Problem Set 1, PS1 due Wednesday May 19

PS1-1 Do not attempt to completely solve following problems from the Cengel text but take only the fist step and identify in each problem the type of thermodynamic systems involved and the heat and work flows and their directions. Problems: 4-29, 4-149, 5-186, 7-166, 9-94.

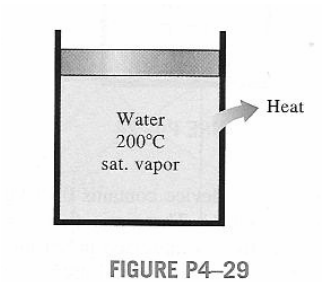


FIGURE P4–29

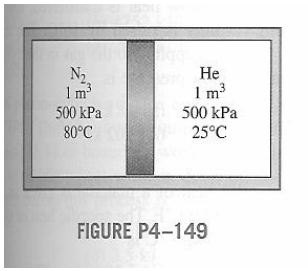


FIGURE P4–149

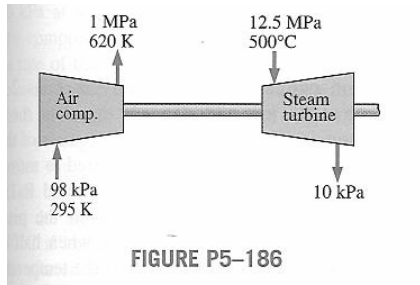


FIGURE P5–186

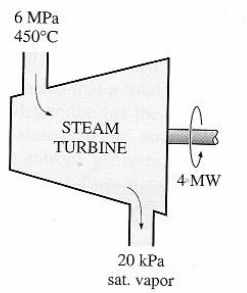


FIGURE P7–166

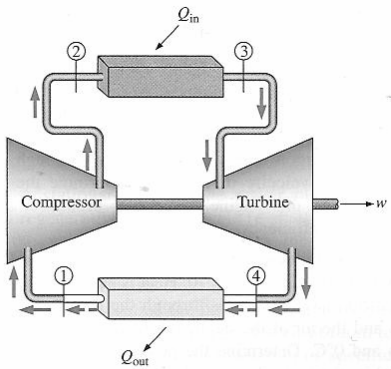


FIGURE P9–94

PS1-2 A mass of 1.2 lbs of steam at an initial pressure of 500 psi, an initial specific volume of 1.701 ft^3/lb and an initial internal energy of 1363.3 Btu/lb, undergoes a polytropic process defined as, pv^n = constant, with n=2 to a final internal energy of 990.58 Btu/lb in a piston cylinder mechanism. During the process 342.9 Btu are transsferred from the steam. Determine the final specific volume and work done.

PS1-1

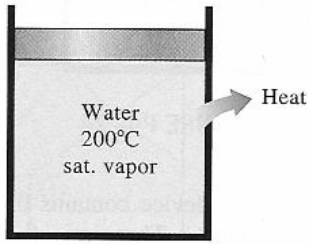


FIGURE P4–29

1 closed thermodynamic system
and the surroundings thermodynamic system

heat is rejected by the closed water system to the surroundings system

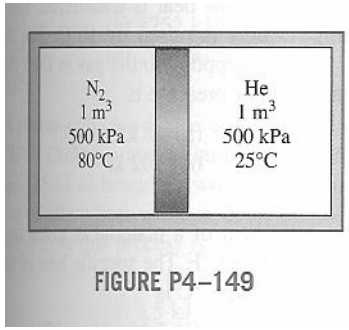


FIGURE P4–149

2 closed thermodynamics systems
mass of helium and la\mass of nitrogen

stationary piston:
heat is transferred from the closed nitrogen system to the closed helium system
moving piston:
heat is transferred from the closed nitrogen system to the closed helium system
work is done on the closed helium system by the closed nitrogen system

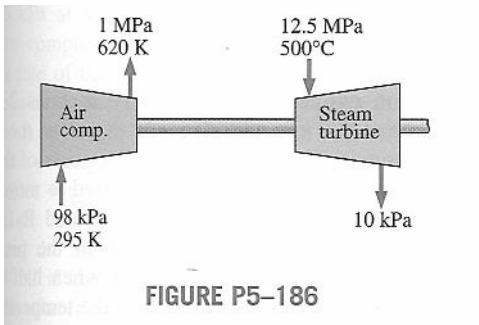


FIGURE P5–186

2 open thermodynamic systems

work is done by the open turbine system on the open compressor system

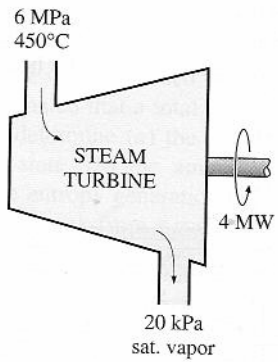


FIGURE P7–166

1 open thermodynamic system and the surroundings thermodynamic system

work is done on the surroundings system by the open turbine thermodynamic system

PS1-1

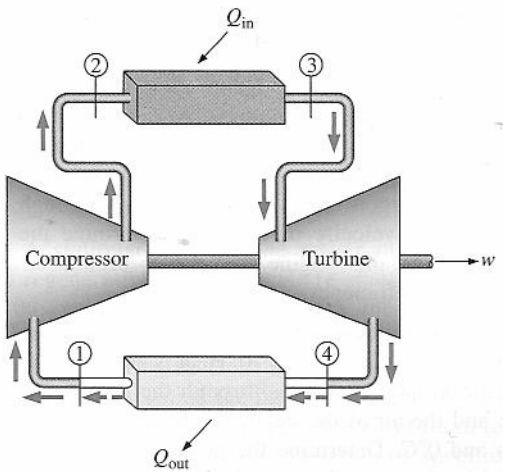


FIGURE P9–94

4 open thermodynamic systems and the surroundings system

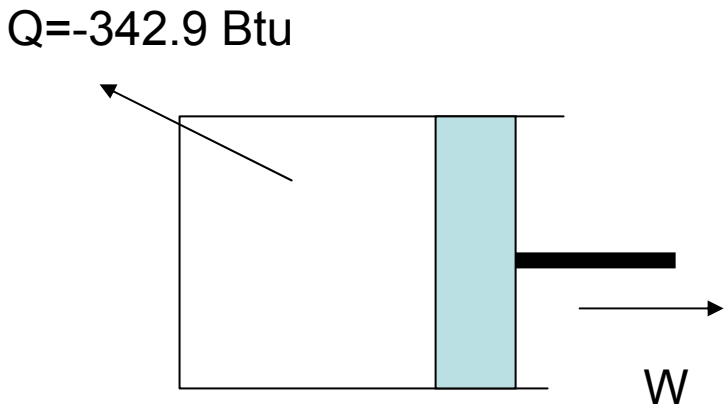
Compressor 1-2 work is done by the open turbine system on the open compressor system.

Combustor 2-3 heat is added to the open combustor system by the surroundings system

Heat Exchanger 4-1 heat is rejected by the open heat exchanger system to the surroundings system.

Turbine 3-4 Work is done by the open turbine system on the open compressor system and on the surroundings system

PS1-2



First Law for a Process, $Q = \Delta U + W$

$$Q = m \times (u_1 - u_2) + W$$

$$-342.9 \text{ Btu} = 1.2 \times (990.58 - 1363.3) + W$$

$$-342.9 \text{ Btu} = -447.26 + W$$

$W = +104.36$ Btu, Work done by the system

The system expands. Work is done on the surroundings

Polytropic Process : $pv^n = \text{constant}$

$$pv^n = p_1 v_1^n = \text{constant}$$

$$p = \frac{p_1 v_1^{\,n}}{v^n}$$

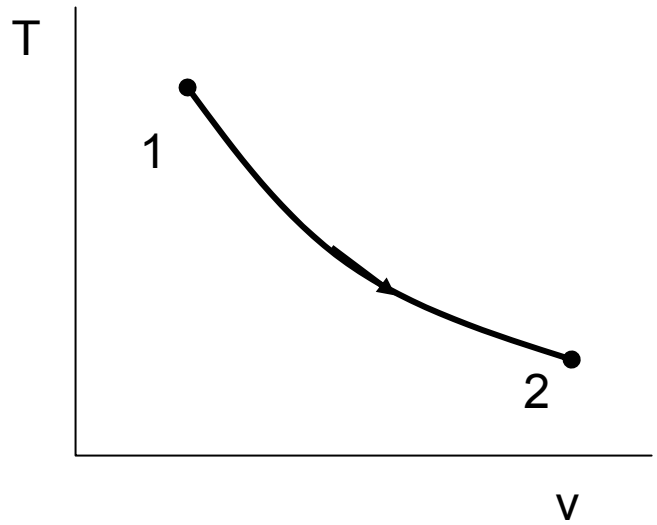
$$W = m\int \frac{p_1 v_1^{\,n}}{v^n} dv = m \times p_1 v_1^{\,n} \int_{v_1}^{v_2} \frac{1}{v^n} dv = \frac{m \times p_1 v_1^{\,n}}{1-n} \left(\frac{1}{v^{n-1}} \right)$$

$$W = -m \times p_1 v_1^{\,2} \left(\frac{1}{v_2} - \frac{1}{v_1} \right)$$

$$104.36 \text{ Btu} \times 778 \text{ ft lb/Btu}$$

$$= 1.2 \text{ lb} \times 500 \text{ lb/in}^2 \times 144 \text{ in}^2/\text{ft}^2 \text{x} \left(1.701 \text{ ft}^3\right)^2 \left(\frac{1}{v_2} - \frac{1}{1.701 \text{ ft}^3} \right)$$

$$v_2 = 3.8 \text{ ft}^3/\text{lb}$$



$$p_2 = p_1 \left(\frac{v_1}{v_2} \right)^2 = 500 \left(\frac{1.701}{3.8} \right)^2 = 100 \text{ psi}$$

$u_g @ 100\text{psi} = 807.29 \Rightarrow$ superheat