University of Technology
Mechanical Engineering Department
Final Year Examination 2015-2016

Subject: Thermodynamics II | **Year:2nd**
Division: All | **Exam Time: 3 Hrs.**
Examiner(s):Dr. Zainab Hasoun& Dr. Dheya Ghanim | **Date:31 / 5/ 2016**

Notes:- (1) Answer (Four) Questions Only. (2) Steam tables and chart are allowed.

Q1. A-) closed vessel of fixed volume ($0.6 m^3$) contain dry steam at (3.5 bar). The vessel cooled until the pressure is (2 bar) .Find the mass of the steam, the dryness fraction and the amount of heat transferred. Draw the p-v diagram of the process. **[6M]**

B-) A two-stage, single acting air compressor running in an atmosphere at (1.013 bar) and (15 °C) has a free air delivery of ($3\ m^3/min$). The suction pressure and temperature are ($0.9\ bar$) and (35 °C) respectively. The delivery pressure is (32 bar). The machine is designed for minimum work and it utilizes a complete intercooler. The polytropic index is (1.25). The compressor runs at (500 rpm) and has a clearance volume for both stages are (5%) of the swept volume while the stroke length is twice bore diameter. Find:

i. Isothermal efficiency and volumetric efficiency.
Ii. Heat exchanged with the surrounding.
iii- Cylinder bore and stroke length for the 1st stage. **[9M]**

Q2.A-) What is the cutoff ratio? How does it affect the thermal efficiency of a Diesel cycle? Explain with drawing. **[2M]**

B-) Derive the thermal efficiency of Otto air standard cycle. **[3M]**

C-) In a dual combustion cycle the maximum temperature is (2000 °C) and the maximum pressure is (70 bar), the compression ratio is (18/1).Calculate the thermal efficiency and the mean effective pressure when the pressure and temperature at the start of compression are (1 bar) and (17 °C) respectively. **[10M]**

Q3.A-) Why is the throttling valve not replaced by an isentropic turbine in the ideal vapor-compression refrigeration cycle? **[3M]**

B-) Air enters the compressor of a gas turbine at (100kPa), (300 K) . The air is compressed in two stages to (900kPa), with intercooling to (300K) between the stages at a pressure of (300kpa). The turbine inlet temperature is (1480K) and the expansion occurs in two stages, with reheat to (1420K) between the stages at a pressure of (300kPa). The compressor and turbine stage efficiencies are (84%) and (82%) , respectively. The net power developed is (1.8MW). Determine (a) the mass flow rate of the cycle, in kg/s, (b) the thermal efficiency of the cycle and (c) the back work ratio.
If a regenerator with effectiveness of 75% is used in the cycle. Find (a), (b) and(c). Draw the T-s diagram for both cases. **[12M]**

Q4. A-) An ideal vapor-compression refrigeration cycle operates at steady state with Refrigerant 134a as the working fluid. Saturated vapor enters the compressor at (2 bar), and saturated liquid exits the condenser at (8 bar). The mass flow rate of refrigerant is (7 kg/min) .Determine (a) The compressor power, in Kw, (b) The refrigerating capacity, in tons, (c) The coefficient of performance, and (d) Draw the cycle on T-s diagram. **[10M]**

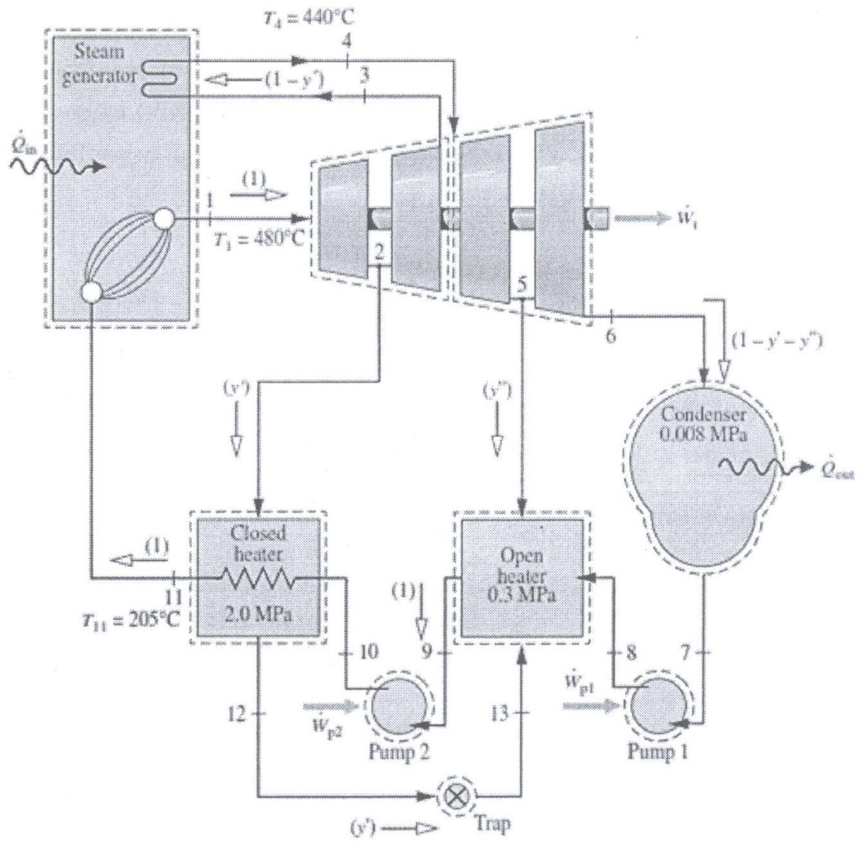
B-) For a specified pressure ratio, why does multistage compression with intercooling decrease the compressor work, and multistage expansion with reheating increase the turbine work? Explain with sketch. **[5M]**

Q5. A-) Consider a simple ideal Rankine cycle. For five cases below,choose the right answer**(I) increases, (II) decreases, (III) remains the same**.

1-What is the effect of fixed turbine inlet conditions and lowering the condenser pressure **on heat rejected.**
2-What is the effect of fixed turbine inlet temperature and condenser pressure with increasing the boiler pressure **on thermal efficiency**.
3-What is the effect of fixed boiler and condenser pressures with superheating the steam to a higher temperature **on moisture content at turbine exit.**
4-What is the effect of fixed boiler and condenser pressures with reheating the steam **on work turbine**.
5-What is the effect of fixed boiler and condenser pressures with regenerative the steam **on work pump**.

[5M]

B-) Consider a reheat–regenerative vapor power cycle with two feedwater heaters, a closed feedwater heater and an open feedwaterheater.Steam enters the first turbine at (8 MPa),(480°C) and expands to (0.7MPa). The steam is reheated to (440°C) before entering the second turbine,where it expands to the condenser pressure of (0.008 MPa). The net power output of the cycle is (100 MW). Determine (a) the thermal efficiency, (b) the mass flow rate of the steam entering the first turbine, in kg/h.



[10M]

(Take $c_{p,air} = 1.005$ kJ/kg K and $\gamma = 1.4$ for all compression processes, and as $c_{p,gas} = 1.15\ kJ/kg\ K$ and $\gamma = 1.333$ for all combustion and expansion processes.)

Q1: A)

$V = 0.6\ m^3$

$P_1 = 3.5$ bar (dry steam)

$P_2 = 2$ bar Find: $m = ?$, $X_2 = ?$, $Q = ?$

@ $P_1 = 3.5$ bar (dry sat) $\Rightarrow v_1 = v_g = 0.524\ m^3/kg$

$h_1 = h_g = 2732.4\ kJ/kg$

$\therefore u_1 = h_1 - P_1 v_1$

$= 2732.4 - 3.5\times10^2 * 0.524 = 2549\ kJ/kg$

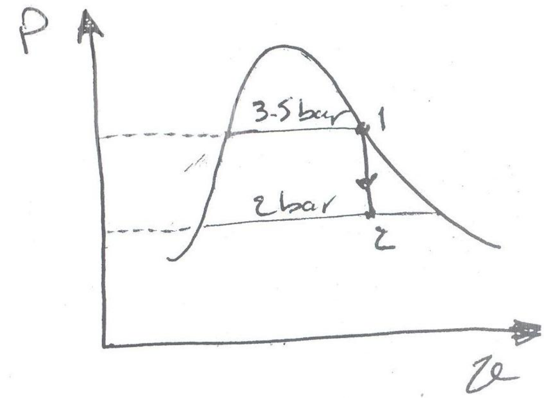
$$m = \frac{V}{v_1} = \frac{0.6}{0.524} = 1.145\ kg$$

@ $P_2 = 2$ bar $\Rightarrow v_g = 0.886\ m^3/kg$ & $v_f = 0.00106\ m^3/kg$

$\because v_1 = v_2 = 0.524$ & $v_2 < v_g$ $\therefore$ wet steam

$\therefore v_2 = X_2 v_g$

$0.524 = X \cdot 0.886 \Rightarrow X_2 = 0.591$



$Q = m \cdot \Delta u$

$h_2 = h_{f2} + X_2 h_{fg2}$

$= 504.7 + (0.591)*2201.9 = 1806.2\ kJ/kg$

$\therefore u_2 = h_2 - P_2 v_2 = 1806.02 - 2*10^2*0.524 = 1701.2\ kJ/kg$

$\therefore Q = 1.145(1701.2 - 2549)$

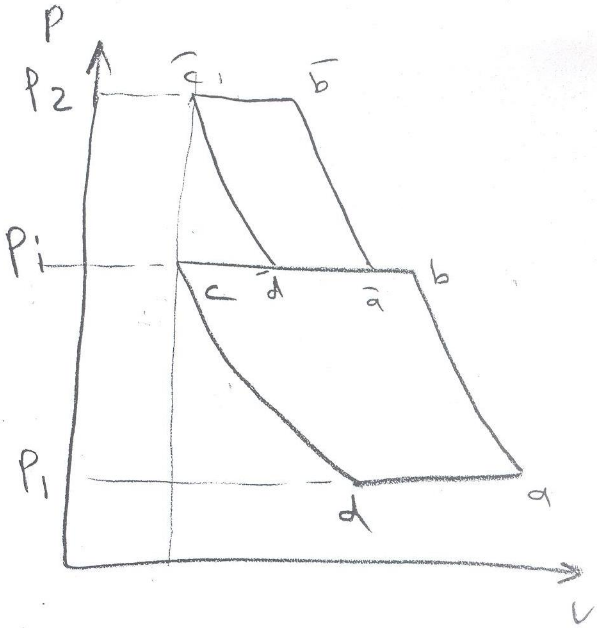
$= -970.7\ kJ$

Q3: A)

cheaper to have irreversible expansion through an expansion valve, and to make ideal vapor-compression cycle more closely to the actual cycle.

Q1 B

Sol.



$$\dot{m} = \frac{PV}{RT} = \frac{1.013*10^2*3}{0.287*288} = 3.676\ Kg/min$$

$$= 0.0612\ Kg/s$$

$$\because \frac{P_1}{P_i} = \frac{P_i}{P_2} \Rightarrow \frac{P_i}{P_1} = \frac{\sqrt{P_1P_2}}{P_1} = \sqrt{\frac{P_2}{P_1}}$$

$$\therefore \frac{P_i}{P_1} = \sqrt{\frac{P_2}{P_1}} = \sqrt{\frac{32}{0.9}} = 5.962\ bar$$

$$\dot{W}_{iso} = \dot{m}RT_1 \ln\frac{P_2}{P_1}$$

$$= 2*\left(\dot{m}RT_1 \ln\frac{P_i}{P_1}\right)$$

$$= 2*3.676*0.287*308 \ln 5.962$$

$$= 1160.31\ Kg/min \Rightarrow 19.33\ KW$$

$$\dot{W} = \frac{n}{n-1}\dot{m}RT_1\left[\left(\frac{P_i}{P_1}\right)^{\frac{n-1}{n}} - 1\right]*2$$

$$= 2*\frac{1.25}{0.25}*3.676*0.287*308\left[(5.962)^{\frac{0.25}{1.25}} - 1\right]$$

$$= 1394.50\ Kg/min \Rightarrow 23.241\ KW$$

(ii) $$\eta_{iso} = \frac{\dot{W}_{iso}}{\dot{W}} = \frac{19.33}{23.241} = 0.8317$$

$$= 83.17\%$$

$$\frac{P_f V_f}{T_f} = \frac{P_1 V_1}{T_1}$$

$$\text{F.A.D. Per cycle}, V_f = (V_a - V_d) * \frac{T_f}{T_1} * \frac{P_1}{P_f}$$

$$= \left[V_s + V_c - V_c\left(\frac{P_i}{P_1}\right)^{\frac{1}{n}}\right] * \frac{T_f}{T_1} \cdot \frac{P_1}{P_f}$$

$$= V_s\left[1 + 0.05 - 0.05(5.962)^{\frac{1}{1.25}}\right] * \frac{288}{308} * \frac{0.9}{1.013}$$

$$= 0.706\, V_s$$

(i)

$$\therefore \varepsilon_v = \frac{\text{F.A.D Per cycle}}{V_s} = \frac{0.706\, \cancel{V_s}}{\cancel{V_s}} = \underline{\underline{0.706}}$$

$$\because T_i = T_1\left(\frac{P_i}{P_1}\right)^{\frac{n-1}{n}} = 308\,(5.962)^{\frac{0.25}{1.25}}$$

$$= 440.178\,K$$

ii)

$$Q - W = \Delta H$$

$$Q_{1st,\,stage} = W + \Delta H = Q_{2nd\,,stage}$$

$$\therefore Q_{L_{(1+2)}} = W_{L_{(1+2)}} + \left[\dot{m} c_p (T_i - T_1)\right] * 2$$

$$= -23.241 + \left[\frac{3.676}{60} * 1.005 * (440.17 - 308)\right] * 2$$

$$= -6.965\, KW$$

$$Q_{intercooler} = \dot{m} c_p (T_1 - T_i)$$

$$= \frac{3.676}{60} * 1.005 * (308 - 440.178)$$

$$= -8.138\, KW$$

$$\therefore Q_{t} = -6.965 - 8.138 = -15.10\, KW$$

(iii)

$$V_i = \frac{\dot{V}_i}{m * N} = 0.706\, V_s$$

$$\frac{3}{1 * 500} = 0.706\, V_s$$

$$\therefore V_s = 0.008498\, m^3$$

$$\therefore V_s = \frac{\pi D^2}{4} * L$$

$$\because L = 2D$$

$$V_s = \frac{\pi D^3}{2}$$

$$\therefore D = 0.1755\, m = 17.55\, cm$$

$$\therefore L = 2 * 17.55 = 35.11\, cm$$

Q2

A/

Cutoff ratio is the ratio of the cylinder volumes after and before the combustion process. As the cutoff ratio decreases, the efficiency of the diesel cycle increases.

(B)

$$\eta_{th,otto} = \frac{W_{net}}{q_{in}} = 1 - \frac{q_{out}}{q_{in}} = 1 - \frac{T_4 - T_1}{T_3 - T_2}$$

$$= 1 - \frac{T_1\left(\frac{T_4}{T_1} - 1\right)}{T_2\left(\frac{T_3}{T_2} - 1\right)}$$

$V_2 = V_3$ & $V_4 = V_1$

$T_2 = T_1 r_v^{\gamma-1}$, $T_3 = T_4 r_v^{\gamma-1}$

$$\frac{T_1}{T_2} = \left(\frac{V_2}{V_1}\right)^{\gamma-1} = \left(\frac{V_3}{V_4}\right)^{\gamma-1} = \frac{T_4}{T_3}$$

$$= 1 - \frac{T_4 - T_1}{T_4 r_v^{\gamma-1} - T_1 r_v^{\gamma-1}} \Rightarrow 1 - \cancel{\frac{(T_4 - T_1)}{(T_4 - T_1) r_v^{\gamma-1}}}$$

$$= 1 - \frac{1}{r_v^{\gamma-1}}$$

$$r_v = \frac{V_1}{V_2}$$

Q2

c

sol.

$r_v = 18/1$

$T_2 = T_1 (r_v)^{\gamma - 1}$

$= (17 + 273)(18)^{0.4}$

$= 921 K$

$\frac{T_3}{T_2} = \frac{P_3}{P_2} = r_p$

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

$P_2 = 1 \left(\frac{921}{290}\right)^{\frac{1.4}{0.4}}$

$P_2 = 57$ bar

$T_3 = T_2 \left(\frac{70}{57}\right)$

$= 921 (1.228)$

$= 1131 K$

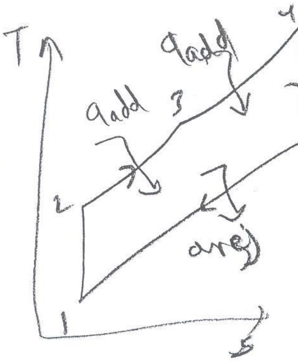
$\frac{T_5}{T_4} = \left(\frac{V_4}{V_5}\right)^{\gamma-1}$

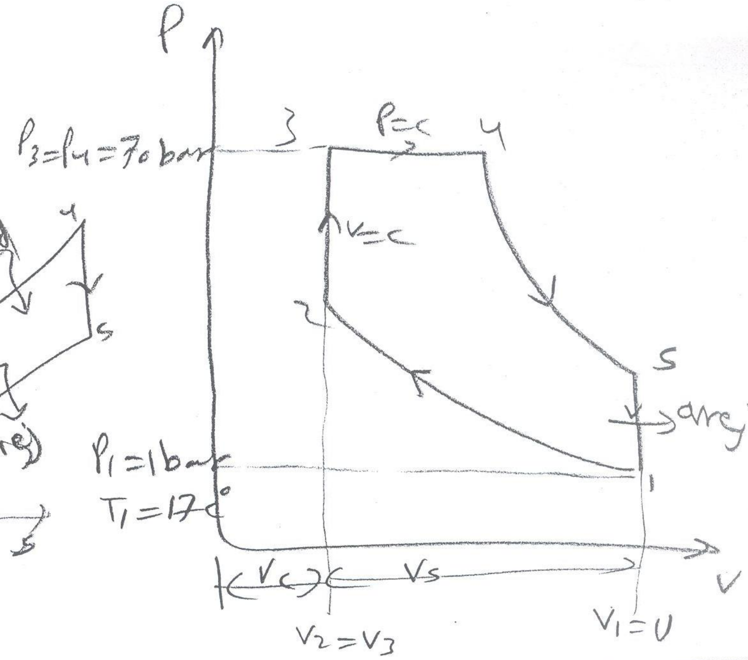
$T_5 = T_4 \left(\frac{r_c}{r_v}\right)^{\gamma-1}$

$\frac{T_4}{T_3} = \frac{V_4}{V_3} = r_c$

$= \frac{2000 + 273}{1131}$

$= 2$





$T_5 = 2273 \left(\frac{2}{18}\right)^{0.4}$

$= 945 K$

$q_{add} = c_v (T_3 - T_2) + c_p (T_4 - T_3)$

$= 0.718 (1131 - 921) + 1.005 (2273 - 1131)$

$= 1298.5 \, kJ/kg$

$q_{rej} = c_v (T_5 - T_1)$

$= 0.718 (945 - 290)$

$= 470.29 \, kJ/kg$

$\eta = 1 - \frac{q_{rej}}{q_{add}} = 0.637$

$W_{net} = q_{add} - q_{rej} = 828.21 \, kJ/kg$

$V_s = \frac{R T_1}{P_1} \left(\frac{r_v - 1}{r_v}\right) \Rightarrow \frac{0.287 \times 290}{100} \left(\frac{18 - 1}{18}\right)$

$= 0.786 \, m^3$

$P_m = \frac{W_{net}}{V_s} = \frac{828.21}{0.786} = \underline{10.5 \text{ bar}}$

Q3: B)

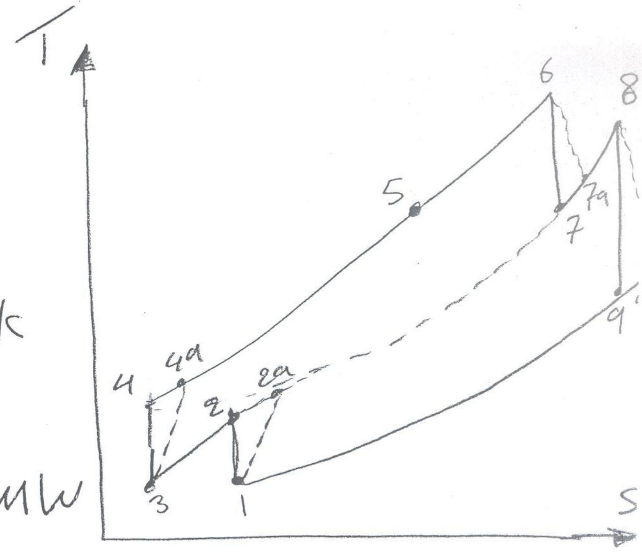
$P_1 = 100\,kPa,\ T_1 = 300\,k$

$P_4 = 900\,kPa,\ P_2 = P_3 = 300\,kPa$

$T_3 = 300\,k,\ T_6 = 1484\,k,\ T_8 = 1420\,k$

$P_7 = P_8 = 300\,kPa$

$\eta_c = 0.84,\ \eta_T = 0.82,\ W = 1.8\,MW$



$$T_2 = T_1 \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}} = 300\left(\frac{300}{100}\right)^{\frac{0.4}{1.4}} = 410.6\,k$$

$$T_{2a} = T_1 + \frac{T_2 - T_1}{\eta_c} = 300 + \frac{410.6 - 300}{0.84} = 431.6\,k$$

$$\frac{T_4}{T_3} = \left(\frac{P_4}{P_3}\right)^{\frac{k-1}{k}} \Longrightarrow T_4 = 300 * \left(\frac{900}{300}\right)^{\frac{0.4}{1.4}} = 410.6\,k$$

$$T_{4a} = T_3 + \frac{T_4 - T_3}{\eta_c} = 300 + \frac{410.6 - 300}{0.84} = 431.6\,k$$

$$\frac{T_7}{T_6} = \left(\frac{P_7}{P_6}\right)^{\frac{k-1}{k}} \Longrightarrow T_7 = 1480\left(\frac{300}{900}\right)^{\frac{0.4}{1.4}} = 1081.2\,k$$

$$T_{7a} = T_6 - \eta_T (T_6 - T_7) = 1480 - 0.82(1480 - 1081.2) = 1153.1\,k$$

$$\frac{T_9}{T_8} = \left(\frac{P_9}{P_8}\right)^{\frac{k-1}{k}} \Longrightarrow T_9 = 1420\left(\frac{100}{300}\right)^{\frac{0.4}{1.4}} = 1037.4\,k$$

$$T_{9a} = T_8 - \eta_T (T_8 - T_9) = 1420 - 0.82(1420 - 1037.4) = 1106.3$$

$$W_{net} = [W_{T1} + W_{T2}] - [W_{C1} + W_{C2}]$$

$$W_{T(1+2)} = c_p\left[(T_6 - T_{7a}) + (T_8 - T_{9a})\right]$$
$$= 1.005\left\{(1480 - 1153.1) + (1420 - 1106.3)\right\}$$
$$= 643.8\ kJ/kg$$

$W_{c(1+2)} = c_p[(T_{2a}-T_1) + (T_{4a}-T_3)]$

$= 1.005[(431.6-300) + (431.6-300)] = 264.5$ kJ/

$\therefore w_{net} = 643.8 - 264.5 = 379.2$ kJ/kg

(a) $\dot{W}_{net} = \dot{m}\, w_{net} \Rightarrow \dot{m} = \dfrac{1.8\times10^3}{379.2} = 4.74$ kg/s

(b) $\eta_{th} = \dfrac{w_{net}}{q_{in1}+q_{in2}}$

$q_{in1}+q_{in2} = c_p[(T_6-T_{4a}) + (T_8-T_{7a})]$

$= 1.005[(1480-431.6) + (1420-1153.1)] = 1321.8$ kJ/k

$\therefore \eta_{th} = \dfrac{379.2}{1321.8} = 0.286$ or 28.6%

(c) $r_{bw} = \dfrac{W_c}{W_T} = \dfrac{264.5}{643.8} = 0.4108$ or 41.08%

If a regenerator with $\varepsilon = 75\%$ is used $\Rightarrow W_c$ & W_T dose not change $\Rightarrow w_{net}$ is the same

$\therefore$ (a) $= 4.74$ kg/s

(b) $q_{in1}+q_{in2} = c_p[(T_6-T_5) + (T_8-T_{7a})]$

$T_5 = T_{4a} + \varepsilon(T_{9a}-T_{4a})$

$= 431.6 + 0.75(1106.3-431.6) = 937.6$ K

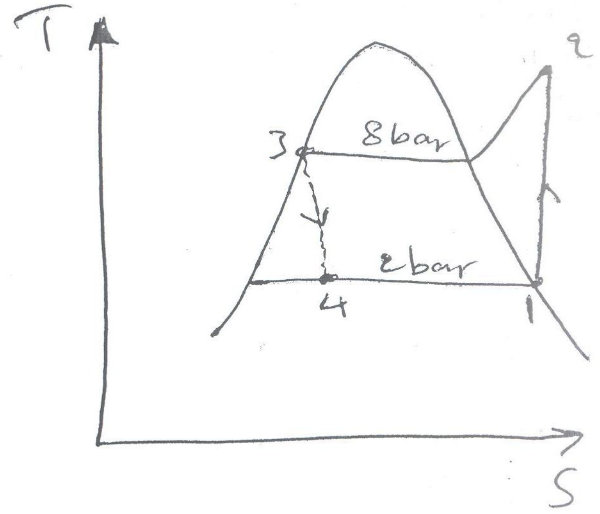
$\therefore q_{in1}+q_{in2} = 1.005[(1480-937.6)+(1420-1153.1)] = 813.3$ kJ/kg

(b) $\therefore \eta_{th} = \dfrac{379.2}{813.3} = 0.466$ or 46.6%

(c) $r_{bw} = 41.08\%$

Q4: A)

From Refrigerant 134a table:



① @ $P_1 = 2\,bar$, sat. vapor $\Longrightarrow$

$h_1 = h_g = 241.3\ kJ/kg$
& $S_1 = 0.9253\ kJ/kg.k$

② @ $P_2 = 8\,bar$, $S_2 = S_1 \Longrightarrow$

$h_2 = 269.9\ kJ/kg$ by interpolation between ($S = 0.9066$ & $S = 0.9374$)

③ @ $P_3 = 8\,bar$, sat. liquid $\Longrightarrow h_3 = 93.42\ kJ/kg$

④ Throttling Process $\Longrightarrow h_4 = h_3 = 93.42\ kJ/kg$

(a) $\dot{W}_c = \dot{m}(h_2 - h_1)$

$$= \frac{7}{60}(269.9 - 241.3) = 3.34\ kW$$

(b) $\dot{Q}_L = \dot{m}(h_1 - h_4)$

$$= \frac{7}{60}(241.3 - 93.42) = 17.25\ kW * \frac{60}{211}$$

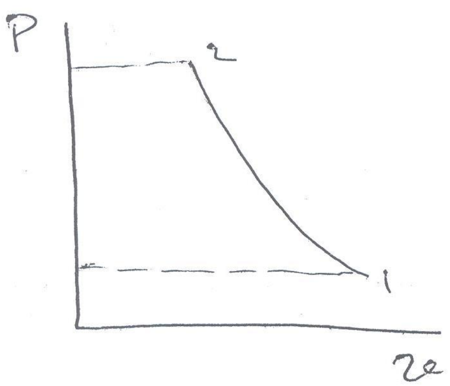
$$= 4.91\ tons$$

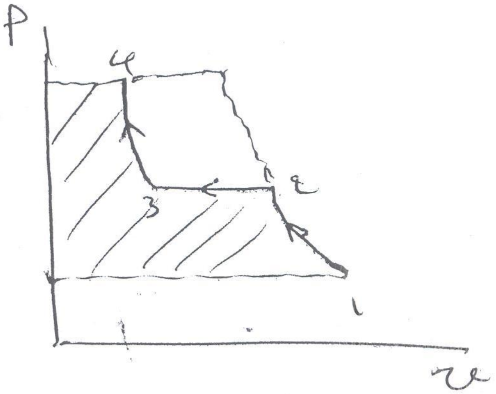
(c) $$C.O.P = \frac{\dot{Q}_L}{\dot{W}_{in}}$$

$$= \frac{17.25}{3.34} = 5.16$$

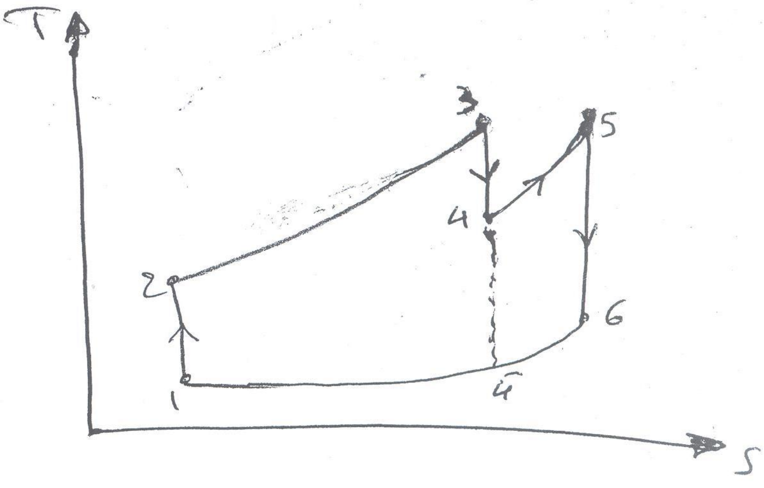
Q4: B)

using multistage compression with intercooling, the compression process becoms nearly isthermal at the compressur inlet temperature, and specific volume is reduc and in turn the compression work decreases, as shown in fig.





using multistage expansion with reheating, the expansion process becoms nearly isothermal and the specific volume is increase which increas the work output as, shown in fig.:



Q5 B

Sol.

$h_1 = 3348.4 \text{ kJ/kg}$

$h_2 = 2963.5 \text{ kJ/kg}$

$h_3 = 2741 \text{ kJ/kg}$

$h_4 = 3353.3 \text{ kJ/kg}$

$h_5 = 3101.5 \text{ kJ/kg}$

$h_6 = h_f + x_6 h_{fg}$

or $h_6 = 2428.5 \text{ kJ/kg}$

$h_7 = h_f = 173.88 \text{ kJ/kg}$

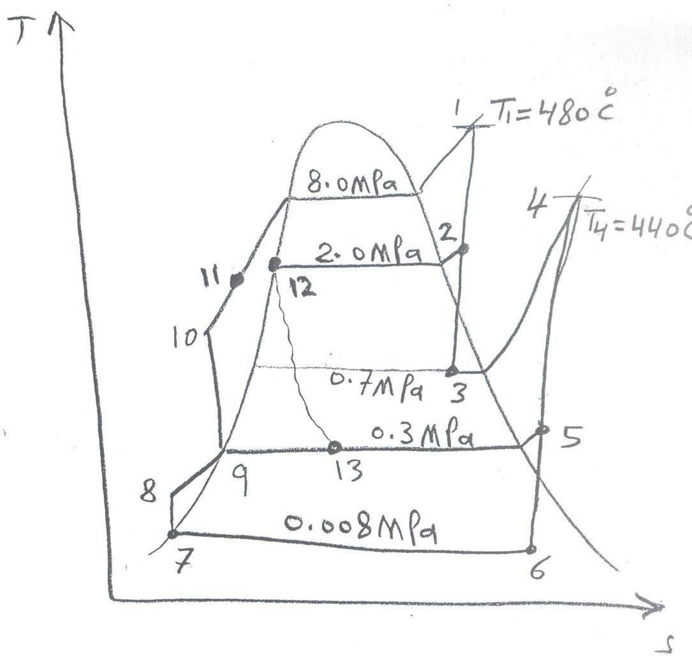
$$h_8 = h_7 + v_7 (P_8 - P_7)$$
$$= 173.88 + (1.0084)(0.3 - 0.008)$$
$$= 174.17 \text{ kJ/kg}$$

$h_9 = h_f = 561.47 \text{ kJ/kg}$

$$h_{10} = h_9 + v_9 (P_{10} - P_9)$$
$$= 561.47 + (1.0732)(8.0 - 0.3)$$
$$= 569.73 \text{ kJ/kg}$$

$h_{12} = h_{13} = h_f = 908.79 \text{ kJ/kg}$

$$h_{11} = h_f + v_f (P_{11} - P_{sat})$$
$$= 875.1 + (1.1646)(8.0 - 1.73)$$
$$= 882.4 \text{ kJ/kg}$$



$$\bar{y} = \frac{h_{11} - h_{10}}{h_2 - h_{12}} = 0.1522$$

$$0 = \bar{\bar{y}} h_5 + (1 - \bar{y} - \bar{\bar{y}}) h_8 + \bar{y} h_{13} - h_9$$

$$\bar{\bar{y}} = \frac{(1-\bar{y}) h_8 + \bar{y} h_{13} - h_9}{h_8 - h_5}$$
$$= 0.0941$$

(a)

$$\frac{\dot{W}_{t_1}}{\dot{m}_1} = (h_1 - h_2) + (1 - \bar{y})(h_2 - h_3)$$
$$= 572.9 \text{ kJ/kg}$$

$$\frac{\dot{W}_{t_2}}{\dot{m}_1} = (1-\bar{y})(h_4 - h_5) + (1 - \bar{y} - \bar{\bar{y}})(h_5 - h_6)$$
$$= 720.7 \text{ kJ/kg}$$

$$\frac{\dot{W}_{P_1}}{\dot{m}_1} = (1 - \bar{y} - \bar{\bar{y}})(h_8 - h_7)$$
$$= 0.22 \text{ kJ/kg}$$

$$\frac{\dot{W}_{P_2}}{\dot{m}_1} = (h_{10} - h_9)$$
$$= 8.26 \text{ kJ/kg}$$

$$\frac{\dot{Q}_{in}}{\dot{m}_1} = (h_1 - h_{11}) + (1-\bar{y})(h_4 - h_3)$$

$$= 2984.4 \text{ KJ/Kg}$$

$$\eta = \frac{\left(\frac{\dot{W}_{t1}}{\dot{m}_1} + \frac{\dot{W}_{t2}}{\dot{m}_1}\right) - \left(\frac{\dot{W}_{p1}}{\dot{m}_1} - \frac{\dot{W}_{p2}}{\dot{m}_1}\right)}{\dot{Q}_{in}/\dot{m}_1}$$

$$= 0.431 \longrightarrow 43.1\%$$

(b)

$$\dot{m}_1 = \frac{\dot{W}_{cycle}}{\left(\frac{\dot{W}_{t1}}{\dot{m}_1} + \frac{\dot{W}_{t2}}{\dot{m}_1}\right) - \left(\frac{\dot{W}_{p1}}{\dot{m}_1} - \frac{\dot{W}_{p2}}{\dot{m}_1}\right)}$$

$$= \frac{(100 \text{ MW}) * 3600 \text{ s/h} * 10^3 \text{ KW/MW}}{1285.1 \text{ KJ/Kg}}$$

$$= 2.8 * 10^5 \text{ Kg/h}$$

Q5 A

1- (II) decreases
2- (I) increases
3- (II) decreases
4- (I) increases
5- II decreases

University of Technology
Mechanical Engineering Department
Final Year Examination 2014/2015

Subject: Thermodynamic II
Division :All
Examiner: Drs. of Thermodynamics Lectures

Class :2nd year
Time: 3 Hrs.
Date: 7/6/2015

Notes:- **(1)** Answer **(Four)** Questions Only. **(2)** Steam tables and chart are allowed.

Q1:(A) Steam is throttled from (7 bar) and dryness fraction (0.96) to a pressure of (3.5 bar). Determine final steam conditions. Draw the process on P-V diagram.

(5 marks)

(B) A refrigerator uses refrigerant-134a as the working fluid and operates on an ideal vapor-compression refrigeration cycle between (0.12 MPa) and (0.7 MPa). The mass flow rate of the refrigerant is (0.05 kg/s). Show the cycle on a T-s diagram and determine :(a) the compressor power, in kw, (b) the refrigeration capacity, in tons, (c) the rate of heat rejection to the environment, (d) the coefficient of performance.

(10 marks)

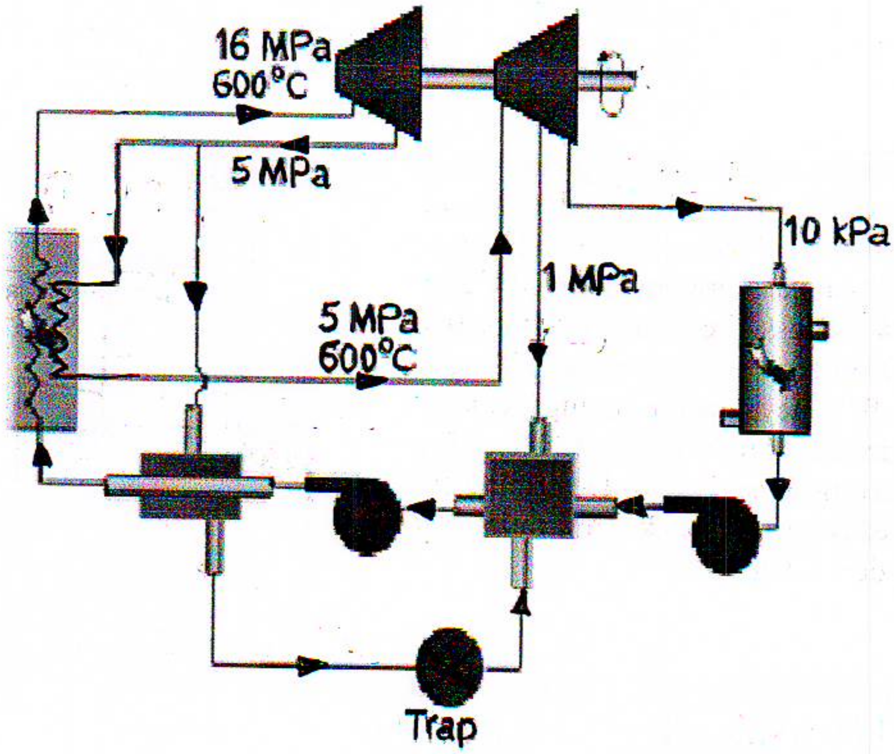
Q2:

(A) How do actual vapor power cycles differ from ideal cycle?

(3 marks)

(B) A steam power plant operates on an ideal reheat regenerative Rankine cycle with one open feed water heater, one closed feed water heater, and one reheater . Determine the fractions of steam extracted from turbines and thermal efficiency of the cycle. Draw the T-s diagram of the power plant.

(12 marks)



Q3: (A) Define the compressor volumetric efficiency and prove that it is given by:

$$\eta_v = 1 - \frac{V_c}{V_s}\left[\left(\frac{p_2}{p_1}\right)^{\frac{1}{n}} - 1\right]$$

(5 marks)

(B) - A three-stage reciprocating air compressor works between limits of (1bar) and (64bar). The index of compression in each stage is (1.28), the temperature at start of compression in each stage is (32°C), and the intermediate pressures are so chosen that the work is divided equally among the stage. Neglecting clearance calculate:

a) The volume of free air delivered per KW h at (1.013bar) and (15°C).

b) The temperature at delivery from each stage.

c) The isothermal efficiency.

(10 marks)

Q4: (A) Compare between the Otto, Diesel and Dual standard cycles on the basis of thermal efficiency for:

1-The same compression ratio and same heat added.

2-The same maximum pressure and same heat added.

Sketch the cycles on the (T-s) and (P-v) diagrams.

(5 marks)

(B) An engine working on the dual combustion cycle has a compression ratio of (15/1). The pressure and temperature at the beginning of compression are (97 KN/m^2) and (27 °C) respectively, the maximum cycle pressure and temperature are (6.2 MN/m^2) and (1350°C) respectively. If the initial volume is (0.084 m^3), calculate: a- pressure,volume and temperature at the end of each process in the cycle, b- work done per cycle, c- thermal efficiency, d- mean effective pressure.

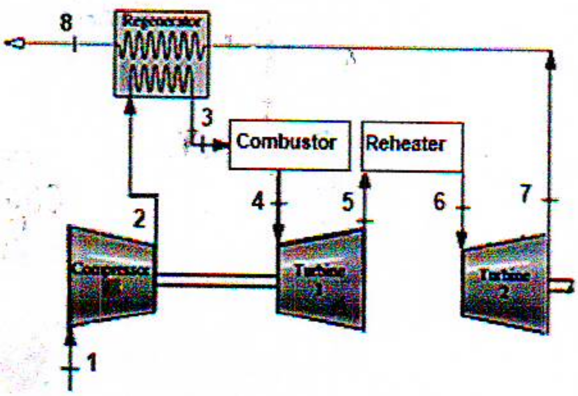
(10 marks)

Q5: (A) Prove with aid of sketch that for ideal gas turbine cycle:

$$\tau_{th} = 1 - (1/\, r_p{}^{(\gamma-1/\gamma)})$$

(5 marks)

(B): A regenerative gas turbine power plant with a reheater is shown. Air enters the compressor at (1 bar), (30 °C) with a mass flow rate of (6.0 Kg/s). The pressure ratio across the compressor is (6). The temperature at turbine stages inlet is (1500 K). The isentropic efficiency of the compressor is (85%) and of each turbine stage is (80%). The regenerator effectiveness is (70 %). Determine (a) the thermal efficiency, (b) the back work ratio, and (c) the net power developed.



(10 marks)

Take: $c_{p,\ air} = 1.005\ \mathrm{kJ/kg.K}$ $\qquad \gamma_{air} = 1.4$

$c_{p,\ gas} = 1.150\ \mathrm{kJ/kg.K}$ $\qquad \gamma_{gas} = 1.3$

Subject: Thermodynamics II | **Year: 2nd**
Division: All | **Exam Time: 3 Hrs.**
Examiner(s): Dr. Zainab Hassoun & Dr. Dheya Ghanim | **Date: 15 / 6 / 2014**

Notes:- (1) Answer (Four) Questions Only. (2) Steam tables and chart are allowed.

Q1. A-) Define briefly; The Reciprocating Compressor, The Volumetric Efficiency, Free Air Delivery, Mean Effective Pressure and the Ideal Intermediate Pressure.

[10M]

B-) A two-stage, single acting air compressor draws in (4 m^3/min) of atmospheric air at (1.013 bar) and (15 °C) and delivers it at (20 bar) and (160 °C). The suction pressure and temperature are (0.9 bar) and (35 °C) respectively and the intermediate pressure is (4 bar). The compression and expansion index is (1.25) for both stages, the clearance volume is 5% of swept volume. Draw compressor stages cycle on p-v diagram and Find:

i. Isothermal efficiency and volumetric efficiency.
ii. Heat exchanged with the surrounding.

[15M]

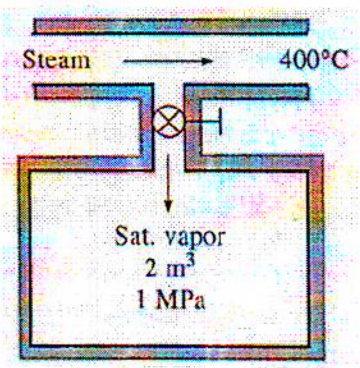
Q2.A-) For a specified pressure ratio, why does multistage compression with intercooling decrease the compressor work, and multistage expansion with reheating increase the turbine work? explain that with drawing.

[10M]

B-) Consider an ideal gas-turbine cycle with two stages of compression and two stages of expansion. The pressure ratio across each stage of the compressor and turbine is 3. The air enters each stage of the compressor at 300K and each stage of the turbine at 1200K. Determine the back work ratio and the thermal efficiency of the cycle, assuming (a) no regenerator is used and (b) a regenerator with 80 percent effectiveness is used. Use constant specific heats at room temperature.

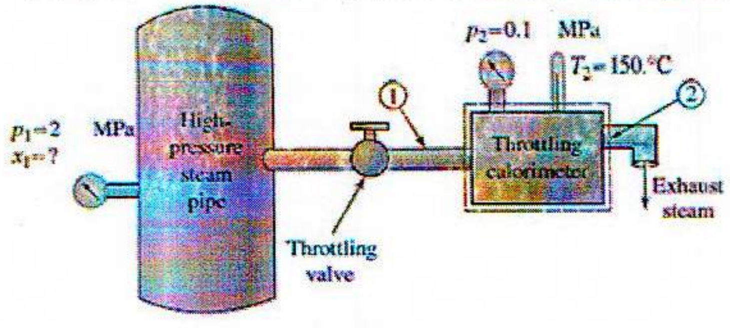
[15M]

Q3. A-) A $2m^3$ rigid insulated tank initially containing saturated water vapor at 1 MPa is connected through a valve to a supply line that carries steam at 400 °C. Now the valve is opened, and steam is allowed to flow slowly into the tank until the pressure in the tank rises to 2 MPa. At this instant the tank temperature is measured to be 300 °C. Determine the mass of the steam that has entered and the pressure of the steam in the supply line.



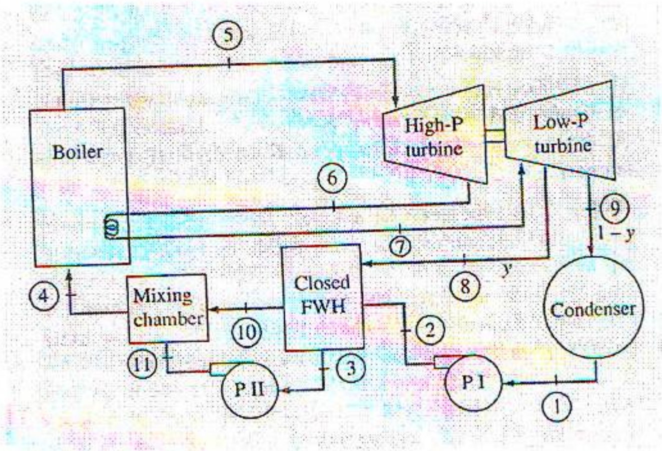
[15M]

B-) Wet steam flows in a pipe at 2 MPa. An insulated throttling calorimeter is attached to the pipe and a small portion of the steam is withdrawn and throttled to atmospheric pressure. The temperature and pressure of the throttled steam in the calorimeter are 150°C and 0.1 MPa. Determine the quality of the wet steam in the pipe.



[10M]

Q4. A steam power plant operates on the reheat-regenerative Rankine cycle with a closed feedwater heater. Steam enters the turbine at 12.5 MPa and 550 °C at a rate of 24 kg/s and is condensed in the condenser at a pressure of 20 kPa. Steam is reheated at 5 MPa to 550 °C. some steam is extracted from the low-pressure turbine at 1.0 MPa, is completely condensed in the closed feedwater heater, and pumped to 12.5 MPa before it mixes with the feedwater at the same pressure. Assuming an isentropic efficiency of 88 percent for both the turbine and the pump, determine (a) the temperature of the steam at the inlet of the closed feedwater heater, (b) the mass flow rate of the steam extracted from the turbine for the closed feedwater heater, (c) the net power output, and (d) the thermal efficiency.



[25M]

Q5. A-)State with sketch the cycles on a T-s diagram the differences between the **actual** and the **ideal** vapor- compression refrigeration cycle.

[10M]

B-) A vapor-compression refrigeration system operates at a steady state on an ideal refrigeration cycle using Refrigerant 134a as the working fluid. Saturated vapor enters the compressor at -10°C and saturated liquid leaves the condenser at 28°C. The mass flow rate of the refrigerant is 5 kg/min. Find:

a. The compressor power in kW.
b. The refrigerating capacity in tons.
c. The coefficient of performance.
d. draw T-s diagram of the cycle.

[15M]

University of Technology
Department of Machines and Equipment Engineering
FinalYear Examination 2012/2013

Subject: Thermodynamics II | Year:2nd
Division: All | Exam Time: 3 Hrs.
Examiner(s):Dr. A. A. KH. Al-Mosawi& Dr. D. G. M. Al-Taliby | Date:27 / 05/ 2013

Note:-Answer (Four) Questions Only.

Q1.

a) Prove graphically that the isothermal process is the best choice for reciprocating compressors. How it can be achieved?

[5% Mark]

b) A single – acting two – stage compressor with complete intercooling delivers (6 kg/min) of air at (16 bar). Assuming an intake state of (1 bar) and (15°C), and that the compression and expansion processes are reversible and polytropic with (n=1.3), Calculate:

(i) The power required.(ii) The thermal efficiency.(iii) The free air delivery. Isothermal

(iv) The net heat transferred in each cylinder and in the intercooler.

V If the clearance ratio for the low and high pressures cylinders are (0.04) and (0.06) respectively, calculate the swept and clearance volumes for each cylinder.The speed is (420 r.p.m).

[20% Mark]

Q2.

a) Sketch a diagram for a single stage reciprocating compressor denoting the main parts and dimensions.

[5% Mark]

b) Aregenerative gas turbine with intercooling and reheat operates at steady state. Air enters the compressor at 100 kPa, 300 K with a mass flow rate of $6\ kg/sec$. The pressure ratio across the two-stage compressor is 10. The pressure ratio across the two-stage turbine is also 10. The intercooler and reheater each operate at 300 kPa. At the inlets to the turbine stages, the temperature is 1500 K. The temperature at the inlet to the second compressor stage is 300 K. the isentropic efficiency of each compressor and turbine stage is 80%. The regenerator effectiveness is 75%. The mechanical efficiency is 99%. Determine (a) the thermal efficiency, (b) the back work ratio, (c) the work ratio and (d) the net power developed.

[20% Mark]

Q3.

a) Show that for a reciprocating compressor, the indicated power is given by;

$$W = \frac{n}{n-1} R\,(T2 - T1)$$

By using the steady flow energy equation.

b) What is the effect of dryness - fraction (x) on the performance of the power plant and how can be measured practically.

c) What is the advantage and disadvantage of both open and closed heaters.

d) What are the important factors which can be used to measure the performance of the power plants.

[25%Mark]

اقلب الصفحة رجاءا

Q4.

a) Why is the reversed Carnot cycle executed within the saturation dome not a realistic model for refrigeration cycles?

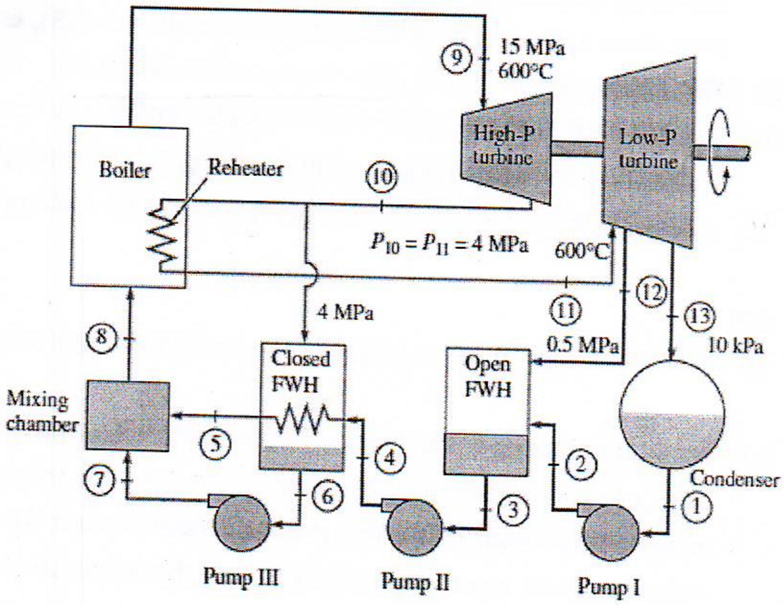
[5%Mark]

b) A refrigerator uses refrigerant -134a as the working fluid and operates on an ideal vapor-compression refrigeration cycle between 0.12 MPa and 0.7 MPa. If the mass flow rate of the refrigerant is 0.05 kg/s, show the cycle on a T-S diagram with respect to saturation lines. Determine (a) the rate of heat removal from the refrigerated space and the power input to the compressor, (b) the rate of heat rejection to the environment, and (c) the coefficient of performance of the refrigerator.

[20%Mark]

Q5.

Consider a steam power plant shown that operates on an ideal reheat–regenerative Rankine cycle with one open feedwater heater, one closed feedwater heater,and one reheater. Steam enters the turbine at (15 MPa) and (600°C) and is condensed in the condenser at a pressure of (10 kPa). Draw cycle on (T-s) diagram and determine the thermal efficiency of the cycle. Neglect pumps work.



[25%Mark]

(Take $c_{p,air} = 1.005$ kJ/kg . K and $\gamma = 1.4$ for all compression processes, and as $c_{p,gas} = 1.15\ kJ/kg\ .K$ and $\gamma = 1.333$ for all combustion and expansion processes.)

مع التمنيات بالنجاح والتوفيق

University of Technology
Mechanical Engineering department
Final Year Examination 2011-2012

Date: 10/06/2012
Subject: Thermodynamics II
Examiners: Dr. Arkan Al Taie & Dr. Abdulkareem Khudhair

Time: 3 hours
Class: 2nd year

Notes: 1. Steam tables and chart are allowed.
2. Attempt Four questions only.

Q1:

a) What are the main reasons behind using water vapor in thermal power plants?
b) What is the influence of vacuum pressure in the condenser on power plant performance? State the limitations.
c) A vessel of volume ($0.04\ m^3$) contains a mixture of saturated water and saturated steam at a temperature of (250.3 °C) the mass of the liquid is ($9\ kg$). Find the mass and specific volume of the mixture.

[15M]

Q2:

a) In an experimental procedure show the variation of volume and temperature of a cube of ice originally at a low temperature (-10^{0}C), being heated at constant pressure of 1 atmosphere until (200^{0}C). Sketch T-V and T-s diagrams.
b) Derive an equation for the indicated power required for a 4 stage reciprocating compressor; assume complete intercooling and the machine is designed for minimum work. State your assumptions clearly.

[15M]

Q3:

a. Prove graphically that the isothermal process is the best choice for reciprocating compressors. How it can be acheived?
b. A two-stage, single acting air compressor running in an atmosphere at (1.013 bar) and (15 °C) has a free air delivery of($4.0\ kg/min$). The suction pressure and temperature are ($0.9\ bar$) and (35 °C) respectively. The delivery pressure is (36 bars). The machine is designed for minimum work and it utilizes a complete intercooler. The polytropic index is (1.25). The compressor runs at (600 rpm) and has a clearance volume (5%) of the swept volume while the stroke length is twice bore diameter. Find:
   i. Isothermal efficiency and volumetric efficiency.
   ii. Heat exchanged with the surrounding.
   iii. Cylinder bore and stroke length for the 1st stage.

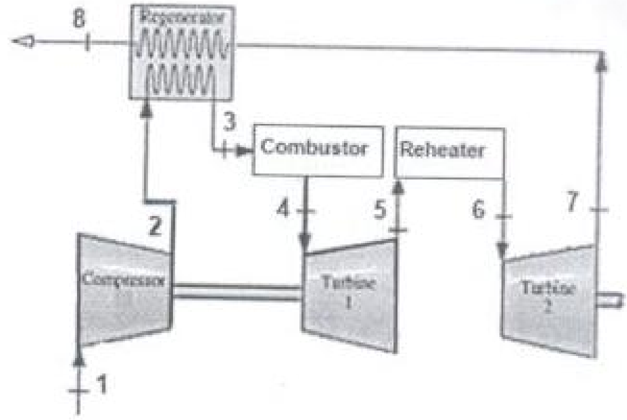
[15M]

اقلب الصفحة رجاء P.T.O.

Q4:

A regenerative gas turbine power plant with a re heater is shown. Air enters the compressor at ($1\ bar$), (30 °C) with a mass flow rate of ($6.0\ kg/s$). The pressure ratio across the compressor is (6). The temperature at turbine stages inlet is ($1500\ K$). The isentropic efficiency of the compressor is (85%) and of each turbine stage is (80%). The regenerator effectiveness is (70%). Determine (a) the thermal efficiency, (b) the back work ratio, and (c) the net power developed.

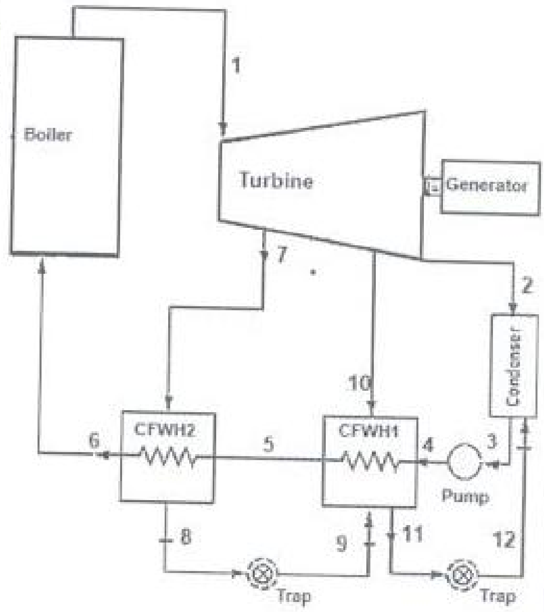
[15M]



Q5: Consider a regenerative steam power plant with two optimally placed closed type feed water heaters with drains cascaded backward as shown. Steam enters the turbine at ($8.0\ MPa$), (520 °C) and expands to ($10\ kPa$). The *net* power output of the cycle is ($100\ MW$). Cooling water temperature deference at condenser is (30 °C). Determine:

a) The thermal efficiency
b) The S.S.C.
c) Steam mass flow rate, in kg/h.
d) Cooling water mass flow rate.

[15M]



Take:

$c_{p,\ air} = 1.005\ kJ/kg.K \qquad \gamma_{air} = 1.4$

$c_{p,\ gas} = 1.150\ kJ/kg.K \qquad \gamma_{gas} = 1.3$

$C_{water} = 4.2\ kJ/kg.K$

Good Luck

لاحظ الصفحة الاولى رجاء

THE UNIVERSITY OF TECHNOLOGY

MECHANICAL ENGINEERING DEPARTMENT FIRST TERM EXAM

CLASS: SECOND YEAR DATE: 8 / 1 / 2005

SUBJECT: THERMODYNAMICS II TIME ALLOWED 1 &1/2 HRS

Notes: Steam Tables and Charts are Allowed. All Questions are to be Attempted.

Q1) a. Draw a simplified flow diagram for an ideal Rankine Cycle with superheat and reheat. **(b)**. State the task of each component. **(c)**. Discuss steam formation process and sketch it on a T-S diagram.

Q2) A vessel having a capacity of **0.6 m^3** contains steam at **15 bar, 250^{0}C**. Steam is blown off until the pressure drops to **4 bar**, after which the valve is closed and the vessel is cooled until the pressure is **3 bar**. Assuming that the expansion of the gas remaining in the vessel is isentropic during blow-off, calculate **(a)** the mass of steam blown off, **(b)** the dryness fraction of the steam in the vessel after cooling, **(c)** the heat transferred during the cooling process.

Q3) Steam at **3 MPa, 300^{0}C** leaves the boiler and enters the high pressure turbine (in a reheat cycle) and is expanded to **300 kPa.** The steam is then reheated to **300^{0}C** and expanded in the second stage turbine to **10 kPa.** What is the effi

(a) it is assumed to be internally reversible?, **(b)** the isentropic efficiency of both turbines is **0.87**, and of the pump is **0.85**?.

GOOD LUCK Dr ARKAN ALTAIE Dr ABDULKARIM

Mech. Eng. Dept.
2th Year B.Sc Course
Thermodynamics
Steam charts and tables are allow

University of Tech.
Mid Term Exam
2003/2004

Time: Two hrs
Examiners
Dr.Hussein M. Mashy
Dr. Moayed R. Hasan

Q1. (a) A rigid vessel of volume 0.1 m^3 containing steam at 14 bar and dryness fraction 0.9. The vessel is cooled until it's pressure becomes 5.7 bar, show the process on T-s and p-v diagrams and find,
1- the mass of steam 2- the final steam condition 3- the amount of heat rejected.

(2.5 Marks)

(b) A vertical insulated cylinder with a cross-sectional area of 0.1 m^2 contains 1 kg water at 15 ^{0}C, and a piston resting on the water exerts a constant pressure of 7 bar. An electric heater forms the bottom of the cylinder and heats the water at the rate of 500 W. Calculate the time taken for the piston to rise through a distance of 1 m.

(2.5 Marks)

Q2. Answer one of the following questions.
(a) Although Carnot cycle is the most efficient cycle for a given temperatures of source T1 and sink T2, we do not select it as the ideal cycle for steam power cycles. Explain why?

(5 Marks)

(b) A steam power plant operates between a boiler pressure of 42 bar and a condenser pressure of 0.035 bar. Take dry saturated steam at the inlet to the turbine, for a Carnot cycle show the processes on a T-s diagram and calculate,
1- the cycle efficiency 2- the work ratio 3- the specific steam consumption.

(5 Marks)

Q3. (a) Explain why throttling calorimeter can not be used to measure the dryness fraction if the steam is very wet? Discuss the working principle of combined method to measure the dryness fraction and prove that,

$$x_1 = \frac{x_2 \cdot m_s}{m_w + m_s}$$

Show the processes of this method on a T-s and h-s diagrams.

(3.5 Marks)

(b) Define each of the following:
saturation temperature, unsaturated water, degree of superheat.

(1.5 Marks)

Q4. One of the familiar nonsteady-flow processes is pressure cooker. A certain pressure cooker has a volume of 0.006 m^3 and absolute operating pressure of 175 kPa. Initially, it contains 1 kg of water. Heat is supplied to the pressure cooker at the rate of 500 W for 30 min after the operating pressure is reached. Steam leaves the pressure cooker as saturated vapor and during the process at all times the pressure is constant, determine,

1- the temperature at which cooking takes place
2- the amount of water left in the pressure cooker at the end of the process.

(5 Marks)

الجامعة التكنولوجية/ قسم هندسة المكائن والمعدات

المرحلة : الثانية	امتحان الدور الاول	الزمن : ثلاث ساعات
المادة : حرارة II	2004/2005	التاريخ : 29 / 5 / 2005
مدرس المادة :لجنة الحراريات		ملاحظة: أجب عن اربعة أسئلة فقط

Q1:- A) for steam Rankine cycle, with dry saturated steam at entry to the turbine, operates between 50 bar and 0.035 bar, evaluate thermal efficiency and work ratio. Compare the results with that of Carnot cycle. Which one is the best and why?

B) Explain briefly the behavior of pure water under constant pressure process on T-v diagram for the range of temperatures below (0C°) to above (100C°).

Q2:- A) for air standard dual cycle, prove that:-

$$\eta_{th} = 1 - \frac{1}{r_v^{(\gamma-1)}}\left[\frac{r_p * r_c^{\gamma} - 1}{(r_p - 1) + \gamma * r_p(r_c - 1)}\right]$$

Where r_v : compression ratio; r_c : cut-off ratio ; r_p : pressure ratio

B) A petroleum engine based on Otto cycle has a compression ratio of (5:1). Heat addition is 2600 kJ/kg. Calculate cycle efficiency, mean effective pressure and peak pressure. Sketch the cycle on (p-v) & (T-s) diagrams.

$\gamma = 1.4$ $Cp = 1.005$ $Cv = 0.718$

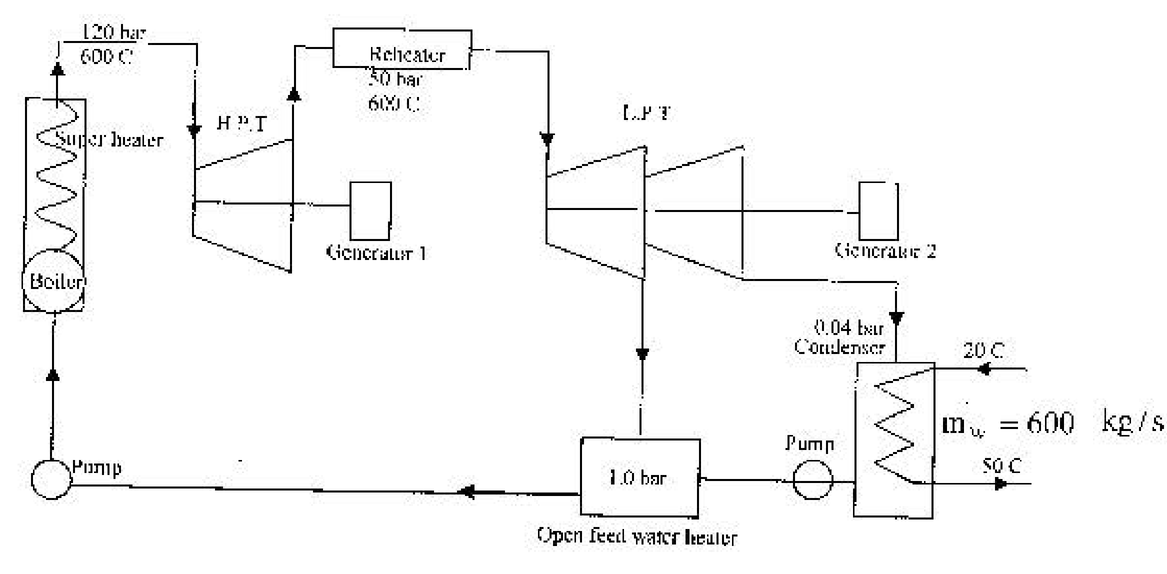
Q3:- A) what are the simplifying assumptions which should be made during analysis of air standard cycle.

B) A gas power plant operates on simple gas turbine cycle. Inlet conditions are (20C°) & (1.013 bar) while compression ratio is (5:1). Maximum cycle temperature is (950C°). The compressor and turbine isentropic efficiencies are (0.78) and (0.75) respectively. Calculate cycle efficiency and work ratio.

Q4:- for the power plant sketched below, both turbines isentropic efficiency is (0.85). An electrical generator is connected to each turbine, and the mechanical and generator efficiencies are (0.95) & (0.90) for both. One open feed water heater of pressure (1.0 bar) is used. Calculate:-

- The plant cycle thermal efficiency.
- The specific steam consumption.
- The total generated electrical power.

(Neglect pumps work)



الجامعة التكنولوجية
قسم هندسة المكائن و المعدات
امتحانات الدور الأول للعام الدراسي (٢٠٠١-٢٠٠٢)

المرحلة: الثانية
المادة: ديناميك حرارة
التاريخ: ٢٠٠٢/٦/١٠

الزمن : ثلاث ساعات
مدرس المادة: د. محمد ناصر حميد الفتال
عبد الستار جواد محمد الصراف

الملاحظات: يسمح باستخدام جداول و خرائط البخار

Q 1)

A mass of 1 kg of saturated steam at 10 bar is expanded through a reversible non-flow process following the law [$pv^n = c$] to the pressure of 1 bar and dryness fraction of 0.88. Sketch the (p-v) and (T-s) diagrams and find the work and heat transfer during the process.

(10 marks)

Q 2)

A three-stage, single-acting reciprocating compressor has a free air delivery of 40 m^3/hr. The inlet air temperature of each stage is 27°C, and the first stage has pressure ratio of (3/1). The air enters the first and last stage at 95 and 997.5 kN/m^2 respectively. The compressor works for an overall pressure ratio of (42/1) and a polytropic index of 1.25

Neglecting the clearance, sketch the indicator diagram (p-V) of this cycle and calculate:

a) the isothermal efficiency

b) the water outlet temperature from each intercooler if the water enters the both intercoolers at 19°C and flow rate of 1.5 kg/min.

Take for air that; $c_p = 1.005$ kJ/kg K
$R = 0.287$ kJ/kg K

And for water; $c_w = 4.2$ kJ/kg K

(14 marks)

س٧: خزانان مربوطان بمنظومة انابيب كما في الشكل (6) . اذا كانت خواص المضخة معطاة كما يلي :

$\eta p = -190000Q^2 + 8590Q$, $hp = 31 - 12000Q^2$

حيث hp معطاة بالامتار و Q m^3/s و ηp هي كفاءة المضخة كنسبة مئوية.
احسب مقدار الكلفة التشغيلية للمضخة لكي تضخ ما مقداره $(10000)m^3$ من الماء الى الخزان الاعلى اذا كانت كلفة 1kwh هي 0.35ID . اهمل الخسائر الثانوية.

س٨: انبوبان كلاهما بطول (L) وقطر D_2, D_1 على التوالي مربوطان على التوازي ، مقدار الخسارة h_1 عندما يجري خلالهما تدفق كلي مقداره Q . اذا تم ربط الانبوبان على التوالي وبنفس التدفق الكلي Q وبخسارة مقدارها h_2 واذا كان $D_1 = 2D_2$ ، جد نسبة h_1 الى h_2. اهمل الخسائر الثانوية واعتبر ان قيمة معامل الاحتكاك (f) قيمة ثابتة.

س٩: اذا كانت قوة الاعاقة (F_d) لجسم غاطس جزئيا يعتمد على السرعة النسبية (V) بين الجسم والمائع والخاصية الخطية للبعد (ℓ) ، ارتفاع خشونة السطح (ε) ، كثافة المائع (ρ) ولزوجة المائع (μ) والتعجيل الارضي (g) . اوجد تعبير لقوة الاعاقة باستخدام طريقة التحليل البعدي.

س١٠: سائل بين صفيحتين متوازيتين في حالة جريان طباقي مستقر الشكل رقم (7). اذا كانت لزوجة السائل $(\mu = 0.08 Pa.s)$ جد توزيع السرعة $(u = f(y))$ ، الاجهاد القصي عند الصفيحة المتحركة وكمية التدفق لكل متر من عرض الصفيحة للحالات التالية :

أ- $P_1 = P_2$ ب- $P_1 = 2P_2 = 8000kpa$

الجامعة التكنولوجية/ قسم هندسة المكائن والمعدات

المرحلة: الثانية / حرارة II — الامتحان: الدور الأول — الزمن: ثلاث ساعات

لجنة الحراريات — 2010/2009 — التاريخ: 09/ 06 / 2010

ملاحظة:اجب عن أربعة أسئلة فقط

Q1. Attempt **two** of the following:

a. Explain the behavior of pure water, using a (T-v) diagram, under heating process at constant pressure of (1 atm). Show the changes that take place starting with a box of ice at low temperature and ending with a superheated steam.

7.5 Marks

b. The partial evaporation of (1 kg) of saturated water at (7 bar) is accompanied by the transfer of (100 kJ) of work. Find the dryness fraction of steam formed and the increase in internal energy of the fluid during the change of phase.

7.5 Marks

c. A mass of (0.12 kg) of steam, initially saturated at (10 bar), expands reversibly in a cylinder until the pressure becomes (1 bar). The volume is then found to be (0.17 m^3). Assume that the process is polytropic, find:

i. Index of expansion.
ii. Heat transferred during the process.
iii. Enthalpy change.
iv. Sketch the process on a (T-s) diagram.

7.5 Marks

Q2.

a. For a Diesel cycle:

i. Draw the cycle on (T-s) and (p-v) diagrams.
ii. Sketch cylinder arrangement.
iii. Derive an expression of the thermal efficiency in terms of compression ratio and cut-off ratio.

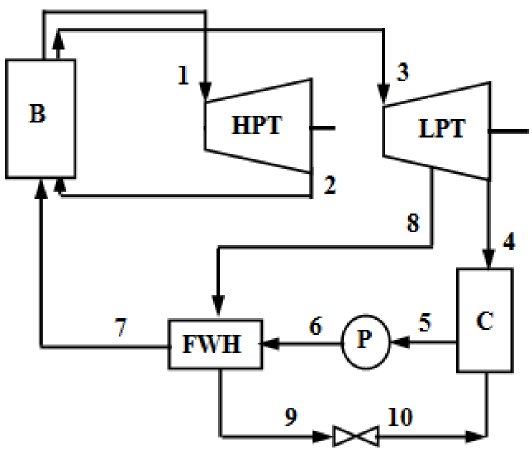
5 Marks

b. A four-stroke petrol engine operates on an air standard cycle has a volume of (0.45 m^3). The condition at the beginning of compression stroke is a pressure of (1 bar) and temperature of (30 ^oC), while at the end of this process the pressure is (11 bar).a (210 kJ) of heat is added at constant volume. The engine runs at (210 rpm). Determine:

i. P, T and v at all salient points in the cycle.
ii. Percentage clearance.
iii. Thermal efficiency.
iv. Net work per cycle and ideal power developed.
v. Mean effective pressure.

10 Marks

Q3. Consider a steam power plant, as shown, that operates on a reheat–regenerative simple Rankine cycle with one closed feedwater heater cascaded backward and a perfect reheater to produce (100 MW). Steam enters the turbine at (15 MPa) and (600°C) and is condensed in the condenser at a pressure of (10 kPa). Steam is extracted for the optimally placed closed feedwater heater from the low-pressure turbine. Represent cycle on (T-s) diagram and determine:



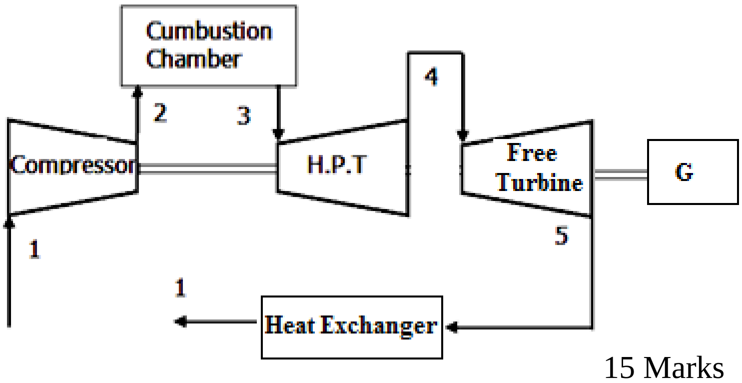
i. Cycle thermal efficiency, work ratio and steam specific consumption.
ii. Steam mass and amount of heat rejected.

15 Marks

يتبع رجاءا

Q4. A gas turbine power unit, with a free power turbine used to drive an electric generator, has a pressure ratio of (9) and the maximum temperature of ($800\ ^{o}C$). The isentropic efficiencies of the compressor, HPT, and FPT are (0.8), (0.83) and (0.85) respectively, and the mechanical efficiency of both shafts is (98%). The air intake conditions are (1.01 bar) and ($25\ ^{o}C$). Represent the cycle on (T-s) diagram and calculate:

i. Pressure between LPT and FPT.
ii. Unit thermal efficiency.
iii. Shaft power output when the mass flow rate is ($60\ kg/s$).



15 Marks

Q5. A two-stage, single-acting reciprocating air compressor running at ($300\ r.p.m$) delivers a ($5.0\ kg$) of air per minute at ($16\ bar$). The compressor has a complete intercooler and is designed for minimum work for a compression and expansion index of (1.2). The induction conditions are ($0.95\ bar$) and ($30\ ^{o}C$) and the air free conditions are (1.013 bar) and (15 ^{o}C). The clearance volume is (6 %) of the swept volume and that the bore is equal to the stroke. The Mechanical efficiency is (87%). Calculate:

i. The free air delivery in (m^3/min).
ii. Shaft horse power required.
iii. The diameter and length of compressor cylinders.
iv. The heat rejected to the surrounding.

15 Marks

Note: ***Answer <u>four</u> questions only.***

مع التمنيات بالنجاح والتوفيق

الجامعة التكنولوجية/ قسم هندسة المكائن والمعدات

المرحلة: الثانية / حرارة II | الامتحان: الدور الثاني | الزمن: ثلاث ساعات

د. أركان خلخال /د.عبد الكريم عباس | 2010/2009 | التاريخ: 01 / 09 / 2010

ملاحظة:اجب عن أربعة أسئلة فقط

Q1. a) Prove that the isentropic work of a pump in steam power plant is expressed in terms of saturated water specific volume and pressure rise.

5 Marks

b) Superheated steam at a temperature of ($275.6\ C^O$) and a pressure of (4 bar) is expanded polytropically to the dry steam line at ($0.4\ bar$)and then is compressed isothermally until it attains a saturated liquid state in non-flow processes. Calculate the work done per unit mass of steam. Sketch the two processes on (T-s, p-v) diagrams.

10 Marks

Q2. a) Write down Five conditions for a heat cycle to be considered as an air standard cycle.

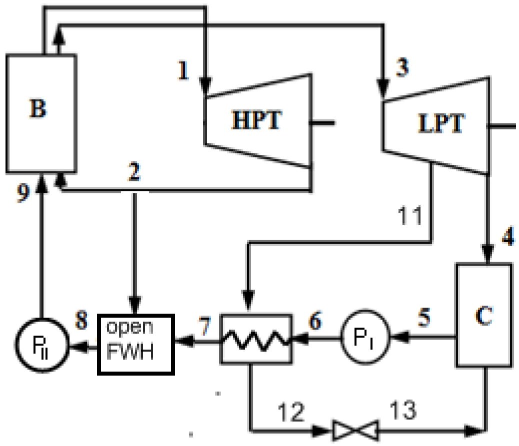
5 Marks

b) An air standard dual combustion cycle has a mean effective pressure of ($10\ bar$). The minimum pressure and temperature are ($1\ bar$) and (17 ℃) respectively, and the compression ratio is ($16/1$). Calculate the maximum cycle temperature when the thermal efficiency is (60%). The maximum cycle pressure is ($60\ bar$).

10 Marks

i. Temperatures at cycle salient points.
ii. Cut-off ratio and pressure ratio.
iii. Percentage clearance.

Q3. Consider a steam power plant, as shown, that operates on a reheat–regenerative ideal Rankine cycle with one open FWH and one closed FWH cascaded backward, to produce ($100\ MW$). Steam enters the HPT at ($15\ MPa$) and ($600°C$) and exit at ($4\ MPa$). Some steam is extracted for the open FWH before reheating it to ($600°C$). Steam is condensed in the condenser at a pressure of ($10\ kPa$). Steam is extracted for the optimally placed closed feedwater heater from the low-pressure turbine. Represent cycle on (T-s) diagram and determine:

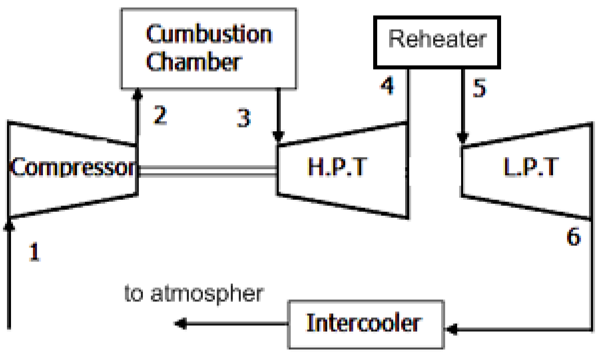


i. Cycle thermal efficiency.
ii. Work ratio.
iii. Steam specific consumption.

15 Marks

Q4. In a gas power plant that operates on a modify Brayton cycle, air is compressed through a pressure ratio of ($6{:}1$) from (15℃) and ($1\ bar$). It is then heated to the maximum temperature of (750℃) and expanded in two stages with overall pressure ratio of (6), where the air being reheated between the two stages to (750℃). The efficiency for compressor is (0.83) and for turbine is (0.85). The mechanical efficiency is (0.95). Neglect pressure losses at combustion chamber and reheater, draw cycle on (T-s) diagram and calculate:

a) Pressure ratio for HPT and LPT.
b) Net output work and plant cycle efficiency..



15 Marks

اقلب الصفحة رجاءا

Q5. A two-stage, single-acting reciprocating air compressor running at ($360\, r.p.m$) delivers a ($6.0\, kg$) of air per minute at ($25\, bar$). The compressor has a complete intercooler and is designed for minimum work for a compression and expansion index of (1.25). The induction conditions are ($0.95\, bar$) and (30 ℃) and the air free conditions are (1.013 bar) and (15 ℃). The clearance volume is ($6\,\%$) of the swept volume and that the bore is equal to the stroke for both stages. Calculate:

i. The free air delivery in (m^3/min).
ii. Power required.
iii. The diameter of compressor cylinders.
iv. The heat rejected to the surrounding.

15 Marks

Note: ***Answer <u>four</u> questions only.***

مع التمنيات بالنجاح والتوفيق

الجامعة التكنولوجية/ قسم هندسة المكائن والمعدات

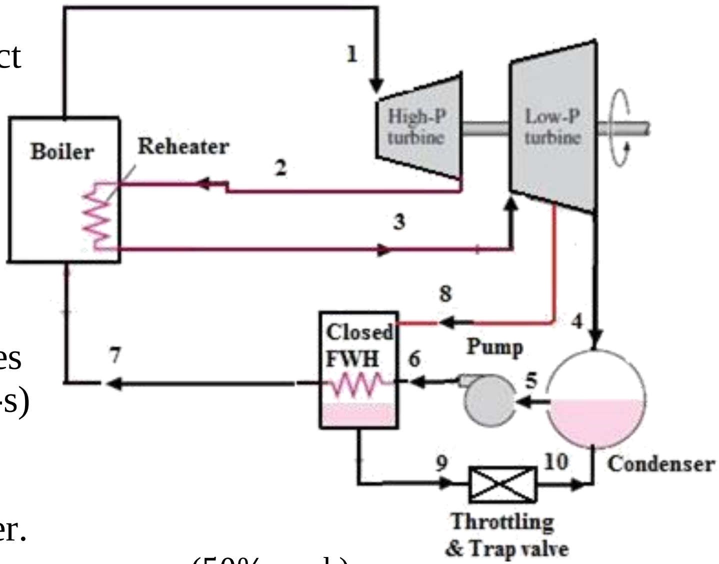
المرحلة : الثانية	امتحان الفصل الأول	الزمن : $1\frac{1}{2}$ ساعة
المادة : حرارة II	2010/2009	التاريخ : 2010/01/14

مدرس المادة :لجنة الحراريات

Q1.

A steam power plant utilizes a perfect reheater and one closed type feed water heater with drains cascaded backward. Steam enters the high pressure turbine at $(6\ MPa)$, $(500\ ^oC)$ and leaves the low pressure turbine at $(6\ kPa)$. The isentropic efficiency for expansion and compression processes is (0.8). The power plant produces $(50\ MW)$. Draw the plant steam cycle on (T-s) diagram and Calculate:-

a. Steam power plant cycle performance.
b. Water mass flow rate entering the boiler.



(50% mark)

Q2.

A) Why Pressure and temperature are not enough to identify water properties in the wet steam region? (10% mark)

B) A combined separating and throttling calorimeter is used to determine the dryness fraction of steam in a main. The pressure of the steam in the main and the separator is $(6.5\ bar)$. After throttling to $(1.5\ bar)$ the temperature is $(127°C)$. During a ten minutes test an $(0.09\ kg)$ of water is collected at the separator and $(1.53\ kg)$ of water condensate is collected after throttling.

- Calculate the dryness fraction of the steam in the main. (30% mark)
- What is the purpose of each components of the calorimeter? (10% mark)

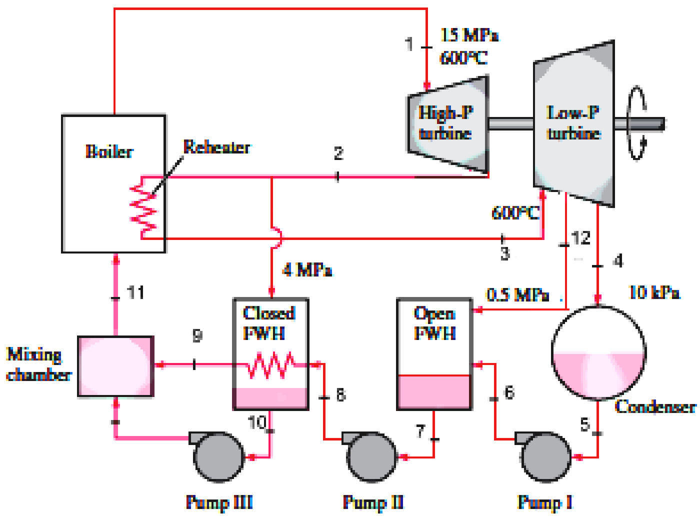
مع التمنيات بالنجاح والتوفيق

الجامعة التكنولوجية/ قسم هندسة المكائن والمعدات

المرحلة: الثانية | امتحان الفصل الأول/المؤجلين | الزمن: ($1\frac{1}{2}$) ساعة

المادة: حرارة II | 2009 \ 2010 | التاريخ: 06 / 04 / 2010

Q1: - Consider a steam power plant that operates on an ideal reheat–regenerative Rankine cycle with one open feedwater heater, one closed feedwater heater, and one reheater. Steam enters the turbine at ($15\ MPa$) and ($600\ °C$) and is condensed in the condenser at a pressure of ($10\ kPa$). Some steam is extracted from the turbine at ($4\ MPa$) for the closed feedwater heater and the remaining steam is reheated at the same pressure to ($600\ °C$). The extracted steam is completely condensed in the heater and is pumped to ($15\ MPa$) before it mixes with the feedwater at the same pressure. Steam for the open feedwater heater is extracted from the low-pressure turbine at a pressure of ($0.5\ MPa$). This power plant produces ($100\ MW$). Draw cycle on T-s diagram and determine:



i. Cycle thermal efficiency.
ii. Steam mass flow rate entering the first turbine.

Q2: - A) what is the influence of condenser pressure and temperature on cycle performance? And what is the limitation.

B) A mass of ($0.12\ kg$) steam initially saturated at ($10\ bar$) expands reversibly in a cylinder until the pressure is ($1.0\ bar$). The volume is then found to be ($0.17\ m^3$). Assuming that the process is polytropic, find the index of expansion and the heat transfer during the process. Sketch the (T-s) diagram.

مع التمنيات بالنجاح والتوفيق

University of Technology
Department of
Mechanical Engineering
Lecturers: Dr. Arkan Kh. & Dr. Abdul-Kareem A.
Date: 29/01/2012 | 1st semester | **Time: 2 hours**

Year: 2011/2012 | Subject: Thermodynamics II | 2nd Class

Answer two questions only

Q1: -

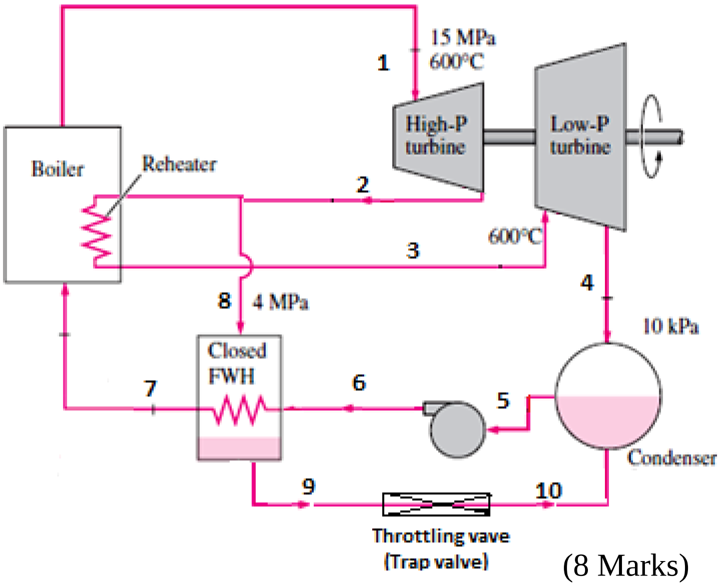
a) What are the main reasons for using water steam in power plant and no other substance steam? (2 Marks)

b) (2.0 kg) of steam is initially at (3.0 bar). The steam is heated at constant volume to (4.0 bar) to become saturated. And then it is compressed isentropically to (10 bar). Sketch T-s diagram and find the final temperature and the heat and work transfer. (5 Marks)

Q2:-

A regenerative Rankine cycle with a reheater utilizes one closed feed water heater, as illustrated, operates between 15 MPa and 10 kPa. Steam enters HPT at 600 ℃ and expands to 4 MPa. Some steam is extracted to the FWH at 4 MPa. Steam is reheated to 600 ℃ and then enters LPT. This plant produces 100 MW. Draw cycle on T-s diagram and calculate

i. Cycle efficiency, work ratio and specific steam consumption.
ii. Steam mass flow that enters the boiler.

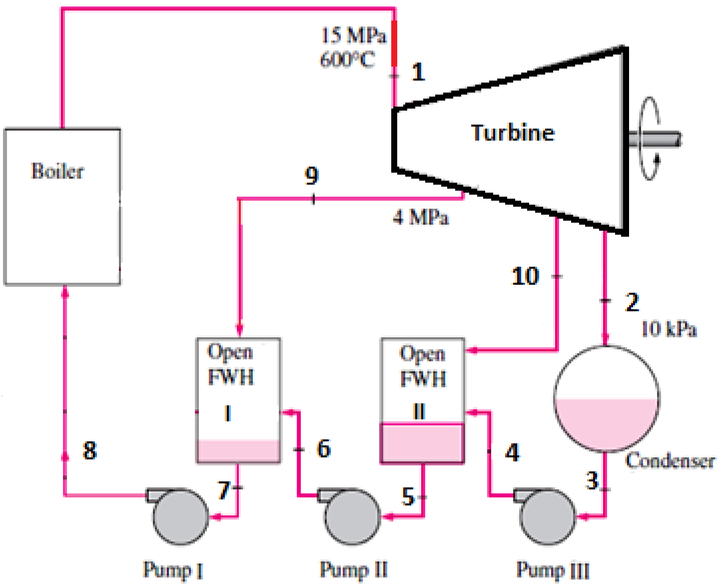


(8 Marks)

Q3:-

A regenerative Rankine cycle utilizes two open feed water heaters, as illustrated, operates between 15 MPa and 10 kPa. Steam enters the turbine at 600 ℃ and expands to 10 kPa. Some steam is extracted to the first FWH at 4 MPa and to the second FWH which is optimally placed. This plant produces 100 MW. Draw cycle on T-s diagram and calculate

i. Cycle efficiency, work ratio and specific steam consumption.
ii. Steam mass flow that enters the boiler.



(8 Marks)

Answer two questions only مع التمنيات بالموفقية

الجامعة التكنولوجية/ قسم هندسة المكائن والمعدات

المرحلة: الثانية	امتحان الفصل الثاني	الزمن: ساعة و نصف
المادة: حرارة II	2009/2010	التاريخ: 2010/04/15

Q1:-

a) Why do we study air standard cycles? What are the assumptions that must be imposed to treat the heat cycles as an air standard cycles?

b) The displacement volume of an internal combustion engine is ($5.6\ liters$). The processes within each cylinder of the engine are modeled as an air-standard Diesel cycle with a cutoff ratio of (2.4). The state of the air at the beginning of compression is fixed by ($p_1 = 95\ kPa$), ($T_1 = 27\ ^oC$), and ($V_1 = 6.0\ liters$). Draw cycle on p-v diagram and determine the net work per cycle, in kJ, the power developed by the engine, in kW, and the thermal efficiency, if the engine speed is ($1500\ rpm$).

Q2:-

a) Derive an expression for work ratio in Brayton cycle in terms of minimum and maximum cycle temperature and pressure ratio. Discuss the effect of each parameter on the work ratio.

b) A single–stage, single air compressor running at ($1000\ rpm$) delivers air at ($25\ bar$). the induction air conditions are (1.013 bar) and (15 ^{o}C), the air delivery is ($0.25\ m^3/min$). The clearance volume is (3%) of swept volume and the stroke/bore ratio is ($1.2/1$). Calculate the bore, the stroke and the isothermal efficiency of this machine. Take the index of compression and expansion as (1.3).

مع التمنيات بالنجاح والتوفيق/لجنة الحراريات

الجامعة التكنولوجية/ قسم هندسة المكائن والمعدات الجامعة التكنولوجية/ قسم هندسة المكائن والمعدات

المرحلة: الثانية	امتحان الفصل الثاني	الزمن: ساعة و نصف
المادة: حرارة II	2009/2010	التاريخ: 2010/04/15

Q1:-

a) Why do we study air standard cycles? What are the assumptions that must be imposed to treat the heat cycles as an air standard cycles?

b) The displacement volume of an internal combustion engine is ($5.6\ liters$). The processes within each cylinder of the engine are modeled as an air-standard Diesel cycle with a cutoff ratio of (2.4). The state of the air at the beginning of compression is fixed by ($p_1 = 95\ kPa$), ($T_1 = 27\ ^oC$), and ($V_1 = 6.0\ liters$). Draw cycle on p-v diagram and determine the net work per cycle, in kJ, the power developed by the engine, in kW, and the thermal efficiency, if the engine speed is ($1500\ rpm$).

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a) Derive an expression for work ratio in Brayton cycle in terms of minimum and maximum cycle temperature and pressure ratio. Discuss the effect of each parameter on the work ratio.

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مع التمنيات بالنجاح والتوفيق/لجنة الحراريات

الجامعة التكنولوجية/ قسم هندسة المكائن والمعدات

المرحلة : الثانية | امتحان الفصل الثاني/مؤجلين | الزمن : ساعة و نصف

المادة : حرارة II | 2010/2009 | التاريخ : 2010/05/17

A. A single stage, double acting air compressor running at ($750\ rpm$) has a F.A.D. of ($14\ \mathrm{m^3/min}$) measured at (1.013 bar) and ($15\ ^oC$). Pressure and temperature in the cylinder during induction are (0.95 bar) and($32\ ^oC$). The delivery pressure is (7 bar) and the index of compression and expansion is($n = 1.3$). The clearance volume is (5%) of swept volume and the stroke to bore ratio is ($1.5/1.0$). Calculate the volumetric efficiency and compressor cylinder length.

B. In an Otto cycle the maximum and minimum temperature are ($1500\ ^oC$) and ($15\ ^oC$) and the heat supply per kg of air is ($800\ kJ$). Initial pressure is (1.0 atm). Calculate the thermal efficiency and mean effective pressure. If the cycle is considered as Brayton (Joule) cycle, what will be the heat supply per kg of air and the cycle thermal efficiency for the same pressure ratio? Draw both cycles on (p-v) and (T-s) diagram.

مع التمنيات بالنجاح والتوفيق/لجنة الحراريات

الجامعة التكنولوجية/ قسم هندسة المكائن والمعدات

المرحلة : الثانية | امتحان الفصل الثاني/مؤجلين | الزمن : ساعة و نصف

المادة : حرارة II | 2010/2009 | التاريخ : 2010/05/17

C. A single stage, double acting air compressor running at ($750\ rpm$) has a F.A.D. of ($14\ \mathrm{m^3/min}$) measured at (1.013 bar) and ($15\ ^oC$). Pressure and temperature in the cylinder during induction are (0.95 bar) and($32\ ^oC$). The delivery pressure is (7 bar) and the index of compression and expansion is($n = 1.3$). The clearance volume is (5%) of swept volume and the stroke to bore ratio is ($1.5/1.0$). Calculate the volumetric efficiency and compressor cylinder length.

D. In an Otto cycle the maximum and minimum temperature are ($1500\ ^oC$) and ($15\ ^oC$) and the heat supply per kg of air is ($800\ kJ$). Initial pressure is (1.0 atm). Calculate the thermal efficiency and mean effective pressure. If the cycle is considered as Brayton (Joule) cycle, what will be the heat supply per kg of air and the cycle thermal efficiency for the same pressure ratio? Draw both cycles on (p-v) and (T-s) diagram.

مع التمنيات بالنجاح والتوفيق/لجنة الحراريات