Question #78790

In an air compressor the pressures at inlet and outlet are 1bar and 5bar respectively. The temperature of the air at inlet is 15 degree C and the volume at the beginning of compression is three times that at the end of compression. Calculate the temperature of the air at outlet and the increase of internal energy per kg of air?

Answer:

Assume the air is an ideal gas. The ideal gas equation of state is given by:

$$pV = mRT, \tag{1}$$

where *p*, *V* and *T* – pressure, volume and absolute temperature respectively,

m – the mass of air, which remains constant while compression occures,

R = 287 J/(kg·K) – the gas constant of air.

Since *mR = const*, (1) yields:

$$\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}, \tag{2}$$

$$T_2 = T_1\frac{p_2V_2}{p_1V_1}, \tag{3}$$

where subscripts 1 and 2 corresponds to the inlet and outlet parameters, respectively.

Substitute into (3):

$$T_2 = (15 + 273)\frac{5}{1 \cdot 3} = 480\ \text{K} = 207°\text{C}.$$

The increase of internal energy per kilogram of air compressed is given by:

$$\Delta u = \alpha R \Delta T, \tag{4}$$

where α = 2.5 – the number of degrees of freedom divided by two (since the number of degrees of freedom of air is 5).

Substitute into (4):

$$\Delta u = 2.5 \cdot 287 \cdot (207 - 15) = 137{,}760\ \text{J/kg} = 137.76\ \text{kJ/kg}.$$