UNIVERSITI SAINS MALAYSIA

First Semester Examination
2013/2014 Academic Session

December 2013/January 2014

EMH 332 – Applied Thermodynamics
[Termodinamik Gunaan]

Duration : 3 hours
[Masa : 3 jam]

Please check that this paper contains **SEVEN (7)** printed pages, and **SIX (6)** questions before you begin the examination.

*[Sila pastikan bahawa kertas soalan ini mengandungi **TUJUH (7)** mukasurat bercetak, dan **ENAM (6)** soalan sebelum anda memulakan peperiksaan.]*

Appendix/*Lampiran :*

1. Formula for Internal Combustion Engine [3 pages/mukasurat]

INSTRUCTIONS : Answer **FIVE (5)** questions only. You may answer all questions in **English** OR **Bahasa Malaysia** OR a combination of both.

***[ARAHAN :** Jawab **LIMA (5)** soalan sahaja. Calon boleh menjawab semua soalan dalam **Bahasa Malaysia** ATAU **Bahasa Inggeris** ATAU kombinasi kedua-duanya.]*

Answer to each question must begin from a new page.
[Jawapan untuk setiap soalan mestilah dimulakan pada mukasurat yang baru.]

In the event of any discrepancies, the English version shall be used.
[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai.]

Table for Property Tables Booklet is provided.
Jadual Sifat Bendalir Termodinamik adalah dibekalkan.

Q1. [a] State Dalton's law of partial pressure and show that how the partial pressure of a component in a gaseous mixture related to the mole fraction of that component.

Nyatakan hukum Dalton bagi tekanan separa dan tunjukkan bagaimana tekanan separa komponen gas campuran berkait dengan pecahan mol bagi komponen tersebut.

(30 marks/*markah***)**

[b] A rigid tank contains 0.35kg of steam of quality 0.2 and 0.1kg of oxygen gas. The temperature of mixture measured is 90^{o}C, calculate the tank volume.

Sebuah tangki tegar mengandungi 0.35kg wap dengan kualiti 0.2 dan 0.1kg gas oksigen. Suhu campuran diukur adalah 90^{o}C, kirakan isipadu tangki.

(30 marks/*markah***)**

[c] A tank of volume 2m^3 containing O_2 at 600kPa and 310K is connected through a pipe line to another tank of volume 4m^3 containing CO_2 at 100kPa and 290K. The gases mix adiabatically and come to an equilibrium state. Determine:

Sebuah tangki berisipadu 2m^3 mengandungi O_2 pada 600kPa dan 310K disambungkan melalui sebuah saluran paip kepada sebuah tangki lain berisipadu 4m^3 mengandungi CO_2 pada 100kPa dan 290K. Gas bercampur secara adiabatic dan mencapai keadaan keseimbangan. Tentukan:

(i) The final temperature
Suhu akhir

(ii) The final pressure
Tekanan akhir

(iii) The Molar mass
Molar jisim

(iv) The gas constant
Pemalar gas

(40 marks/*markah***)**

Q2. [a] Using the diagrams, differentiate the induced and natural draught cooling towers.

Dengan menggunakan gambarajah, bezakan menara penyejukan secara sedutan paksa dan tabie

(20 marks/*markah***)**

[b] The temperature of the air in two rooms is same 25°C but the relative humidity are 50% and 60% in first and second rooms respectively. Compare the dew point temperature of the air in both rooms.

Suhu udara di dalam dua buah bilik adalah sama 25°C tetapi kelembapan relatif masing-masing adalah 50% dan 60% bagi bilik pertama dan kedua. Bandingkan titik suhu embun bagi udara bagi kedua-dua bilik.

(30 marks/*markah***)**

[c] An air-conditioning system takes in atmospheric air at 15°C and 30% relative humidity at steady rate of 50m^3/min and conditions it to 25°C and 50% relative humidity. The atmospheric air is first heated to 22°C in the heating section and then humidified by the injection of hot steam in the humidifying section. Assuming that the entire process takes place at a pressure of 101.325kPa, determine:

Sebuah sistem penyaman udara mengambil udara atmosfera pada 15°C dan kelembapan relatif 30% pada kadar mantap 50m^3/min dan keadaannya menjadi 25°C and kelembapan relatif 50%. Udara atmosfera pada mulanya dipanaskan kepada 22°C dalam seksyen pemanasan dan kemudian dilembapkan dengan suntikan aliran panas di dalam seksyen pelembapan. Anggapkan keseluruhan proses berlaku pada tekanan 101.325kPa, tentukan:

(i) The specific humidity in the heating section
Lembapan tentu di dalam seksyen pemanasan

(ii) The power supply in the heating section
Kuasa bekalan di dalam seksyen pemanasan

(iii) The required mass of flow rate of the steam in the humidifying section
Kadar aliran jisim yang dikehendaki di dalam seksyen pelembapan

(50 marks/*markah***)**

Q3. [a] Distinguish between proximate and ultimate analysis
Bezakan di antara analisis proximate dan ultimate

(20 marks/*markah***)**

[b] Methane obtained from a certain source is burnt with dry air in stoichiometric combustion. Establish the stoichiometric equation and evaluate the air fuel ratio by volume.

Metana didapati daripada sebuah sumber tertentu yang dibakar dengan udara kering didalam pembakaran stoikiometer. Binakan persamaan stoikiometer dan tentukan nisbah udara bahanapi berdasarkan isipadu.

(30 marks/*markah***)**

[c] A mixture of 1kmol of CO and 2kmol of O_2 is hented to 2000K at a pressure of 4atm. Determine the equilibrium composition, assuming that the mixture consists of CO_2, CO and O_2.

Campuran 1kmol CO dan 2kmol O_2 dipanaskan kepada 2000K pada tekanan 4atm. Tentukan komposisi keseimbangan, anggapkan campuran terdiri daripada CO_2, CO dan O_2.

(50 marks/*markah***)**

Q4. [a] Provide an illustrative description about the combustion process in spark ignition (SI) engine.

Berikan penerangan bergambar tentang proses pembakaran di dalam enjin cucuhan bunga api (SI).

(40 marks/*markah***)**

[b] A four cylinder, four stroke SI engine having a bore of 10 cm and stroke 9 cm runs at 4000 rpm. The fuel used has a carbon content of 84.50 % and hydrogen content of 15.50% by weight. The volumetric efficiency of the engine at 75% of full throttle and at 4000rpm is 0.85 referred to 300 K and 100kPa. The engine is to be supplied with a mixture of air coefficient 0.95 when running at 75 % of full throttle. Calculate:

Sebuah enjin SI empat silinder, empat lejang mempunyai jara 10cm dan lejang 9cm beroperasi pada 4000rpm. Bahanapi yang digunakan mempunyai nilai karbon 84.50% dan nilai hydrogen 15.50% berdasarkan berat. Kecekapan isipadu bagi enjin pada 75% pendikit penuh dan 4000rpm adalah 0.85 pada 300K dan 100kPa. Enjin dibekalkan dengan pemalar campuran udara 0.95 apabila beroperasi pada 75% pendikit penuh. Kirakan:

(i) The throat diameter of the venturi if the air velocity at throat is not exceed of 200m/s under the above operating conditions.

Garis pusat kerongkong venturi jika halaju udara pada kerongkong tidak melebihi 200m/s pada keadaan operasi diatas.

(ii) The rate of fuel flow in kg/s at the pressure drop at venturi throat.

Kadar aliran bahan api dalam kg/s pada kejatuhan tekanan di kerongkong venturi.

Discharge coefficient for the venturi is 0.8 and the area ratio of the venturi 0.8 (Take R for air as 0.287 kJ/kgK and R for fuel vapor is 0.09kJ/kgK)

Pemalar luahan bagi venturi ialah 0.8 dan nisbah luas bagi venturi 0.8 (Ambil R bagi udara sebagai 0.287kJ/kgK dan R bagi wap bahan api adalah 0.09kJ/kgK)

(60 marks/*markah***)**

Q5. [a] Draw the Otto and Diesel cycles on the P-V and T-S diagram and explain their processes.

Lukiskan kitar Otto dan Diesel pada gambarajah P-V dan T-S dan terangkan proses-proses tersebut.

(30 marks/*markah***)**

[b] A Misubishi Diesel Engine SGR-T4 has a direct fuel system and is turbocharged with an intercooler of using jacket-water. This is used as a stationary engine to drive 550 kW (60Hz) generator at the speed of 1800rpm. The main specifications of the engine are as follows:

Sebuah enjin Diesel Mitsubishi SGR-T4 mempunyai sistem bahan api terus dan caj turbin dengan sebuah penyejuk selepas dengan menggunakan jaket-air. Ini menggunakan enjin tetap bagi memandu 550kW (60Hz) penjana pada kelajuan 1800rpm. Spesifikasi utama bagi enjin adalah seperti berikut:

Engine type *Jenis Enjin*	**4 stroke, 6 cylinder, water cooled** *4 lejang, 6 silinder, penyejukan air* *Turbocharged diesel engine.* *Enjin diesel caj-turbin*
Bore × stroke *Jara x lejang*	170 mm × 180 mm
Compression ratio *Nisbah mampatan*	r = 14:1
Generator transmission efficiency *Kecekapan penghantaran penjana*	90%
Mechanical efficiency, η_{mech}	83 %
Fuel consumption *Penggunaan bahan api*	204 g/kW.hr
Fuel /Air ratio *Nisbah bahan api/udara*	0.05
Heating value of fuel *Nilai pemanasan bahan api*	44.2 MJ/kg

Determine:
Tentukan:

(i) Torque
Tork

(ii) Brake thermal efficiency
Kecekapan terma brek

(iii) Brake mean effective pressure (BMEP)
Tekanan efektif min brek

(iv) Indicated specific fuel consumption
Penggunaan bahan api tentu tercatat

(v) Actual efficiency
Kecekapan sebenar

(vi) Volumetric efficiency
Kecekapan isipadu

(70 marks/*markah***)**

Q6. [a] If the clearance ratio of an ideal single stage reciprocating compressor is CR, the volumetric efficiency is given by

Jika nisbah ruang bagi sebuah pemampat unggul berlejang peringkat tunggal adalah CR, tunjukkan kecekapan isipadu diberikan sebagai

$$\eta_{vol} = 1 - CR\left(r_p^{\frac{1}{n}} - 1\right)$$

(30 marks/markah)

[b] A single acting reciprocating compressor runs at 360rev/min and takes in air at 100kPa and 15°C and compresses it in 3 stages at 6.4MPa. The free air delivery is 0.057m^3/s. There is an intercooler between each stage, which returns the air to 15°C. Each stage has one piston with a stroke of 100mm, calculate:

Sebuah pemampat berlejang tunggal beroperasi pada 360pusingan/min dan menyedut udara pada 100kPa dan 15°C and memampatkannya dalam 3 peringkat pada 6.4MPa. Hantaran udara bebas ialah 0.057m^3/s. Terdapat penyejuk diantara setiap peringkat, yang mana mengembalikan udara pada 15°C. Setiap peringkat mempunyai satu omboh dengan lejang 100mm, kirakan:

(i) The interstage pressure
Tekanan antara peringkat

(ii) The indicated power per stage
Kuasa tertera per peringkat

(iii) The heat rejected from each cylinder
Haba terbuang daripada setiap silinder

(iv) The heat rejected from each intercooler
Haba terbuang daripada setiap penyejuk-antara

(v) The isothermal efficiency
Kecekapan isoterma

(vi) The swept volume of each stage
Isipadu tersapu bagi setiap peringkat

(vii) The bore of each cylinder
Jara bagi setiap silinder

Ignore leakage and the effect of the clearance volume. The index of compression is 1.3 for all stages.

Abaikan kebocoran dan kesan isipadu ruang. Indeks mampatan adalah 1.3 bagi semua peringkat.

(70 marks/markah)

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Formula for Internal Combustion Engine

The compression ratio, r:

$$r = \frac{V_{\max}}{V_{\min}}$$

The mean effective pressure, MEP

$$MEP = \frac{W_{net}}{V_{\max} - V_{\min}} = \frac{w_{net}}{v_{\max} - v_{\min}}$$

The indicated mean effective pressure, pi

$$p_i = \frac{net\_area\_of\_diagram}{length\_diagram} \times cons\tan t$$

Work done per cycle = $p_i \times A \times L$

The indicated power, ip:

$$ip = p_i AL \times (cycles/time)$$

For four-stroke engine:

$$ip = \frac{p_i ALNn}{2}$$

For two-stroke engine:

$$ip = p_i ALNn$$

Where n is the no. of cylinders.

Brake power (bp)

This is to measure the engine output. The engine is connected to the break or dynamometer.

T= WR

The brake power is then given by

$$bp = 2\pi NT$$

Friction power (fp) and mechanical efficiency, η_m

The difference between ip and bp:

Fp = ip – bp

The mechanical efficiency:

$$\eta_m = \frac{bp}{ip}$$

For multi cylinder engines such as four cylinder engine, the bp

$$bp = (ip_1 - L_1) + (ip_2 - L_2) + (ip_3 - L_3) + (ip_4 - L_4)$$

Break mean effective pressure (bmep)

The bp is obtained using dynamometer,

$$bp = \eta_m \times ip$$

For a four-stroke engine,

$$bp = \frac{\eta_m \times p_i ALNn}{2} \quad \text{or}$$

$$bp = \frac{p_b ALNn}{2} \quad \text{where} \quad p_b = \eta_m \times p_i$$

For the frictionless engine, the bmep

$$\frac{p_b ALNn}{2} = 2\pi NT$$

Thus, $p_b = K \times T$ where K = constant

The overall efficiency of the engine is given by the brake thermal efficiency,

$$\eta_{BT} = \frac{bp}{m_{fuel} \times Q_{net,v}}$$

Specific fuel consumption, sfc

The specific fuel consumption (sfc) is the mass flow rate of fuel consumed per unit power output,

$$sfc = \frac{m_{fuel}}{bp}$$

The indicated thermal efficiency, η_{IT} is defined as

$$\eta_{IT} = \frac{ip}{m_{fuel} \times Q_{net,v}}$$

Volumetric Efficiency, η_V

$$\eta_V = \frac{V}{V_S}$$