UNIVERSITY OF JORDAN
SCHOOL OF ENGINEERING
MECHANICAL ENGINEERING DEPARTMENT

الجامعة
الاردنية

MidTerm Examination

Term: Summer ~ **Year:** 2016-2017

Course Name: Thermodynamic II

Course No.: 0904342

Instructor: Eng.Rebhi AlMashaleh

Date: Thursday 29-06-2017

Duration: 70 minute

Number of pages: (includes cover page) 7

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Reg. No.: 0147182

Serial No.:

Section No.	1

Directions: This is a 70 Minutes, Open-book and closed-notes examination. You are expected to do your own work. Your mobile must be turned off and you have to deliver it before your entrance to the exam hall.

Grading Scheme

Question	Question Grade	Student Grade
1	10	8.5
2	12	11
3	8	8
Total Score	30	Σ= 27.5

Problem 1: (10 marks) Multiple Answer Questions

1. The Carnot cycle cannot be realized in practice, the reason being that

(A) The pump work is very large

(B) The heat addition cannot accomplished at constant temperature

(C) Both of the mentioned

(D) None of the above

2. Rankine cycle efficiency of a good steam power plant may be in the range of

(A) 15 to 20% (B) 35 to 45% (C) 70 to 80% (D) 90 to 95%

3. The cycle that after partial expansion in turbine, steam is brought back to boiler is called

(A) Reheating cycle (B) Regeneration cycle (C) Cogeneration cycle (D) Combined cycle

4. The actual work in the turbine and pump compared to isentropic ones are

(A) Both Greater than the isentropic ones

(B) Both Less than the isentropic ones

(C) For pump less but for turbine greater

(D) For turbine less but for pump greater

5. The undesirable effect when increasing the boiler pressure can be corrected by

(A) Reheating the steam (B) Adding vacuum pump (C) Regenerative the steam (D) Superheating the steam

6. An Open FWH regenerative is basically

(A) Direct mixing of the steam and feed water

(B) Indirect mixing of steam and feed water in a heat exchanger

(C) Both of the mentioned

(D) None of the above

7. If we ________ the superheat at constant pressure then the cycle efficiency ________

(A) Decrease, increases (B) Increase, decreases (C) Increase, increases (D) Decrease, decreases

8. To prevent erosion of blades in turbine, quality should not fall below

(A) 85% (B) 90% (C) 95% (D) 100%

9. The efficiency of regenerative cycle is greater than that of the Rankine cycle since

(A) The mean temperature of heat addition increases

(B) The mean temperature of heat addition decreases

(C) The pump work decreases

(D) None of the mentioned

10. The correct sequence of expansion in a reheat cycle is

(A) HP turbine – LP turbine – constant pressure in boiler

(B) HP turbine – constant pressure in boiler – LP turbine

(C) LP turbine – constant pressure in boiler – HP turbine

(D) LP turbine – HP turbine – constant pressure in boiler

1. The compressor in refrigeration cycle is used to

(A) Raise the pressure of the refrigerant

(B) Raise the temperature of the refrigerant

(C) Circulate the refrigerant through the refrigeration cycle

(D) All of the above

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2. One ton of the refrigeration is

(A) The standard unit used in refrigeration problems

(B) The cooling effect produced by melting 1 ton of ice

(C) The refrigeration effect to freeze 1 ton of water at 0°C into ice at 0°C in 24 hours

(D) The refrigeration effect to produce 1 ton of ice at NTP conditions

3. Freon group of refrigerants are

(A) Chlorofluorocarbons (B) Hydrofluorocarbons (C) Ammonia (D) carbon dioxide

4. For obtaining high COP, the pressure range of compressor should be

(A) High (B) Low (C) Optimum (D) Any value

5. In a refrigeration system, the expansion device is connected between the

(A) Compressor and condenser

(B) Condenser and receiver

(C) Receiver and evaporator

(D) Evaporator and compressor

6. The refrigerant for a refrigerator cycle should have

(A) Minimum mass flow rate

(B) Low boiling point

(C) High enthalpy of vaporization

(D) All of the above

7. The COP increases sharply with evaporator temperature increase, particularly:

(A) At high condensing temperatures

(B) At low condensing temperatures

(C) At high compressor work

(D) None of the above

8. The major drawback of ammonia which makes it unsuitable for domestic use is

(A) Its toxicity (B) Its high cost (C) Its low boiling point (D) Its effect on the ozone layer

9. The major problem associated with Air-source heat pump is:

(A) The frost accumulation on the evaporator coils

(B) Its lower COP

(C) Its expensive cost

(D) Its effect on the ozone layer

10. Cascade refrigeration cycle used in case of

(A) Large pressure range in the cycle

(B) Poor performance for a reciprocating compressor

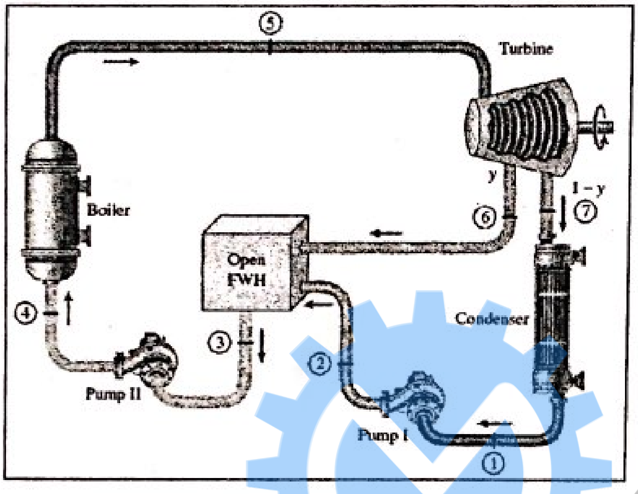
(C) Low temperature applications required

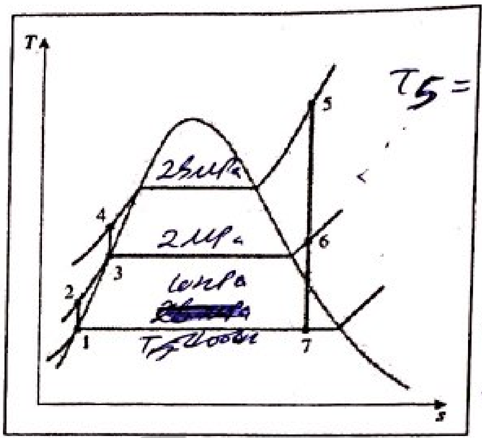
(D) All of the above

Problem 2: (12 marks)

A steam power plant operating on Simple Ideal Regenerative Rankine Cycle with OFWH.
The steam enters the turbine at 25 MPa and 1000K, it expands to 2 MPa where some steam is extracted to the OFWH.Then the remaining steam enters the condenser at 10 kPa, Calculate :

1) Quality of steam at OFWH inlet and turbine exit.
2) Work output of turbine and work input to the pumps.
3) Heat suplied in the boiler and lost in the condenser. q_{in} $-q_{out}$
4) Mass fraction used for regeneration.
5) Thermal efficiency of the cycle.
6) Carnot efficiency.





700 3777.6
727 4043.8
800
8006.5425
6.8419
6.7184

State 1: $P_1 = 10\,kPa$, $T_1 = 1000K$ } $h_1 = 191.81\ kJ/kg$, $v_1 = 0.00101\ m^3/kg$

State 2: $P_2 = 2\,MPa$, $s_2 = s_1$ } $h_2 = h_1 + v_1[P_2 - P_1]$ (w_{P_1})
$= 191.81 + 0.00101[2000 - 10] = 193.81\ kJ/kg$

State 3: $P_3 = 2\,MPa$ } $h_3 = 908.47\ kJ/kg$, $v_3 = 0.001177\ m^3/kg$

State 4: $P_4 = 25\,MPa$, $s_3 = s_4$ } $h_4 = h_3 + v_3[P_4 - P_3]$ (w_{P_2})
$= 908.47 + 0.001177[25000 - 2000] = 949.18\ kJ/kg$ (935.85 ?)

State 5: $P_5 = 25\,MPa$, $T_5 = 1000K$ } $h_5 = 3848.30\ kJ/kg$, $s_5 = 6.7409\ kJ/kg \cdot K$

State 6: $P_6 = 2\,MPa$, $s_5 = s_6 = 6.7409$ } $h_6 = 3009.14\ kJ/kg$ (3023)

State 7: $P_7 = 10\,kPa$, $s_7 = s_5$ } $x = \frac{s_7 - s_f}{s_{fg}} = \frac{6.7409 - 0.6492}{7.4996} = 0.8122$

$h_7 = h_f + x h_{fg}$
$= 191.81 + (0.8122 * 2392.1) = 2134.6\ kJ/kg$

$\dot{E}_{in} = \dot{E}_{out}$

$y h_6 + (1-y) h_2 = h_3$

$y = \frac{h_3 - h_2}{h_6 - h_2}$

$y = \frac{\dot{m}_6}{\dot{m}_5}$

$y = \frac{908.47 - 193.81}{3009.14 - 193.81}$

$\frac{\dot{m}_6}{\dot{m}_5} = 0.253$

$= 0.253$

$= 25\%$

$q_{in} = h_5 - h_4$

$= 3848.3 - 949.18$

$= 2899.12 \ kJ/kg$ 2914.5

$q_{out} = (1-y)(h_7 - h_1)$

$= (1 - 0.253)(2134.6 - 191.81)$

$= 1451.26 \ kJ/kg$

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

$= 2899.12 - 1451.26$

$= 1447.8$ 1490.468

$\eta_{th} = 1 - \frac{q_{out}}{q_{in}}$

$= 1 - \frac{1451.26}{2899.12}$

$= 0.499 \approx 49.9\% \approx 50\%$

$\eta_{th, Carnot} = 1 - \frac{T_{min}}{T_{max}}$

$= 1 - \frac{45.81 + 273}{1000}$

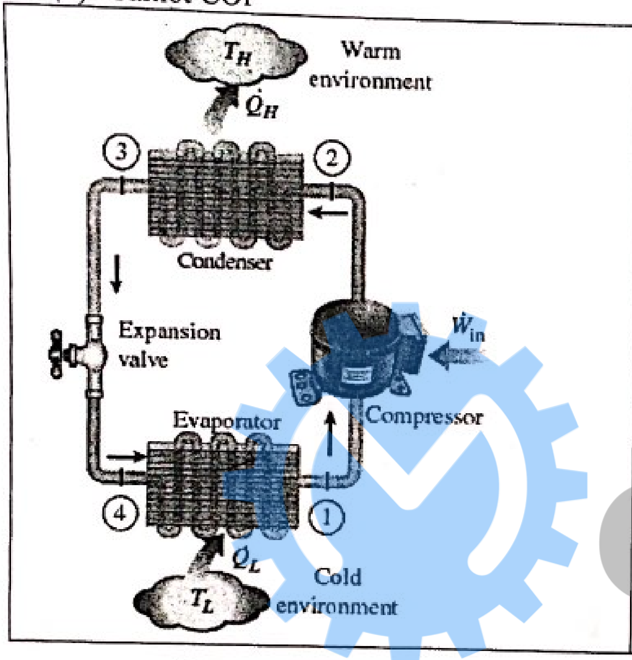
$= 0.6811$

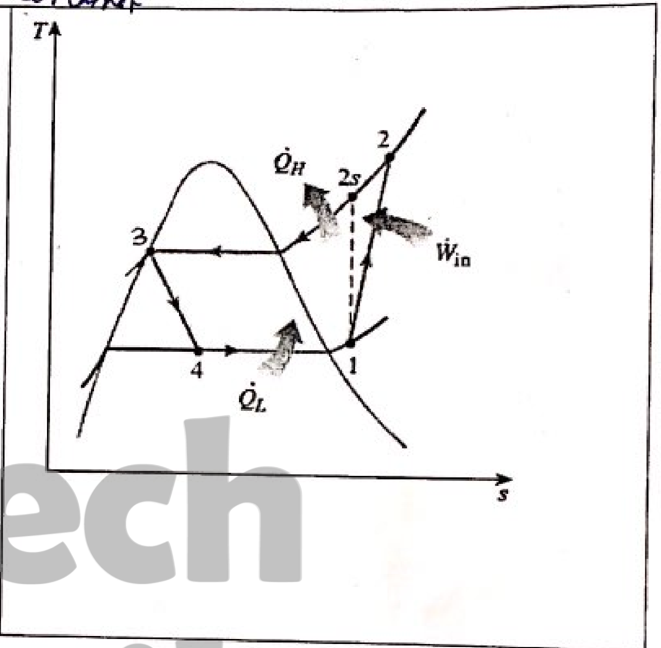
$= 68\%$ 0.6986

Problem 3: (8 marks)

An Actual Vapor Compression Refrigeration Cycle uses refrigerant R134a to maintain a space at −13°C by rejection heat to ambient air at 27°C . The refrigerant enters the compressor at 100kPa superheated by 6.4°C at mass flow rate of 0.05 kg/s . The isentropic efficiency of the compressor is 85% . The refrigerant leaves the condenser at 39.4°C as saturated liquid, calculate:

1) The cooling load provided by this cycle. 40
2) The COP for the cycle. COP
3) The compressor power needed for this cycle. Q_L , Q_H
4) Carnot COP
COPcarnot





$P_1 = 100kPa$
$T_1 = T_{sat} + \Delta T$
$= -26.4 + 6.4$ } $h_1 = 239.52$ kJ/kg
$= -20 c^\circ$ $s_1 = 0.9721$ kJ/kg.K

$P_{sat}@39.4 = 1000kPa$
$P_2 = P_3 = 1000kPa$ } $h_{2s} = 289.14$ kJ/kg
$s_{2s} = s_1 = 0.9721$ kJ/kg.K

$P_3 = 1000kPa$ } $h_3 = 107.34$
$s_3 = 0.3919$

$h_4 = h_3 = 107.34$ kJ/kg

$P_4 = 100kPa$
$h_4 = 107.34$ } $s_4 = 0.4368$ kJ/kg.K

$$\eta_c = \frac{h_{2s} - h_1}{h_2 - h_1}$$

$$0.85 = \frac{289.14 - 239.52}{h_2 - 239.52} \Rightarrow h_2 = 297.9 \text{ kJ/kg}$$

$$\left.\begin{array}{l} P_2 = 1000 \text{ kPa} \\ h_2 = 297.9 \text{ kJ/kg} \end{array}\right\} s_2 = 0.9984 \text{ kJ/kg.k}$$

$$Q_L = \dot{m}(h_1 - h_4) = 0.05(239.52 - 107.34) = 6.609 \text{ kW}$$

$$Q_H = \dot{m}(h_2 - h_3) = 0.05(297.9 - 107.34) = 9.528 \text{ kW}$$

$$\dot{W}_{in} = \dot{m}(h_2 - h_1) = 0.05(297.9 - 239.52) = 2.919 \text{ kW}$$

$$COP_R = \frac{Q_L}{\dot{W}_{in}} = \frac{6.609}{2.919} = 2.264$$

$$COP_{R,Carnot} = \frac{T_L}{T_H - T_L} = \frac{(-13 + 273)}{[27 - (-13)]k} = 6.5$$