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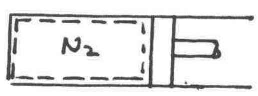
PROBLEM 2.28

KNOWN: N_2 gas within a piston-cylinder assembly undergoes a compression where the p-V relation is $pV^{1.35} = \text{constant}$.

FIND: Determine the volume at the final state and the work.

SCHEMATIC & GIVEN DATA:



$pV^{1.35} = \text{constant}$
$p_1 = 0.2\ \text{MPa},\ V_1 = 2.75\ m^3$
$p_2 = 2\ \text{MPa}$

ENGR. MODEL:

1. The N_2 is the closed system.
2. The p-V relation during compression is specified.
3. Volume change is the only work mode.

ANALYSIS: (a) $p_1 V_1^n = p_2 V_2^n \Rightarrow V_2 = \left(\frac{p_1}{p_2}\right)^{\frac{1}{n}} V_1$, $n = 1.35$. Thus,

$$V_2 = \left(\frac{0.2\ \text{MPa}}{2\ \text{MPa}}\right)^{\frac{1}{1.35}}(2.75\ m^3) = 0.5\ m^3 \longleftarrow$$

(b) Since volume change is the work mode, Eq. 2.17 applies. Following the procedure of part (a) of Example 2.1 we have

$$W = \frac{p_2 V_2 - p_1 V_1}{1-n} = \frac{(2\ \text{MPa})(0.5\ m^3) - (0.2\ \text{MPa})(2.75\ m^3)}{1-1.35} \left|\frac{10^6\ N/m^2}{1\ \text{MPa}}\right| \left|\frac{1\ kJ}{10^3\ N\cdot m}\right|$$

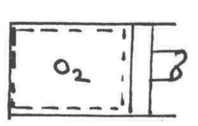
$$= -1285.7\ kJ \longleftarrow$$

PROBLEM 2.29

KNOWN: O_2 gas within a piston-cylinder assembly undergoes an expansion where the p-V relation is $p = AV^{-1} + B$.

FIND: Determine the initial and final pressures and the work.

SCHEMATIC & GIVEN DATA:



$p = AV^{-1} + B$
$A = 0.06\ \text{bar}\cdot m^3$
$B = 3.0\ \text{bar}$
$V_1 = 0.01\ m^3,\ V_2 = 0.03\ m^3$

ENGR. MODEL:

1. The O_2 is the closed system
2. The p-V relation during expansion is specified.
3. Volume change is the only work mode.

ANALYSIS:

(a) $p_1 = [(0.06\ \text{bar}\cdot m^3)/0.01\ m^3] + 3.0\ \text{bar}$

$\therefore\ p_1 = 9.0\ \text{bar}$

$p_2 = [(0.06\ \text{bar}\cdot m^3)/(0.03\ m^3)] + 3.0\ \text{bar}$

$\therefore\ p_2 = 5.0\ \text{bar} \longleftarrow$

(b) Since volume change is the work mode, Eq. 2.17 applies. That is,

$$W = \int_{V_1}^{V_2} p\,dV = \int_{V_1}^{V_2}\left[\frac{A}{V} + B\right]dV = A \ln\frac{V_2}{V_1} + B(V_2 - V_1)$$

$$= (0.06\ \text{bar}\cdot m^3)\ln\left(\frac{0.03\ m^3}{0.01\ m^3}\right) + (3.0\ \text{bar})[0.03 - 0.01]\ m^3$$

$$= [0.0659 + 0.06]\ \text{bar}\cdot m^3 \left|\frac{10^5\ N/m^2}{1\ \text{bar}}\right| \left|\frac{1\ kJ}{10^3\ N\cdot m}\right|$$

$$= 12.59\ kJ \longleftarrow$$