5.5 Power cycles

Name: _____ Class: _____ Date: _____ **Total: 14 marks**

KEY WORDS Rankine cycle • boiler • exhaust quality

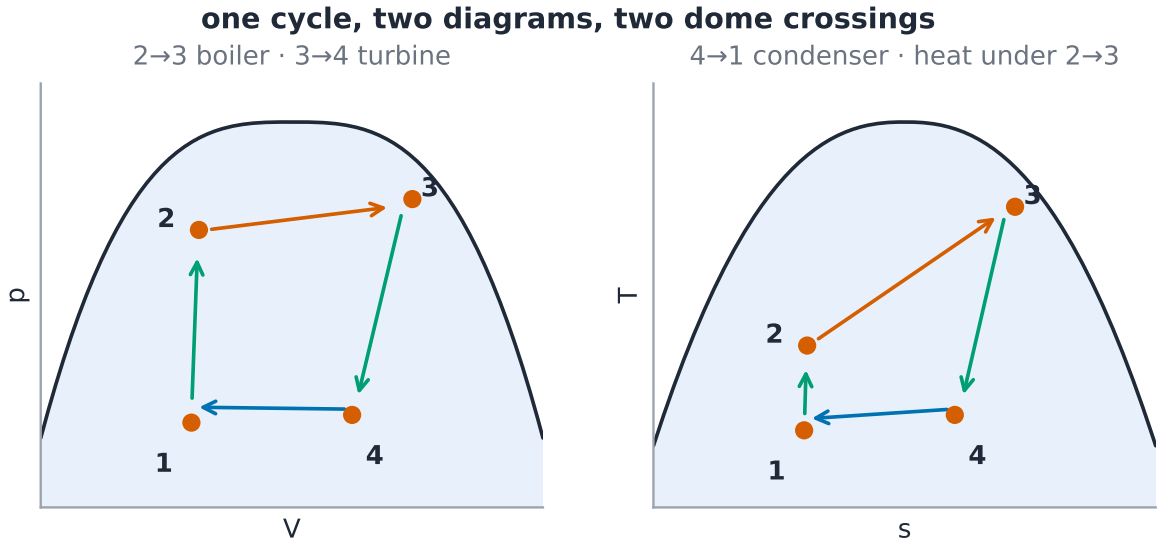
Objective

Walk an ideal Rankine cycle state by state: the isentropic turbine leg through the dome, the liquid pump, heat in, and the thermal efficiency.

1 Key knowledge and worked examples

■ Four components

Turbine: $s_4 = s_3$, $h_4 = h_f + x_4\, h_{fg}$. Pump: $h_2 = h_1 + v_f(p_2 - p_1)$. $\eta = (w_t - w_p)/(h_3 - h_2)$.



*Two dome crossings per lap

■ Worked example. The 4 MPa baseline

$x_4 = (6.0700 - 0.6492)/7.5009 = 0.7227$, $h_4 = 1921.1$; $w_t = 880.3$, $w_p = 4.0$, $q_{in} = 2605.6$: $\eta = 876.3/2605.6 = 33.6\%$ ✓.

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2 Practice

An ideal Rankine cycle: boiler at 8 MPa delivering saturated vapour ($h_3 = 2750.0$ kJ/kg, $s_3 = 5.750$ kJ/(kg K)); condenser at 20 kPa, where $h_f = 250.0$ kJ/kg, $h_{fg} = 2350.0$ kJ/kg, $s_f = 0.830$, $s_{fg} = 7.070$ kJ/(kg K); pump inlet $h_1 = 250.0$ kJ/kg with $v_f = 0.001020$ m^3/kg.

2.1 For this cycle – boiler at 8 MPa giving saturated vapour with $h_3 = 2750.0$ kJ/kg and $s_3 = 5.750$ kJ/(kg K); condenser at 20 kPa with $h_f = 250.0$, $h_{fg} = 2350.0$ kJ/kg, $s_f = 0.830$, $s_{fg} = 7.070$ kJ/(kg K); pump inlet $h_1 = 250.0$ kJ/kg with $v_f = 0.001020$ m^3/kg – the turbine exit quality (four decimals) and exit enthalpy (one decimal, kJ/kg). [4]

2.2 For the cycle of 2.1: the turbine work and the pump work (one decimal each, kJ/kg). [3]

2.3 For the cycle of 2.1: the heat input per kilogram (one decimal, kJ/kg) and the cycle thermal efficiency (one decimal, percent). [3]

2.4 One sentence each: why does raising the boiler pressure raise the efficiency, and why must the exhaust quality be watched even when the arithmetic is clean? [4]

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