Question # 78810

In an air compressor the pressures at inlet and outlet are 1bar and 5bar respectively. The temperature of the air at inlet is 15°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. Thus, from the ideal gas equation we have:

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

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

m is the mass of air (which remains constant),

R = 287 J.kg^{-1}K^{-1} – the gas constant of air.

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

$$\frac{p_1 V_1}{T_1} = \frac{p_2 V_2}{T_2}, \tag{2}$$

$$T_2 = T_1 \frac{p_2 V_2}{p_1 V_1}, \tag{3}$$

where subscripts 1 and 2 corresponds to the inlet and outlet conditions, 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 the air compressed is given by:

$$\Delta u = \frac{N}{2} R \Delta T, \tag{4}$$

where *N* = 5 – the number of degrees of freedom of air.

Substitute into (4):

$$\Delta u = \frac{5}{2} \cdot 287 \cdot (207 - 15) = 137{,}760\text{ J. kg}^{-1} = 137.76\text{ kJ. kg}^{-1}.$$