and the velocity in the large chamber to be effectively zero,

$$T_3 = \frac{1005 \times 393 + \frac{100^2}{2} + 1005 \times 223 + \frac{300^2}{2} - 0}{2 \times 1005}$$

$$T_3 = 332.87562\text{ K} = 59.87562^\circ\text{C}$$