Regenerative Rankine cycle

Consider the regenerative reheat cycle given in the figure. The enthalpy value for each point is given in kJ/kg. Determine the thermal efficiency of this cycle.

Answer: 37%.

Explanation:

Main mass flow $\rightarrow \dot{m}$
Flow at point 9 $\rightarrow \dot{m}_a$
Flow at point 2 $\rightarrow \dot{m}_b$

Conservation of mass gives $\rightarrow \dot{m} = \dot{m}_a + \dot{m}_b$
Conservation of energy over the feedwater heater $\rightarrow \dot{m}h_3 = \dot{m}_a h_9 + \dot{m}_b h_2$
Combining the two conservation equations $\rightarrow \dot{m}_b = \dot{m}\left(\frac{h_9 - h_3}{h_9 - h_2}\right)$

$$\eta_{th} = \frac{\dot{W}_{net}}{\dot{Q}_{in}}$$

$\dot{W}_{net} = \dot{W}_{HPT} + \dot{W}_{LPT} - \dot{W}_{pump1} - \dot{W}_{pump2} = \dot{m}(h_5 - h_6) + \dot{m}_b(h_7 - h_8) - \dot{m}_b(h_2 - h_1) - \dot{m}(h_4 - h_3) = \dot{m}(h_5 - h_6) + \dot{m}\left(\frac{h_9 - h_3}{h_9 - h_2}\right)[(h_7 - h_8) - (h_2 - h_1)] - \dot{m}(h_4 - h_3)$

$\dot{Q}_{in} = \dot{Q}_{boiler} + \dot{Q}_{reheating-boiler} = \dot{m}(h_5 - h_4) + \dot{m}_b(h_7 - h_6) = \dot{m}(h_5 - h_4) + \dot{m}\left(\frac{h_9 - h_3}{h_9 - h_2}\right)(h_7 - h_6)$

Filling in $\rightarrow \eta_{th} = \dfrac{\dot{m}(h_5 - h_6) + \dot{m}\left(\frac{h_9 - h_3}{h_9 - h_2}\right)[(h_7 - h_8) - (h_2 - h_1)] - \dot{m}(h_4 - h_3)}{\dot{m}(h_5 - h_4) + \dot{m}\left(\frac{h_9 - h_3}{h_9 - h_2}\right)(h_7 - h_6)} =$

$0.37 \rightarrow 37\%$