PROBLEM 3.110

KNOWN: Data are provided for air contained in a piston-cylinder assembly fitted with a paddle wheel.

FIND: For the process of the air, find temperature at the final state and Q.

SCHEMATIC & GIVEN DATA:

\[ W_{pw} = -18 \text{ Btu} \]

Work done by paddle wheel

\[ W_{pist} = 13.31 \text{ Btu} \]

\[ p_1 = 30 \text{ lb/in}^2, T_1 = 540^\circ \text{F}, V_1 = 4 \text{ ft}^3 \]

\[ p_2 = 20 \text{ lb/in}^2, V_2 = 4.5 \text{ ft}^3 \]

SOLUTION:

\( \Delta U + \Delta K + \Delta E = Q - W_{pw} - W_{pist} \)

\( Q_{12} = W_{pist} + m(\frac{u_2 - u_1}{T_1}) \)

\( W_{pist} = W_{pw} + W_{pist} = (13.31 \text{ Btu}) + (18 \text{ Btu}) = 31.31 \text{ Btu} \)

\( u_1 = 172.43 \text{ Btu/lb} \)

\( u_2 = 172.85 \text{ Btu/lb} \)

\( m = \frac{P_1 V_1}{R T_1} = \frac{30 \times 144 \text{ in}^2}{18 \text{ ft}^3} \times \frac{1}{297 \text{ ft}^3 \text{ lb}^{-1} \text{F}^{-1}} \times (100 \%) = 0.324 \text{ lb} \)

\( Q_{12} = 2.31 \text{ Btu} + (0.324 \text{ lb})(172.85 - 172.43) \text{ Btu/lb} \)

\[ = 12 \text{ Btu} \]