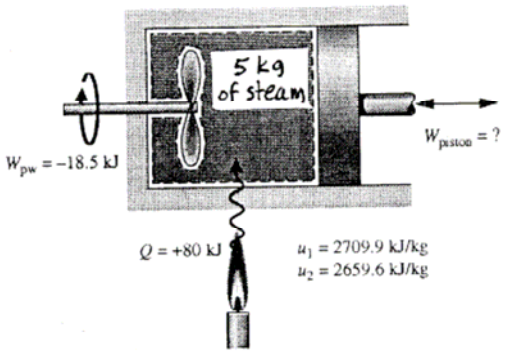
PROBLEM 2.56

KNOWN: Five kg of steam undergo an expansion in a piston-cylinder assembly from state 1 to state 2. During the process there is a known heat transfer to the steam and a known work transfer of energy to the steam by a paddle wheel. The change in specific internal energy of the steam is also known.

FIND: Determine the amount of energy transfer by work from the steam to the piston during the process.

SCHEMATIC & GIVEN DATA:



ENGR. MODEL: 1. The steam is the closed system. 2. There is no change in the kinetic or potential energy from state 1 to state 2.

ANALYSIS: The net work can be determined from an energy balance. That is, with assumption 2

$$\cancel{\Delta KE}^{\,0} + \cancel{\Delta PE}^{\,0} + \Delta U = Q - W$$

or

$$W = Q - \Delta U$$

The net work is the sum of the work associated with the paddlewheel W_{pw} and the work done on the piston W_{piston}:

$$W = W_{pw} + W_{piston}$$

From the given information $W_{pw} = -18.5$ kJ, where the minus sign is required because the paddle wheel transfers energy to the system. Collecting results

$$W_{pw} + W_{piston} = Q - \Delta U$$

or

$$\begin{aligned} W_{piston} &= Q - \Delta U - W_{pw} \\ &= Q - m(u_2 - u_1) - W_{pw} \\ &= 80\,\text{kJ} - 5\,\text{kg}\left(2659.6 - 2709.9\right)\frac{\text{kJ}}{\text{kg}} - (-18.5\,\text{kJ}) \\ &= +350\,\text{kJ} \end{aligned}$$

W_{piston}

where the positive sign indicates that energy is transferred from the steam to the piston as the steam expands during the process.