SULIT

POLITEKNIK MALAYSIA

BAHAGIAN PEPERIKSAAN DAN PENILAIAN
JABATAN PENDIDIKAN POLITEKNIK
KEMENTERIAN PENDIDIKAN TINGGI

JABATAN KEJURUTERAAN MEKANIKAL

PEPERIKSAAN AKHIR

SESI JUN 2015

JJ507 : THERMODYNAMICS 2

TARIKH : 28 OKTOBER 2015
MASA : 8.30 AM - 10.30 AM (2 JAM)

Kertas ini mengandungi **SEMBILAN (9)** halaman bercetak.
Soalan Struktur (6 soalan)
Jawab mana-mana EMPAT (4) soalan sahaja.
Dokumen sokongan yang disertakan : Rumus, Kertas Geraf, Jadual Gas.

JANGAN BUKA KERTAS SOALAN INI SEHINGGA DIARAHKAN

(CLO yang tertera hanya sebagai rujukan)

INSTRUCTION:

This paper consists of **SIX (6)** structured questions. Answer **Four (4)** questions.

ARAHAN :

*Kertas ini mengandungi **Enam (6)** soalan berstruktur. Jawab **Empat (4)** soalan.*

QUESTION 1

SOALAN 1

Steam is supplied to a two-stage turbine at 13 MPa and 600°C. It expanded isentropically in the High Pressure (HP) turbine until it reaches 0.5 MPa, then it is reheated to 500°C and expanded through the Low Pressure (LP) turbine. The condenser pressure of the plant is 9 kPa. Assuming ideal processes and neglecting the feed pump;

Steam dibekalkan dari dandang pada tekanan 13 MPa dan suhu 600°C kepada turbin dua peringkat. Ianya dikembangkan seentropi dalam turbin tekanan tinggi sehingga ia mencapai tekanan 0.5 MPa, kemudian dipanaskan semula kepada 500°C dan dikembangkan dalam turbin tekanan rendah. Tekanan kondenser bagi loji ialah 9 kPa. Anggap proses adalah ideal dan abaikan kerja oleh pam suapan air.

CLO2
C3

a) Sketch and label the T-s diagram for the cycle.
Lakarkan dan labelkan gambarajah T-s bagi kitar.

[3 marks]
[*3 markah*]

CLO1
C3

b) Calculate the following:
Kirakan yang berikut:

i. Heat supplied to the system
Haba masukan ke sistem

[10 marks]
[*10 markah*]

ii. Total work produced.
Jumlah kerja yang dihasilkan

[3 marks]
[*3 markah*]

iii. Thermal efficiency of the cycle
Kecekapan haba kitar

[1 marks]
[*1 markah*]

iv. Specific steam consumption of the cycle
Penggunaan stim tentu kitar

[2 marks]
[*2 markah*]

CLO2
C3

c) From the answers (b), what is the condition of steam at the following:
Daripada jawapan (b), nyatakan keadaan stim pada yang berikut:

i. High Pressure turbine exit
Bahagian keluar turbin tekanan tinggi

[2 marks]
[*2 markah*]

ii. Low Pressure turbine exit
Bahagian keluar turbin tekanan rendah

[2 marks]
[*2 markah*]

i. Condenser entry
Bahagian masukan pemeluwap

[2 marks]
[*2 markah*]

QUESTION 2

SOALAN 2

An ideal Diesel cycle with air as working fluid has a compression ratio of 18 and a cutoff ratio of 2. At the beginning of the compression process, the working fluid is at 100 kPa, 27° C, and 1917 cm^3. Utilizing the cold-air standard assumptions, determine:

Given Cp = 1.005 kJ/kgK, Cv = 0.718 kJ/kgK, γ = 1.4, R = 0.287 kJ/kgK

Satu kitaran Diesel unggul dengan udara sebagai bendalir kerja yang mempunyai nisbah mampatan 18 dan nisbah potong 2. Pada permulaan proses mampatan, bendalir kerja adalah pada 100 kPa, 27 ° C, dan 1917 cm3. Dengan menggunakan andaian kitar udara piawai, tentukan

Diberi Cp = 1.005 kJ/kgK, Cv = 0.718 kJ/kgK, γ = 1.4, R = 0.287 kJ/kgK

CLO2 C3

a) Sketch the P-v and T-s diagram for the cycle

Lakarkan gambarajah P-v dan T-s untuk kitar

[4 marks]

[*4 markah*]

CLO1 C3

b) Calculate:

Kirakan:

i) The maximum temperature that occur during the cycle

Suhu maksimum semasa kitar

[11 marks]

[*11 markah*]

ii) The nett work output (kJ/kg)

Kerja keluaran bersih (kJ/kg)

[6 marks]

[*6 markah*]

iii) The thermal cycle efficiency

Kecekapan terma kitar

[2 marks]

[*2 markah*]

iv) Mean effective pressure for this cycle (M.E.P)
Kecekapan tekanan purata bagi kitar

[2 marks]
[*2 markah*]

QUESTION 3
SOALAN 3

CLO2 C1 a) Define stroke of an internal combustion engine and explain the 2-stroke and 4-stroke engine.
Takrifkan lejang di dalam enjin pembakaran dalam dan terangkan enjin 2 lejang dan enjin 4 lejang.

[6 marks]
[6 markah]

CLO1 C3 b) A 4-stroke diesel engine with 6 cylinders has 280 mm bore and 420 mm stroke. Its rated speed is 600 rpm and it is tested at this speed against a brake which has a torque arm of 100 cm. The net brake load is 7.1 kN and the specific fuel consumption for this engine is 0.231 kg/kWh. The net calorific value of fuel is given 48 200 kJ/kg. Calculate for this engine
Enjin diesel 4 lejang dengan 6 selinder, dengan 280mm garispusat lubang selinder dan 420mm panjang lejang. Kadar kelajuanya ialah 600 p.p.m dan diuji melawan bebanan brake dengan panjang lengan dayakilas 100cm. Bebanan bersih bagi brake ialah 7.1 kN dan nilai penggunaan bahanapi tentunya ialah 0.231 kg/kWj. Nilai kalorific bersih bagi bahanapi ialah 48 200 kJ/kg. Kirakan yang berikut untuk enjin ini

i. The brake power for the above test readings
Kuasa brake bagi nilai bacaan ujian di atas

[3 marks]
[*3 markah*]

ii. The brake mean effective pressure
Purata tekanan berkesan brake

[4 marks]
[*4 markah*]

iii. The brake thermal efficiency
Kecekapan termal brake

[5 marks]
[*5 markah*]

iv. The volumetric efficiency of the engine, if the air-fuel ratio is 24.5:1 at atmospheric condition (P_a = 1.01 bar, T_a = 23°C)
Kecekapan isipadu bagi engine jika nisbah udara-bahanapi ialah 24.5:1 pada keadaan tekanan atmosphere (P_a=1.01 bar, T_a= 23° C)

[7 marks]
[*7 markah*]

QUESTION 4

SOALAN 4

A gas turbine operates with a pressure ratio of 9:1. The plant consists of two units of compressor (with complete and ideal intercooling), a combustion chamber and a turbine. Air enters the compressor at 40°C with a flow rate of 30 kg/s. The maximum temperature in the cycle is 500°C. The mass of fuel for the system is neglected.

Taken C_{pa} = 1.005kJ/kg.K, for an air, γ = 1.4

C_{pg} = 1.15kJ/kg.K, for a combustion gases, γ = 1.33;

R = 0.287 kJ/kgK

Sebuah loji turbin gas beroperasi dengan nisbah tekanan 9:1. Loji terdiri daripada 2 unit pemampat (dengan pendingin antara yang lengkap dan ideal), sebuah kebuk pembakaran dan sebuah turbin. Udara memasuki pemampat pada suhu 40°C dengan kadaralir 30 kg/s. Suhu maksimum semasa kitaran ialah 500°C. Jisim minyak bagi sistem adalah diabaikan.

Ambil nilai C_{pa} = 1.005kJ/kg.K, untuk udara γ_{udara}= 1.4

C_{pg} = 1.15kJ/kg.K; untuk gas pembakaran γ = 1.33

R = 0.287 kJ/kgK

CLO2 C3 a) Sketch block diagram and T-s diagram for the given gas turbine cycle
Lukiskan gambarajah blok dan gambarajah T-s untuk kitar turbin gas yang diberikan

[6 marks]
[*6 markah*]

CLO1 C3

b) Calculate:
Kirakan

i. All temperatures value
Semua nilai suhu

[4 Marks]
[*4 markah*]

ii. The cycle efficiency.
Kecekepan kitar.

[8 Marks]
[*8 markah*]

iii. The work ratio.
Nisbah kerja

[3 Marks]
[*3 markah*]

iv. Net output power in kW
Kerja keluaran bersih dalam kW

[4 Marks]
[*4 markah*]

QUESTION 5

SOALAN 5

a) A refrigerant R-134a vapour-compression operates between 1.0637 bar and 8.8672 bar.
Bahan penyejuk R-134a dimampat didalam stim basah beroperasi di antara tekanan 1.0637bar dan 8.8672 bar.

CLO2 C3

i. Sketch the T – s diagram for the cycle.
Lakarkan gambarajah T – s kitar.

[3 Marks]
[*3 markah*]

CLO1 C3

ii. Calculate ideal refrigerating effect and maximum COP
Kirakan kesan penyejukan unggul dan pekali prestasi maksimum.

[8 Marks]
[*8 markah*]

b) The vapour-compression refrigerator operates between 1.0637 bar and 8.8672 bar with R-134a as refrigerant, having dry saturated vapour enters the compressor and the liquid refrigerant is undercooled by 5 K in the condenser. Assume that the refrigerant is compressed isentropically.

Penyejuk beroperasi antara tekanan 1.0637 bar and 8.8672 bar dan R-134a digunakan sebagai bahan penyejuk. Bahan penyejuk memasuki pemampat dalam keadaan tepu kering dan cecair bahan penyejuk mengalami subdingin 5 K di dalam pemeluwap. Anggapkan bahawa bahan pendingin dimampat seentropi.

CLO2
C3

i. Sketch the T – s diagram for the cycle.
Lakarkan gambarajah T – s kitar.

[3 Marks]
[*3 markah*]

CLO1
C3

ii. Calculate the actual refrigerating effect and the actual COP
Kirakan kesan penyejukan sebenar dan pekali prestasi sebenar

[11 Marks]
[*11 markah*]

QUESTION 6

SOALAN 6

A furnace wall consists of 250 mm firebrick, 125 mm insulating brick and L_3 mm building brick. The temperature of the inside wall is 1200°C and the ambient temperature is 29°C. The heat transfer coefficient for the outside surface (h) is 10W/m^{2}K, and the thermal conductivities (k) of the firebrick, insulating brick, and building brick are 1.4, 1.2 and 0.7 W/m.K respectively.

Sebuah dinding relau terdiri daripada bata api 250 mm, bata penebatan 125 mm dan L_3 mm bata bangunan. Suhu dinding dalaman ialah 1200℃ dan suhu ambient ialah 29℃. Angkali pemindahan haba untuk permukaan luar (h) ialah 10 W/m^{2}K, dan pengaliran termal (k) untuk bata api, bata penebatan dan bata bangunan adalah 1.4, 1.2 dan 0.7 W/m.K masing-masing.

CLO2
C3

a) Illustrate the heat loss diagram across the furnace wall

L akarkan gambarajah kehilangan haba pada bahagian dinding relau.

[4 marks]

[*4 markah*]

CLO1
C3

b) Calculate:

Kirakan:

i. Total resistance (R) of firebrick, insulating brick and building brick in terms of L_3 (assume A = $1m^2$)

Jumlah rintangan (R) bata api, bata penebatan dan bata bangunan.dalam sebutan L_3 (andaikan A = $1m^2$)B

[11 marks]

[*11 markah*]

ii. L_3 value if total heat loss through the furnace is 2kW.

Nilai L_3 jika jumlah kehilangan haba melalui relau adalah 2kW.

[4 marks]

[*4 markah*]

iii. The temperature of wall surface between insulating and building brick

Suhu permukaan antara bata penebatan dan bata bangunan.

[6 marks]

[*6 markah*]

END OF QUESTION

SOALAN TAMAT

ADVANCE STEAM PLANT

$$\eta_{cycle} = \frac{nett\ work}{\sup plied\ heat} = \frac{w_{nett}}{Q}$$

S.S.C (Penggunaan Stim Tentu) = $\frac{3600}{W_{nett}}$

Pump Work = $V_f(P_2 - P_1)\times 10^2$ Work Ratio = $\frac{W_{nett}}{W_{gross}}$

AIR STANDARD CYCLE

Otto Cycle

$$\eta_{th} = 1 - \frac{T_4 - T_1}{T_3 - T_2} = 1 - \frac{1}{r^{\gamma-1}}$$

Compression ratio

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

Diesel Cycle

$$\eta_{th} = 1 - \frac{C_v(T_4 - T_1)}{C_p(T_3 - T_2)}$$

INTERNAL COMBUSTION ENGINE

Indicator Power, i.p = $P_i LANK(2stroke)$

$$= \frac{P_i LANK}{2}(4stroke)$$

Brake Power, b.p = $\frac{2\pi NT}{60}$

Kuasa Geseran (Friction power), f.p = i.p – b.p

$$\eta_{mechanical} = \frac{b.p}{i.p}$$

Kecekapan Terma Brek

$$\eta_{BT} = \frac{b.p}{m_f \times Q_{net,V}}$$

s.f.c = $\frac{fuel\ consumption\quad /hour}{generated\ power}$

Supplied fuel energy = m x N.K

Piston speed = 2LN

Kecekapan Isipadu $\eta_v = \frac{V}{V_s}$

GAS TURBINE

Ideal gas $\frac{T_2}{T_1} = \left[\frac{P_2}{P_1}\right]^{\frac{\gamma-1}{\gamma}}$

Isentropic Efficiencies

$$\eta_p = \frac{T_2 - T_1}{T_2' - T_1} \qquad \eta_T = \frac{T_3 - T_4'}{T_3 - T_4}$$

Compressor work

$$Cp_{air}(T_2' - T_1)$$

Turbine work

$$Cp_{gas}(T_3 - T_4') \qquad \eta_{heat} = \frac{W_{nett}}{Q_{\sup plied}}$$

Work Ratio(Nisbah Kerja)

$$= \frac{Kerja\ Keluaran\ Bersih}{Kerja\ Keluaran\ Kasar}$$

HEAT TRANSFER

$$\frac{1}{U} = \frac{1}{h_A} + \Sigma\frac{x}{k} + \frac{1}{h_B}$$

$$Q = \frac{t_a - t_b}{R_T}$$

$$R = \frac{1}{h_A} \quad R = \frac{\ln\left[\frac{r_2}{r_1}\right]}{2\pi k}$$

REFRIGERATION

$$C.O.P_r = \frac{T_1}{T_2 - T_1} \qquad C.O.P_{hp} = \frac{T_2}{T_2 - T_1}$$

Refrigerated Effect, $Q_{12} = h_1 - h_2$

Work done, $W_{12} = h_2 - h_1$

Tetrafluoroethane – CH_2F–CF_3 (Refrigerant 134a)

Saturation Values							Superheat ($T - T_s$)			
							10 K		20 K	
T	p_s	v_g	h_f	h_g	s_f	s_g	h	s	h	s
[°C]	[bar]	[m³/kg]	[kJ/kg]		[kJ/kg K]		[kJ/kg]	[kJ/kg K]	[kJ/kg]	[kJ/kg K]
−103.30	0.0041	34.032	77.69	335.24	0.4453	1.9616	341.16	1.9955	347.29	2.0287
−100	0.0058	24.341	80.89	337.15	0.4640	1.9439	343.14	1.9776	349.35	2.0106
− 90	0.0155	9.5984	90.97	343.05	0.5205	1.8969	349.27	1.9300	355.70	1.9624
− 80	0.0370	4.2333	101.60	349.09	0.5770	1.8584	355.55	1.8910	362.20	1.9229
− 70	0.0800	2.0522	112.70	355.25	0.6330	1.8270	361.95	1.8592	368.84	1.8907
− 60	0.1591	1.07785	124.23	361.48	0.6884	1.8015	368.44	1.8334	375.57	1.8646
− 50	0.2944	0.60592	136.14	367.76	0.7430	1.7809	374.99	1.8126	382.38	1.8436
− 40	0.5188	0.36089	148.37	374.03	0.7965	1.7644	381.56	1.7960	389.22	1.8269
− 30	0.8435	0.22577	160.89	380.27	0.8490	1.7512	388.12	1.7828	396.07	1.8137
− 25	1.0637	0.18146	167.25	383.37	0.8748	1.7457	391.38	1.7774	399.49	1.8082
− 20	1.3272	0.14725	173.67	386.44	0.9003	1.7408	394.63	1.7726	402.90	1.8034
− 15	1.6393	0.12055	180.16	389.49	0.9256	1.7365	397.86	1.7683	406.29	1.7992
− 10	2.0060	0.09949	186.71	392.51	0.9506	1.7327	401.07	1.7647	409.67	1.7956
− 5	2.4335	0.08273	193.32	395.49	0.9754	1.7294	404.25	1.7614	413.02	1.7924
0†	2.9281	0.06925	200.00†	398.43	1.0000†	1.7264	407.40	1.7587	416.35	1.7897
5	3.4966	0.05834	206.75	401.33	1.0243	1.7238	410.50	1.7562	419.65	1.7874
10	4.1459	0.04942	213.57	404.16	1.0484	1.7215	413.56	1.7542	422.90	1.7855
15	4.8833	0.04208	220.46	406.93	1.0723	1.7194	416.57	1.7524	426.12	1.7838
20	5.7162	0.03599	227.45	409.62	1.0961	1.7176	419.52	1.7508	429.29	1.7825
25	6.6525	0.03092	234.52	412.23	1.1198	1.7158	422.41	1.7494	432.40	1.7813
30	7.7000	0.02665	241.69	414.74	1.1434	1.7142	425.21	1.7482	435.44	1.7803
35	8.8672	0.02304	248.98	417.14	1.1669	1.7126	427.93	1.7470	438.42	1.7795
40	10.163	0.01998	256.38	419.41	1.1903	1.7109	430.55	1.7460	441.32	1.7788
45	11.595	0.01735	263.92	421.53	1.2138	1.7092	433.06	1.7449	444.13	1.7781
50	13.174	0.01510	271.61	423.47	1.2374	1.7073	435.44	1.7438	446.84	1.7775
55	14.910	0.01315	279.46	425.20	1.2610	1.7051	437.69	1.7426	449.45	1.7769
60	16.812	0.01145	287.51	426.69	1.2848	1.7026	439.77	1.7412	451.93	1.7762
65	18.892	0.00997	295.77	427.89	1.3088	1.6995	441.67	1.7397	454.29	1.7754
70	21.161	0.00866	304.29	428.72	1.3332	1.6958	443.36	1.7378	456.50	1.7745
75	23.633	0.00750	313.13	429.09	1.3580	1.6911	444.82	1.7356	458.54	1.7734
80	26.323	0.00645	322.36	428.85	1.3835	1.6851	446.01	1.7330	460.42	1.7721
85	29.249	0.00550	332.16	427.77	1.4101	1.6771	446.88	1.7298	462.09	1.7706
90	32.433	0.00462	342.79	425.40	1.4386	1.6661	447.40	1.7259	463.55	1.7687
95	35.906	0.00375	355.05	420.64	1.4709	1.6491	447.49	1.7212	464.76	1.7663
100	39.728	0.00266	373.53	406.93	1.5193	1.6088	447.04	1.7153	465.65	1.7633
101.00	40.550	0.00196	389.67	389.67	1.5621	1.5621	446.84	1.7139	465.77	1.7626

Molar mass $\tilde{m} = 102.03$ kg/kmol; further properties of the liquid are given on p. 23.

†The datum state for refrigerant properties used to be −40 °C ($h_f = 0$, $s_f = 0$), a temperature at which −40 °C = −40 °F. This datum state is used here for the R717 and R12 tables. Nowadays the datum state chosen is 0 °C ($h_f \doteq 200$ kJ/kg, $s_f = 1.000$ kJ/kg K), a choice which ensures that no negative values of h_f and s_f appear in common refrigerant tables. This datum state is chosen for the R134a table.

It must be remembered that datum states are quite arbitrary and do not affect calculations which involve changes of properties, such as Δh.