31.29 $350\frac{lb_m}{hr}$ **of** $60°F$ **feedwater enters a 90% efficient boiler which burns a fuel with a higher heating value of** $20,000\frac{Btu}{lb}$ **and a unit cost of \$0.50/lb. The water leaves as superheated steam with a temperature of** $400°F$**. The boiler operates at a constant pressure of** $100psia$**. What is the monthly fuel cost assuming continuous operation?**

A. \$6900

B. \$7650

C. \$8500

D. \$9450

Consider the feedwater as State 1 and the leaving steam as state 2. Write an expression for the heat being added to the water.

$$\dot{Q} = \dot{m}\Delta h = \dot{m}\left(h_2 - h_1\right)$$

State 1 is a compressed liquid. Find the enthalpy at State 1 by accounting for the reduction in temperature from the saturation temperature. Use the Properties of Saturated Water and Steam table to obtain the properties needed.

$$T_1 = 60°F$$

$$P_1 = 100psia$$

$$\Delta h = c_p \Delta T$$

$$h_f - h_1 = c_p\left(T_{sat} - T_1\right)$$

$$h_1 = h_f - c_p\left(T_{sat} - T_1\right) = 298.51\frac{Btu}{lb} - \left(1\frac{Btu}{lb°F}\right)(327.8°F - 60°F) = 30.71\frac{Btu}{lb}$$

State 2 is a superheated vapor. Use the Properties of Superheated Steam table to obtain the enthalpy at State 2.

$$T_2 = 400°F$$

$$P_2 = 100psia$$

$$h_2 = 1228.2\frac{Btu}{lb}$$

Determine the heat being added to the water.

$$\dot{Q} = \dot{m}\left(h_2 - h_1\right) = \left(350\frac{lb}{hr}\right)\left(1228.2\frac{Btu}{lb} - 30.71\frac{Btu}{lb}\right) = 419,296\frac{Btu}{hr}$$

Calculate the monthly cost by accounting for the efficiency, the heating value of the fuel, the amount of time in a month, and the fuel cost.

$$Cost = \frac{\left(419,296\frac{Btu}{hr}\right)\left(24\frac{hr}{day}\right)\left(30.4days\right)\left(0.50\frac{\$}{lb}\right)}{\left(0.9\right)\left(20,000\frac{Btu}{lb}\right)} = \$8498$$

Answer C