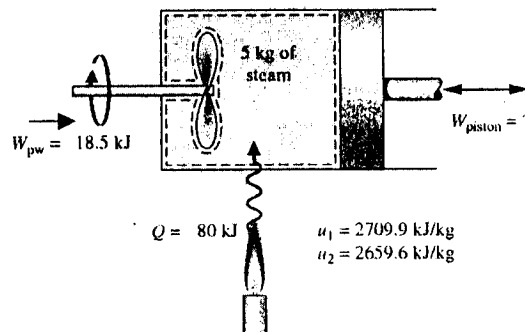


1. As shown in the following figure, 5 kg of steam contained within a piston-cylinder assembly undergoes an expansion from state 1, where the specific internal energy is  $u_1 = 2790.9$  kJ/kg, to state 2, where  $u_2$  is 2659.6 kJ/kg. During the process, the heat transfer to the system is 80 kJ. Also a paddle wheel transfers 18.5 kJ to the steam. The changes in the kinetic energy and potential energy are negligible. Determine the energy transfer from the steam to the piston? (15%)



2. Draw the following designated processes on the assigned diagram.
- Draw in a  $p$ - $V$  diagram the *saturated vapor line*, the *saturated liquid line*, and the *sublimation line* for a normal substance that *contracts* upon freezing. Mark the portion that represents contraction as  $\Delta V$ . (5%)
  - Show on a  $p$ - $V$  for the process of a liquid-vapor mixture in a rigid tank that is heated so as to pass through the critical point. (4%)
  - Draw the process on the  $p$ - $V$  diagram for a pure substance that changes from a compressed liquid to a superheated vapor at a constant temperature. (3%)
  - On the  $T$ - $s$  diagram for the process of a compressed liquid that is heated at constant pressure until a superheated vapor is obtained. (3%)
3. A closed system consists of an ideal gas with mass  $m$  and constant specific heat ratio  $k$ . If kinetic and potential energy changes are negligible, show that for an adiabatic process the work is  $W = \frac{mR(T_2 - T_1)}{1 - k}$ .  $R$  is the gas constant of this ideal gas. (10%)