32.15 $200°F$ **feedwater at** $1000psia$ **enters a boiler and is heated to produce** $100,000\frac{lb}{hr}$ **of 90% quality steam. What is the rate of energy absorption?**

A. $6.3 \times 10^7 \frac{Btu}{hr}$

B. $9.3 \times 10^7 \frac{Btu}{hr}$

C. $9.7 \times 10^7 \frac{Btu}{hr}$

D. $1.1 \times 10^8 \frac{Btu}{hr}$

Consider the entering feedwater as State 1 and the leaving saturated mixture as State 2. Use the Properties of Saturated Water and Steam table to look up the saturation temperature and enthalpy for State 1.

$$P_1 = 1000psia$$

$$T_1 = 200°F$$

$$T_{sat} = 544.7°F$$

$$h_f = 542.7\frac{Btu}{lb}$$

$$h_{fg} = 649.9\frac{Btu}{lb}$$

Since the actual temperature is less than the saturation temperature, the water is a compressed liquid. To find the enthalpy, h_1, use the specific heat capacity, temperature differential, and enthalpy at saturation.

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

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

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

$$h_1 = 542.7\frac{Btu}{lb} - \left(1\frac{Btu}{lb°F}\right)(544.7°F - 200°F) = 198\frac{Btu}{lb}$$

Use the previously obtained enthalpy values from the steam table along with the quality to determine the enthalpy at State 2.

$$h_2 = h_f + \chi h_{fg}$$

$$h_2 = 542.7\frac{Btu}{lb} + (0.9)\left(649.9\frac{Btu}{lb}\right) = 1127.6\frac{Btu}{lb}$$

Calculate the total heat absorbed by the steam.

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

$$\dot{Q} = \left(100,000\frac{lb}{hr}\right)\left(1127.6\frac{Btu}{lb} - 198\frac{Btu}{lb}\right) = 9.3 \times 10^7 \frac{Btu}{hr}$$

Answer B