34.21 A Brayton cycle with regeneration has a regenerator with 60% effectiveness. Air enters the compressor at $60°F$ and $14.7psia$ and is compressed to $150psia$. Air enters the turbine at $1400°F$ and leaves at $600°F$ and $14.7psia$. Assuming the compressor and turbine have isentropic efficiencies of 100%, what is the change in enthalpy during combustion?

A. $108\frac{Btu}{lb}$

B. $119\frac{Btu}{lb}$

C. $197\frac{Btu}{lb}$

D. $204\frac{Btu}{lb}$

Refer to the schematic under Brayton Cycle with Regeneration. Since the compressor is isentropic, determine the temperature at State 2 for a Constant Entropy Process. Use absolute temperature i.e. Rankine.

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\left(\frac{k-1}{k}\right)}$$

$$T_2 = T_1\left(\frac{P_2}{P_1}\right)^{\left(\frac{k-1}{k}\right)} = (520R)\left(\frac{150psia}{14.7psia}\right)^{\left(\frac{1.4-1}{1.4}\right)} = 1009.8R = 549.8°F$$

Apply the effectiveness of the regenerator to determine the temperature at State 3, prior to the combustor.

$$\varepsilon = \frac{h_3 - h_2}{h_5 - h_2} = \frac{c_p\,(T_3 - T_2)}{c_p\,(T_5 - T_2)} = \frac{(T_3 - T_2)}{(T_5 - T_2)}$$

$$T_3 = T_2 + \varepsilon\,(T_5 - T_2) = 549.8°F + 0.6\,(600°F - 549.8°F) = 579.9°F$$

Calculate the change in enthalpy through the combustor.

$$h_4 - h_3 = c_p\,(T_4 - T_3) = \left(0.24\frac{Btu}{lb\cdot°F}\right)(1400°F - 579.9°F) = 196.8\frac{Btu}{lb}$$

Answer C