30

30

Q1 20
Q2 3
Q3 4
Q4 3
Q5 1
Q6 2

12 + 20

University of Jordan
Faculty of Engineering
Department of Mechanical Engineering

Prof. M. A. Hamdan **Date : 28-06-18**
First Examination **Time : Two hours**

Thermodynamics II (90943410)

Name **Student No.**

Problem (1): 20

In an ideal regenerative vapor Rankine cycle, the working fluid leaves the boiler as saturated vapor at 300 kPa. An amount of fluid is withdrawn from the turbine to an open feed water heater, which operates at 200 kPa. If the condenser operates at 30 kPa, sketch the T-S diagram with respect to saturated curve, starting with 1 at the boiler inlet . Also find the followings

a. The amount of the fluid withdrawn from the turbine
b. The net power produced by the cycle
c. Heat added to the cycle
d. The efficiency of the cycle

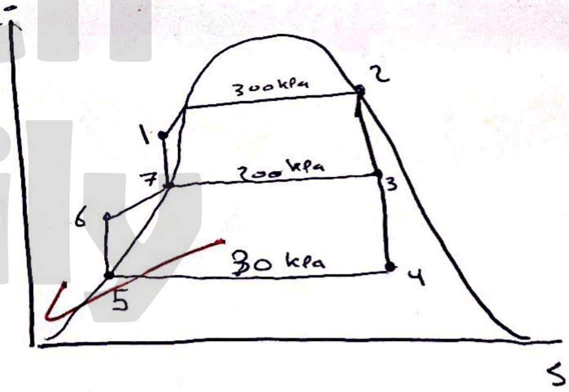
~~assume~~

assume $\dot{m} = 1 \text{ kg/s}$

$P_2 = P_1 = 300 \text{ kPa}$

$P_3 = P_7 = 200 \text{ kPa}$

$P_4 = P_5 = 30 \text{ kPa}$



5 – 6 Pump I $\quad v_5 = 0.001022$ @ f, 30

$w_{pump, I\, in} = v_5 (P_6 - P_5)$

$= 0.001022 (200 - 30) = 0.17374 \text{ kJ/kg}$

$h_6 - h_5 = w_{pump I, in} = 0.17374$

$h_6 - 289.27 = 0.17374 \qquad \boxed{h_6 = 289.44 \text{ kJ/kg}}$

$h_1 - h_7 = v_7 (P_1 - P_7) = w_{pump II, in}$

$h_1 - 504.71 = 0.001061 (300 - 200) = 0.1061 \text{ kJ/kg}$

$h_1 = 504.8161 \text{ kJ/kg}$

$h_2 = 2724.9$ kJ/kg $\quad S_2 = 6.9917$ kJ/kg.K

$S_3 = S_2 \quad 6.9917 = x\, S_{fg} + S_f$

$6.9917 = x\, 5.5968 + 1.5302$

$x = 0.9758$

$h_3 = 0.9758 * 2201.6 + 504.71$

$h_3 = 2653.08$ kJ/kg

$S_4 = S_3 = 6.9917$

$6.9917 = X\, 6.8234 + 0.9441$

$X = 0.8863$

$h_4 = 0.8863 * 2335.3 + 289.27$

$h_4 = \cancel{2925}\ 2359.05$ kJ/kg

$y h_3 + (1-y) h_6 = h_7$

$y \times 2653.08 + (1-y)\, 289.44 = 504.71$

a. $\boxed{y = 0.0910}$

b) $w_{turb\ out} = (h_2 - h_3) + (1 - 0.0910)(h_3 - h_4)$

$= \cancel{20}\ 71.82 + .909\ (294.031)$

$= 339.09$ kJ/kg

$q_{in} = h_1 - h_1 = 2220.08$ kJ/kg

$q_{out} = (.909)(h_4 - h_5)$

$= 1881.43$ kJ/kg

$w_{pump,in} = = \cancel{to}(0.909)\, w_{pump\ I} + w_{pump\ II}$

$= 0.17374(0.909) + 0.1961 = 0.2640$ kJ/kg b)

$w_{net} = q_{in} - q_{out}$

$= 2220 - 1881 = 338.65$ kJ/kg

$Power_{net} = \dot{W}_{net} = 338.65 \times (1 \text{ kg/s})$ kg/kg

$= 338.65$ kW

c) $q_{in} = 2220.08$ kJ/kg

$\dot{Q}_{in \text{ added}} = 2220.08$ kJ/kg $\times$ 1 kg/s $=$

2220.08 kW

d) $\eta = 1 - \dfrac{q_{out}}{q_{in}}$

$= 1 - \dfrac{1881.43}{2220.08}$

$1 - 0.847 = 0.1525$

$= 15.25\%$

---

b) double check

$W_{net} = W_{turbine\ out} - w_{pump\ in}$

$= 339.09 - 0.2640$

$\simeq 338.65$ kJ/kg ✓

Problem (2): An Otto cycle with air as the working fluid has a compression ratio of 8.2. Under cold-air-standard conditions, Determine the thermal efficiency of this cycle.

$$\frac{V_4}{V_3} = \frac{V_1}{V_2} = \frac{V_{max}}{V_{min}} = 8.2$$

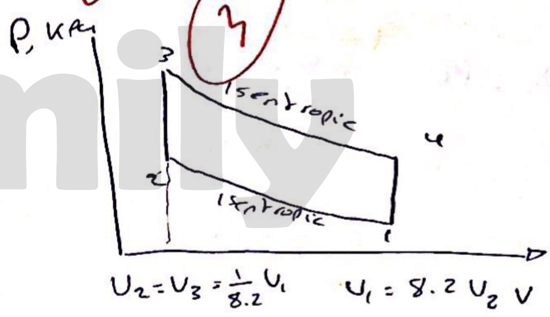
$$\eta = 1 - \frac{1}{r^{(k-1)}}$$

$$\eta = 1 - \frac{1}{8.2^{1.4-1}}$$

$$\eta = 1 - \frac{1}{2.32} = 1 - 0.43 = 0.57$$

$$= 57\%$$

3

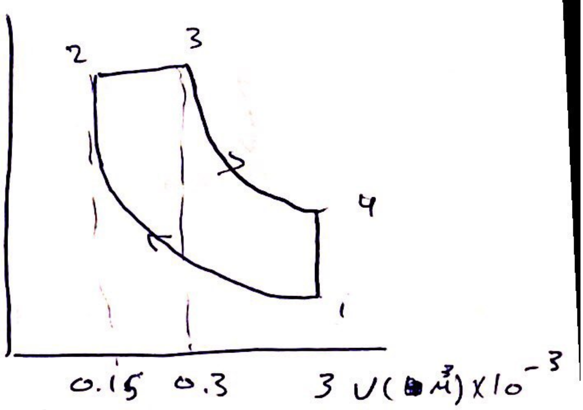


Problem (3): Air in an ideal Diesel cycle is compressed from 3 to 0.15 L, and then it expands during the constant pressure heat addition process to 0.3 L. Under cold air standard conditions, Determine the thermal efficiency of this cycle.

V_1 V_2 V_3

$$r = \frac{V_1}{V_2} = \frac{3}{0.15} = 20$$

$$r_c = \frac{V_3}{V_2} = \frac{0.3}{0.15} = 2$$



$$\eta = 1 - \frac{1}{r^{k-1}}\left[\frac{r_c^{k}-1}{k(r_c-1)}\right]$$

$$= 1 - \frac{1}{20^{(1.4-1)}}\left[\frac{2^{1.4}-1}{1.4(2-1)}\right]$$

$$= 1 - 0.301\left[\frac{1.64}{1.4}\right]$$

$$1 - .353 = 0.647$$

$$= 64.7\%$$

U

$P_1 = P_4$ $\quad P_2 = P_3$

Problem (4): In an ideal Brayton cycle, air is compressed from 95kPa and 25^{0}C to 800kPa. Under cold-air-standard conditions, Determine the thermal efficiency of this cycle.

$$r_p = \frac{P_2}{P_1} = \frac{800\text{ kPa}}{95\text{ kPa}} = 8.42$$

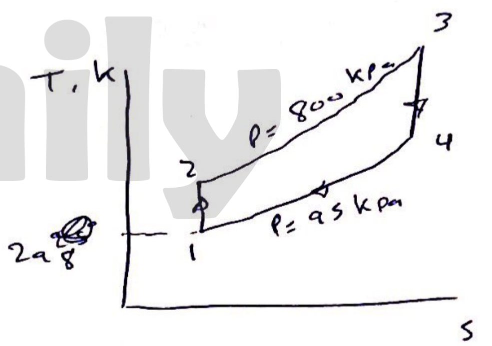
$$\eta_{Brayton} = 1 - \frac{1}{r_p^{(k-1)/k}}$$

$$= 1 - \frac{1}{8.42^{(0.4/1.4)}} = 1 - \frac{1}{1.84}$$

$$\eta = 0.4559$$

$$= 45.6\%$$

3



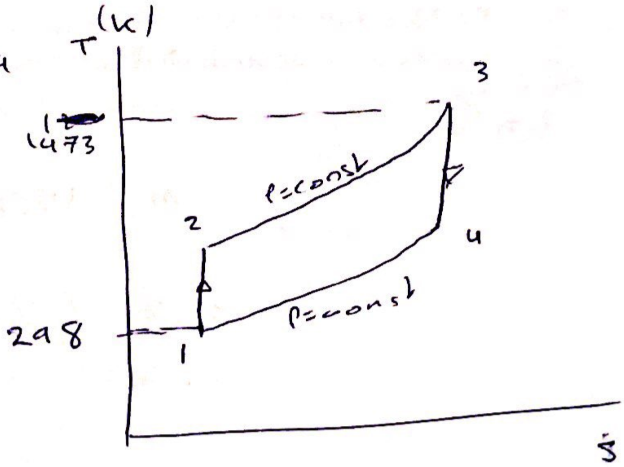
$P_1 = P_4 \quad T_1 \quad P_2 = P_3$

Problem (5): In an ideal Brayton cycle, air is compressed from 100kPa and 25⁰C to 1MPa, and then heated to 1200⁰C before entering the turbine. Under cold-air-standard conditions, the air conditions, determine the air temperature at the turbine exit.

$T_3 = 1200°C \qquad P_3 = 1000 \text{ kPa}$

$T_4 = ?? \qquad P_4 = 100 \text{ kPa}$

3-4 isentropic process



$$\left(\frac{T_4}{T_3}\right) = \left(\frac{P_4}{P_3}\right)^{\frac{K-1}{K}}$$

$$\left(\frac{T_4}{1473}\right) = \left(\frac{100}{1000}\right)^{\left(\frac{1.4-1}{1.4}\right)}$$

1

$$\left(\frac{T_4}{1473}\right) = \left(\frac{1}{10}\right)^{0.285}$$

$$\frac{T_4}{1473} = 0.517$$

$T_4 = 762.9$ K

$T_4 = 489.9$ °C

V_{inlet} $\dot{m}$ U_{exit}

Problem (6): Air enters a turbojet engine at 260 m/s at a rate of 30kg/s, and exits at 800m/s relative to the aircraft. Determine the thrust developed by engine.

$V_{inlet} = 260$ m/s $\quad \dot{m} = 30$ kg/s $\quad U_{exit} = 800$ m/s

$$F_{thrust} = \dot{m}\,(U_{exit} - V_{inlet})$$

$$= 30\,(800 - 260) = 16200 \text{ N}$$

$$= 16.2 \text{ kN}$$

2