Question 1

Wednesday, April 28, 2021 10:32 AM

"I pledge my honor I have abided by the Stevens Honor system."
- Alex Jaskins

A car engine can be modeled as a piston cylinder device. In the engine, 0.002 kg of air is compressed adiabatically from 20°C, 100 kPa to a pressure of 1 MPa before ignition occurs. The isentropic efficiency of this compression process is 45%.

a) How much energy (in *kJ*) is required to compress the gas in reality (i.e. find W_{actual})?

b) Determine the change in entropy of the gas during the isentropic and actual processes.

A.) $\eta = .45$ $\quad E_{in} - E_{out} = \Delta E$

$$W = m(h_1 - h_2) = mc_v(T_2 - T_1)$$

$$T_2 = T_1\left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}} = (293)\left(\frac{1000}{100}\right)^{\frac{1.4-1}{1.4}}$$

$$T_2 = 565.98\ K$$

$$W = mc_p(T_2 - T_1) = (.002)(0.718)(565.98 - 293)$$

$$W = 0.392 \quad kJ$$

$$.45 = \frac{.39}{W_{actual}}$$

$$\boxed{W_{actual} = .87\ kJ}$$

B.) $\Delta S = \frac{dQ}{T_{env}} + S_{gen} = \frac{0}{T} + 0 = 0$

$\Delta S_{isentropic} = 0$

$$\Delta S = \frac{dQ}{T_{env}} + S_{gen}$$

$$\Delta S_{sys} = m(s_2 - s_1) = mc_p \ln\left(\frac{T_2}{T_1}\right)$$

$$\Delta S_{sys} = (.002)(1.005)\ln\left(\frac{565.7}{}\right)$$

$$\Delta S_{sys} = (.002)(1.005)\ln\left(\frac{565.7}{293}\right)$$

$$\Delta S_{sys} = 0.001322\ kJ/K$$