SULIT

POLITEKNIK MALAYSIA

BAHAGIAN PEPERIKSAAN DAN PENILAIAN
JABATAN PENDIDIKAN POLITEKNIK
KEMENTERIAN PENDIDIKAN TINGGI

JABATAN KEJURUTERAAN MEKANIKAL

PEPERIKSAAN AKHIR

SESI DISEMBER 2015

JJ507: THERMODYNAMICS 2

TARIKH : 09 APRIL 2016
MASA : 8.30 AM – 10.30 AM (2 JAM)

Kertas ini mengandungi **SEBELAS (11)** halaman bercetak.
Struktur (6 soalan)
Dokumen sokongan yang disertakan: Formula

JANGAN BUKA KERTAS SOALAN INI SEHINGGA DIARAHKAN

(CLO yang tertera hanya sebagai rujukan)

INSTRUCTION:

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

ARAHAN:

*Kertas ini mengandungi **ENAM (6)** soalan berstruktur. Jawab mana-mana **EMPAT (4)** soalan.*

QUESTION 1

SOALAN 1

CLO2 C1

a) Draw and label the ideal Rankine Cycle on a T-s diagram.
Lukis dan labelkan kitar Rankine sempurna pada rajah T-s.

[6 Marks]
[*6 Markah*]

CLO1 C3

b) A Rankine steam power plant operates between a boiler pressure of 40 bar and a condenser pressure of 0.035 bar. Steam at a boiler pressure is superheated to 500^0C. Calculate:
Sebuah loji kuasa stim Rankine bekerja antara tekanan dandang 40 bar dan tekanan pemeluwap 0.035 bar. Stim pada tekanan dandang dipanas lampaukan kepada 500^0C. Kirakan:

i. Thermal Efficiency with the T-s diagram
Kecekapan terma dengan bantuan rajah T-s

[15 Marks]
[*15 Markah*]

ii. Work Ratio
Nisbah kerja

[2 Marks]
[*2 Markah*]

iii. Specific Steam Consumption
Penggunaan Stim Tentu

[2 Marks]
[*2 Markah*]

QUESTION 2
SOALAN 2

An engine works on a constant volume cycle and has a compression ratio of 9:1. The pressure and temperature at the beginning of the compression process is 112 kN/m^2 and 77 °C respectively. The temperature at the beginning of the expansion process is 1500 °C and $\gamma = 1.4$.

Sebuah enjin petrol yang bekerja pada kitaran isipadu tetap mempunyai nisbah mampatan 9:1. Tekanan dan suhu permulaan proses mampatan ialah 112 kN/m^2 dan 77 °C. Suhu pada permulaan pengembangan proses adalah 1500 °C dan $\gamma = 1.4$.

CLO2 C1 (a) Draw and label the Otto cycle on a P-v diagram.
Lukis dan labelkan kitar piawai Otto pada gambarajah P-v.

[3 marks]
[*3 markah*]

CLO1 C3 (b) Calculate the following values for each kilogram of cycle:
Kira nilai berikut untuk setiap kilogram kitaran:

i. Heat supplied
Haba dibekalkan

[6 marks]
[*6 markah*]

ii. Heat rejected
Haba dikeluarkan

[6 marks]
[*6 markah*]

iii. Thermal efficiency of cycle
Kecekapan kitaran

[4 marks]
[*4 markah*]

iv. Mean effective pressure
Tekanan berkesan efektif

[6 marks]
[*6 markah*]

QUESTION 3
SOALAN 3

A test is performed on a 4-stroke single cylinder engine with the engine speeding at 1200 rpm. The following data were obtained:

Ujian yang dilakukan pada enjin 4 lejang satu silinder dengan kelajuan enjin pada 1200 rpm. Data berikut diperolehi:

Engine cylinder bore *Diameter selinder*	:	0.15 m
Piston swept volume *Isipadu lejang*	:	2.655 m^3/min
Duration of test *Tempoh ujian*	:	20 minutes
Brake power *Kuasa brek*	:	31.42 kW
Specific fuel consumption *Penggunaan bahan api tentu*	:	0.7877 kg/kW hour
The calorific value of fuel *Nilai kalori bahan api*	:	42300 kJ/kg
Cooling water consumption *Penggunaan air penyejuk*	:	483 kg
The inlet temperature of cooling water *Suhu masukkan air penyejuk*	:	17 ^{O}C
The outlet temperature of cooling water: *Suhu keluaran air penyejuk*		77 ^{O}C
The rate of air consumption *Kadar penggunaan udara*	:	170 kg
Exhaust temperature *Suhu ekzos*	:	470 ^{O}C

	Atmospheric temperature *Suhu atmosfera*	:	20 ^{O}C
	Indicated power *Kuasa tertunjuk*	:	39.28 KJ/s
	Specific heat for exhaust *Haba tentu untuk exzos*	:	1.25 kJ/kg K
	Specific heat capacity of water *Haba tentu untuk air*	:	4.18 kJ/kg K

CLO1 C3

a) Calculate
Kirakan

i. The area of cylinder [2 marks]
Luas selinder [*2 markah*]

ii. Torque [2 marks]
Daya kilas [*2 markah*]

iii. Fuel flow rate [4 marks]
Kadar alir bahan api [*4 markah*]

iv. Mechanical efficiency [2 marks]
Kecekapan mekanikal [*2 markah*]

v. Indicated thermal efficiency [3 marks]
Kecekapan haba tertunjuk [*3 markah*]

vi. Stroke length of the engine [2 marks]
Panjang lejang [*2 markah*]

CLO2 C3

b) Complete a table of heat balance for the engine.
Lengkapkan jadual imbangan haba bagi enjin.

[10 marks]
[10 *markah*]

QUESTION 4
SOALAN 4

In a gas turbine, the overall compression ratio is 7/1 and it expands into a two stage turbine.High pressure turbine drives the compressor and the low pressure turbine generate the nett work. The air enters the compressor at 27°C. The hot gas leaves the combustion chamber at 700°C and expand trough the high pressure turbine. After leaving the turbine, the gas passes trough the reheat combustion chamber, which raises the temperature of the gas to 650°C before it expands though the low pressure turbine. The isentropic efficiency of the compressor and the turbine are 0.85 and 0.9 respectively.

Dalam sebuah turbin gas, nisbah tekanan keseluruhan pemampat adalah 7/1 dan gas mengembang kedalam turbin 2 peringkat. Turbin tekanan tinggi menjalankan pemampat dan turbin tekanan rendah menjanakan kerja bersih. Udara memasuki pemampat pada 27°C manakala gas panas meninggalkan kebuk pembakaran pada suhu 700°C lalu mengembang menerusi turbin tekanan tinggi. Selepas gas meninggalkan turbin tersebut, gas dipanaskan semula pada kebuk pembakaran yang menaikan suhu gas kepada 650°C sebelum pengembangan melalui turbin bertekanan rendah. Kecekapan isentropic pemampat dan turbin adalah 0.85 dan 0.9 masing-masing.

Value for air, $\gamma = 1.4$, $C_p = 1.005$ KJ/kg K.
Untuk udara ambil nilai $\gamma = 1.4$, $C_p = 1.005$ KJ/kg K.

Value for gas, $C_p = 1.15$ KJ/kg K, $\gamma = 1.333$.
Untuk gas ambil nilai $C_p = 1.15$ KJ/kg K, $\gamma = 1.33$.

CLO2 C3

a) Sketch the process on a T-s diagrams.
Lakarkan proses pada rajah T-s.

[3 marks]
[*3 markah*]

CLO1
C3

b) Determine:
Tentukan:

i) Nett work done by the low pressure turbine.
Kerja bersih yang dijana pada turbin tekanan rendah.

[17 marks]
[*17 markah*]

ii) Heat supplied.
Haba yang dibekalkan.

[4 marks]
[*4 markah*]

iii) Thermal efficiency of the plant.
Kecekapan terma bagi loji.

[1 mark]
[*1 markah*]

QUESTION 5
SOALAN 5

CLO2
C2

(a) Explain briefly the meaning of refrigeration.
Terangkan dengan ringkas maksud penyejukan.

[4 marks]
[*4 markah*]

CLO2
C1

(b) State **TWO (2)** uses of refrigeration.
*Nyatakan **DUA (2)** kegunaan penyejukan.*

[4 marks]
[*4 markah*]

CLO1
C3

(c) An ammonia refrigerator operates between evaporating and condensing temperature of -16 °C and 50 °C respectively. The vapour is dry saturated at the compressor inlet, the compression process is isentropic and there is no undercooling of the condensate. Calculate for 1 kW of refrigeration.

Sebuah peti sejuk ammonia dikendalikan antara suhu pengewapan dan pemeluwapan -16 °C dan 50 °C masing-masing. Wap adalah kering tepu bila masuk pemampat dan proses pemampatan adalah seentropi dan air pemelowap tidak terlebih sejuk. Hitungkan untuk 1 kW penyejukan.

i. The refrigerating effect.
Kesan Penyejukan.

[5 marks]
[*5 markah*]

ii. Mass flow rate of refrigerant per hour.
Kadar aliran jisim pendingin setiap jam.

[2 marks]
[*2 markah*]

iii. The power input per kW of refrigeration.
Keperluan kuasa untuk setiap kW penyejukan.

[6 marks]
[*6 markah*]

iv. The C.O.P $_{\text{Refrigerant.}}$
C.O.P $_{\text{Penyejuk.}}$

[4 marks]
[*4 markah*]

QUESTION 6
SOALAN 6

The wall of a refrigerator built of fiberglass insulation (thermal conductivity k = 0.035 W/mK) is sandwiched between two layers of a 1 mm thick sheet metal (thermal conductivity k = 15.1 W/mK). The refrigerated space is maintained at 3 ^{O}C and the heat transfer coefficients at the inner and outer of the wall are 4 W/m^{2}K and 9 W/ m^{2}K respectively. The room temperature is 25°C. It is observed that condensation occurs on the surface of the refrigerator when the temperature of the outer surface drops to 20 °C.

Dinding sebuah peti sejuk yang dibina daripada penebat gentian kaca (pekali pengaliran haba, k = 0.035 W/ mK) diapit di antara dua lapisan 1 mm tebal kepingan logam (pekali pengaliran haba, k = 15.1 W/ mK). Ruang peti sejuk kekal pada suhu 3 ^{O}C dan pekali pemindahan haba di sebelah dalam dan luar dinding masing-masing 4 W/ m^{2}K dan 9 W/ m^{2}K. Suhu bilik adalah 25 °C. Dapat dilihat bahawa pemeluwapan berlaku di permukaan peti sejuk apabila suhu permukaan luar jatuh kepada 20 °C.

CLO2
C3

a) Draw the schematic diagram for convection resistance.
Lakarkan gambarajah skematik untuk rintangan perolakan.

[6 marks]
[*6 markah*]

CLO1
C3

b) Calculate
Kirakan

i. Total resistance
Jumlah rintangan

[6 *markah*]
[6 *marks*]

ii. Heat transfer rate
Kadar pemindahan haba

[3 *markah*]
[3 *marks*]

iii. The minimum thickness of fiberglass insulation required in order to avoid condensation on the outer surface
Ketebalan minimum penebat gentian kaca yang diperlukan untuk mengelakkan pemeluwapan pada permukaan luar

[6 *marks*]
[6 *markah*]

iv. The temperature of the inner surface
Suhu permukaan dalam

[*4 markah*]
[4 *marks*]

SOALAN TAMAT

FORMULA / RUMUS

JJ507 – THERMODYNAMICS 2

ADVANCE STEAM PLANT

$$\eta_{cycle} = \frac{\text{Net work}}{\text{Heat supplied}}$$

$$\text{s.s.c.} = \frac{3600}{W_{net}}$$

$$\text{Pump Work} = V_f(P_2 - P_1)$$

$$\text{Work ratio} = \frac{W_{Net}}{W_{Gross}}$$

AIR STANDARD CYCLE

Otto Cycle

$$\eta_{th} = 1 - [1/r^{(\gamma-1)}]$$

Diesel Cycle

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

INTERNAL COMBUSTION ENGINE

$$\text{Indicated Power, i.p.} = P_i LANn \quad \text{(2-stroke)}$$

$$= P_i LANn / 2 \quad \text{(4-stroke)}$$

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

$$\eta_{Mechanical} = \frac{\text{b.p}}{\text{i.p}}$$

$$\text{S.F.C.} = \frac{\text{Fuel consumption / hour}}{\text{Power developed}}$$

$$\text{Energy supplied} = \text{Mass of fuel} \times \text{c.v.}$$

GAS TURBINE

Isentropic Process

$$[T_2/T_1] = [(P_2/P_1)]^{(\gamma-1)/\gamma}$$

Isentropic efficiencies

$$\eta_c = \frac{T_2 - T_1}{T_2' - T_1} \qquad \eta_t = \frac{T_3 - T_4}{T_3 - T_4'}$$

$$\text{Compressor work} = C_p(T_2' - T_1)$$

$$\text{Turbine Work} = C_p(T_5 - T_4')$$

$$\eta_{Heat} = \frac{W_{Nett}}{Q_{Supplied}}$$

REFRIGERATION

$$\text{C.O.P}_r = \frac{T_1}{T_2 - T_1}$$

$$\text{C.O.P}_{hp} = \frac{T_2}{T_2 - T_1}$$

$$\text{Refrigerating Effect, } Q_{14} = h_1 - h_4$$

$$\text{Work input, } W_{12} = h_2 - h_1$$

HEAT TRANSFER

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

$$Q = \frac{t_A - t_B}{R_T}$$

$$R_T = 1/h_A A + \sum x/KA + 1/h_B A$$