November 22 2NE3 QUIZ Solutions

Name: Novoc

[28 marks] We are analyzing the design options for two power plants (option #1 and #2). Power plant #1 and #2 have the common features namely: Both power plants can produce 200 MW of electricity. Both power plants utilize a condenser that operates at 10 kPA. The pump inlet is at saturated liquid conditions for both options. For our study we will assume reversible processes.

Power plant #1 operates at a maximum pressure of 4MPa and a superheat of 500C at the exit of the boiler. Power plant #2 has a maximum pressure of 6MPa and a superheat of 400C at the exit of the boiler.

a) Compute the specific pump power (kJ/kg) in the pump for Plant #1 and #2.
b) Compute the specific heat added in the boiler for Plant #1 and #2 (kJ/kg).
c) Compute the turbine outlet quality for Plant #1 and #2.
d) Compute the specific turbine work for Plant #1 and #2 (kJ/kg).
e) Compute the mass flow rate (kg/s) in Plant #1 and #2.
f) Compute the heat engine efficiency for Plant #1 and #2.
g) Sketch the cycles on a T-s diagram.

Plant #1 | #2

a) ① $v_1 = v_{f@10kPa} = 0.001010$

$h_1 = h_f = 191.81$

Plant #1: $w = -(0.00101)(4000-10) = -4.03$

#2: $w = (0.00101)(6000-1\ldots = -6.05$

b) ② determine h_2

Plant #1: $h_2 = h_1 - (-4.03) = 195.83$

#2: $h_2 = h_1 - (-6.05) = 197.85$

③ determine h_3

Plant #1: $h_3 = 3446$

#2: $h_3 = 3178.3$

determine q

Plant #1: $q_{32} = 3446 - 195.83 = 3250.17$

#2: $q_{32} = 3178.3 - 19\ldots = \cancel{3220}.2980.45$

c) state 3

state 4

Plant #1: $s_3 = 7.0922$

$s_{4s} = s_3$

$x_{4s} = \dfrac{7.0922 - \cancel{0.576}\ 0.6492}{8.1488 - 0.6492} = 0.859$

#2: $s_3 = 6.5432$

$s_{4s} = s_3$

$x_{4s} = \dfrac{\cancel{7.0922}\ 6.5432 - 0.64\ldots}{8.1488 - 0.6\ldots} = 0.780$

d) State 4 h

Plant #1: $h_{4s} = h_f(1-x_{4s}) + h_g(x_{4s}) = 2246.88$

#2: $h_{4s} = 2071.77$

work

Plant #1: $w = h_3 - h_{4s} = 1199.1$

#2: $w = h_3 - h_{4s} = \cancel{908.68}$ 1106.53

$\dot{m}$

Plant #1: $\dot{m} = \dfrac{200000}{(1199.1 - 4.03)} = 167.35$ kg/s

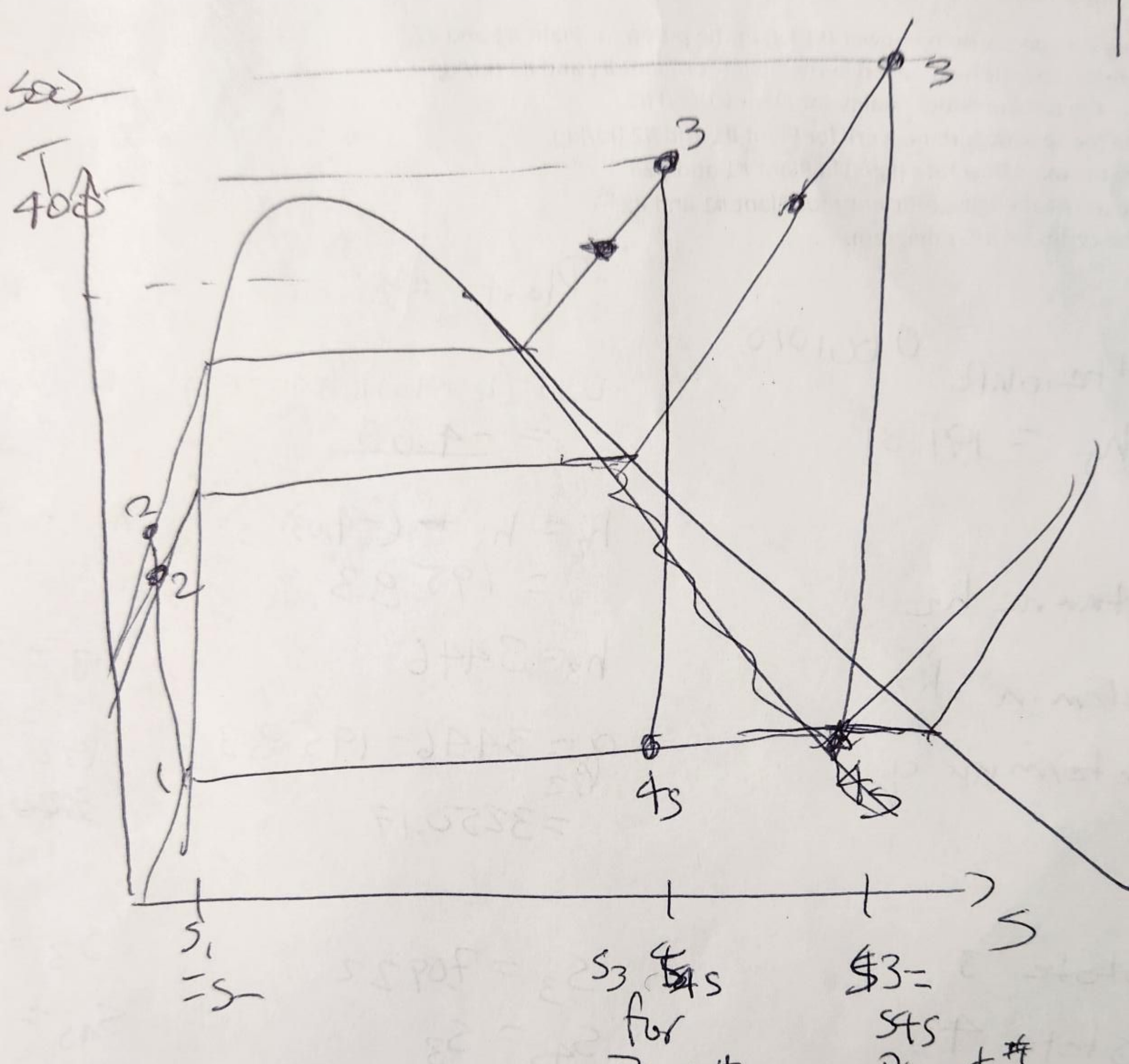
#2: $\dot{m} = \cancel{221.57}$ 181.78 kg/s

2

$$\eta = \frac{W_{net}}{q_{h1}} = \frac{1199.1 - 4.03}{3250} = 36.77\%$$

~~η = 30.3~~

$\eta = 36.92\%$



2NE3 Quiz November 1, 2022 Name:________________

THERE ARE 2 QUESTIONS (see the backside of the paper)

1. A house is heated with a heat pump which operates using R-134a as a fluid. To model the performance of the house we can determine the heat-loss (HL) that is leaving through the walls and attic to be

   $HL \sim C\,(T_{house} - T_{env})$ where C is a constant of 100 W/K.

   Thus a heat pump must supply this amount of heat to the house in order to maintain its temperature. If the environment surrounding the house is at -20 C and is used as the cold reservoir, and the heat is rejected from the heat pump to the house (to keep it warm) which is at 24 C, determine:

   a) The best possible COP for the heat pump.
   b) What is the new COP if the house is at 20C instead of 24 C,
   c) What is the percentage reduction in energy usage when the house is kept at 20 C instead of 24 C.
   d) Discuss if you think the percentage reduction in energy would be the same is the environment temperature was -10 C instead of -20 C.

a) $COP = \frac{|Q_H|}{W_{IN}} = \frac{\cancel{Q(24)+(20)}}{W_{IN}} = \frac{Q_H}{Q_H - Q_L}$

$COP_{BEST} = COP_{\text{Carnot Heat Pump}} = \frac{1}{1 - \frac{Q_L}{Q_H}}$

$= \frac{1}{1 - \frac{T_L}{T_H}}$

$= \frac{1}{1 - \frac{-20+273}{+24+273}} = \underline{6.75}$

b) $COP_{HP} = \frac{1}{1 - \frac{-20+273}{20+273}} = \underline{7.32.}$

0.5

c) $\dot{W} = \cancel{COP}\ Q_H / COP = \frac{C(T_{HOUSE} - T_{ENV})}{COP}$

$\dot{W}_{20°C} = \frac{C(20-(-20))}{COP_{Part B}} = \underline{545}$ 0.5

$\dot{W}_{24°C} = \frac{C(24-(-20))}{COP_{Part A}} = \underline{651}$ 0.5

(flip paper for Question 2)