CBCS Scheme

15ME43

USN

Fourth Semester B.E. Degree Examination, June/July 2017
Applied Thermodynamics

Time: 3 hrs. Max. Marks: 80

Note: 1. Answer FIVE full questions, choosing one full question from each module.
2. Use of thermodynamic data book is permitted.

Module-1

1 a. Obtain air standard efficiency expression for diesel cycle. **(08 Marks)**

b. The compression ratio of an air standard Otto cycle is 8. At the beginning of compression process the pressure is 1 bar and the temperature is 300 K. The heat transfer to the air per cycle is 1900 kJ/kg of air. Calculate:
i) Pressure and temperature at the end of each process of the cycle.
ii) Thermal efficiency. **(08 Marks)**

OR

2 a. With a neat sketch, explain the working of Ram jet. **(06 Marks)**

b. In a constant pressure open cycle gas turbine air enters at 1 bar and 20°C, leaves the compressor at 5 bar. Using the following data, temperature of gases entering the turbine = 680°C, pressure loss in the combustion chamber = 0.1 bar, compressor and turbine efficiency = 0.85 and 0.80, $\gamma = 1.4$, $C_p = 1.024$ kJ/kgK for air and gas, combustion chamber efficiency = 85%, find:
i) The quantity of air circulation if the plant develops 1065 kW.
ii) Heat supplied /kg of air circulation.
iii) The thermal efficiency of the cycle. Mass of the fuel may be neglected. **(10 Marks)**

Module-2

3 a. With a schematic diagram, explain the working of regenerative Rankine cycle. Show the process on T-S and H-S diagram. **(08 Marks)**

b. In a steam power plant operating on ideal Rankine cycle steam enters the turbine at 20 bar with an enthalpy of 3248 kJ/kg and an entropy of 7.127 kJ/kgK. The condenser pressure is 0.1 bar. Find the cycle efficiency and specific steam consumption in kg/kWh. Do not neglect pump work. **(08 Marks)**

OR

4 a. What are the advantages and disadvantages of binary vapour power cycle? **(06 Marks)**

b. In a reheat cycle, the initial steam pressure and the maximum temperature are 150 bar and 550°C. If the condenser pressure is 0.1 bar and the moisture at the condenser inlet is 5% and assuming ideal processes, determine: (i) Reheat pressure, (ii) Cycle efficiency, (iii) Steam rate, steal is reheated to 550°c. **(10 Marks)**

Module-3

5 a. Define the following:
i) Stochiometric air
ii) Enthalpy of formation
iii) Combustion efficiency. **(06 Marks)**

b. During a test on a diesel engine the following observations were made. The power developed by the engine is used for driving a DC generator. The output of the generator was, 210 A at 200 V, the efficiency of generator being 82%. The quantity of fuel supplied to the engine was 11.2 kg/h. Calorific value of fuel being 42600 kJ/kg. The air fuel ratio was 18:1. The exhaust gases were passed through an exhaust gas calorimeter for which the observations were as follows, water circulated through exhaust gas calorimeter = 580 lit/h, temperature rise of water through calorimeter = 36°C. Temperature of exhaust gases at exit from calorimeter = 98°C. Ambient temperature = 20°C. Heat lost to jacket cooling water = 32% total heat supplied. Specific heat of exhaust gases = 1.05 kJ/kgK. Calculate BP of the engine, η_{bt} and draw up heat balance sheet on minute basis. **(10 Marks)**

OR

6 a. With a P-θ diagram, explain the stages of combustion in CI engine. **(08 Marks)**

b. Benzene C_6H_6 is burnt in air and the analysis of the products of combustion yielded the following results:

$CO_2 = 10.96\%$, $CO = 0.5\%$, $O_2 = 7.5\%$, $N_2 = 81.04\%$.

Determine: i) Actual air-fuel ratio on mole basis ; ii) Actual air-fuel ratio on mass basis; iii) Percentage excess air. **(08 Marks)**

Module-4

7 a. With a schematic diagram, explain the working of vapour absorption refrigeration system. Show the processes on T-S diagram. **(08 Marks)**

b. An air conditioning plant is required to supply 60 m^3 of air/minute at a DBT of 21°C and 55% RH. The outside air is at DBT of 28°C and 60% RH. Determine the mass of water drained and capacity of the cooling coil. Assume the air conditioning plant first to dehumidify and then to cool the air. **(08 Marks)**

OR

8 a. With a neat sketch explain the working of winter air conditioning system. Show the processes on psychrometric chart. **(08 Marks)**

b. An air refrigeration system working on Bell-Coleman cycle with 15 TOR capacity has its pressure range 1 bar to 10 bar. Air enters the compressor at –5°C and enters the expander at 25°C. Assuming isentropic expansion and compression, find COP, air flow rate and power required. **(08 Marks)**

Module-5

9 a. Show that for perfect intercooling, stage pressure ratio remains the same in multistage air compressor and hence prove that $Z = \left(\frac{p_{x+1}}{p_1}\right)^{1/x}$ where z = stage pressure ratio, p_1 = initial pressure, x = number of stages. **(09 Marks)**

b. Steam expands from 17 bar and 284°C to 0.7 bar in a convergent-divergent nozzle. Assuming that the expansion is frictionless and the steam discharged is 0.25 kg/s, calculate the diameter of the nozzle, (i) at a point where the pressure is 9.5 bar, (ii) at exit, using H-S chart. **(07 Marks)**

OR

10 a. Briefly explain the different types of flows in a steam nozzle. **(09 Marks)**

b. Determine the size of the cylinder of a double acting air compressor of 45kW in which air is taken at 1 atmosphere and compressed to 16 atmospheric pressure according to the law $PV^{1.25} = C$. Assume speed of the crank as 300 rpm, piston speed = 180 m/min. **(07 Marks)**

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CBCS Scheme

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15ME43

Fourth Semester B.E. Degree Examination, Dec.2017/Jan.2018
Applied Thermodynamics

Time: 3 hrs. Max. Marks: 80

Note: 1. *Answer FIVE full questions, choosing one full question from each module.*
2. *Use thermodynamic data hand book and steam tables is permitted.*

Module-1

1 a. Compare the otto, diesel and dual cycles on P-V diagram and T-S diagrams, when heat is supplied to each cycle is same. **(08 Marks)**

b. Derive air standard efficiency expression for dual combustion cycle. **(08 Marks)**

OR

2 a. With a schematic diagram, explain a closed cycle gas turbine. **(04 Marks)**

b. With the help of neat diagram, explain a Rocket engine. **(04 Marks)**

c. The air enters the compressor of an open cycle constant pressure gas turbine at a pressure of 1 bar and temperature 20°C. The pressure of the air after the compression is 4 bar. The isentropic efficiencies of the compressor and turbine are 80% and 85% respectively. The air fuel ratio is 90 : 1. If flow rate of air is 3 kg/sec. Find (i) Power developed (ii) Thermal efficiency of the cycle.

Assume C_P = 1.0 kJ/kgK and γ = 1.4 for air and gases. Take calorific value of the fuel as 41800 KJ/kg. **(08 Marks)**

Module-2

3 a. List out the factors affecting the efficiency of the Rankine cycle. **(04 Marks)**

b. Compare the Rankine and the Carnot cycles of steam power plants. **(04 Marks)**

c. In a steam power cycle, the steam supply is at 15 bar and dry saturated. The condenser pressure is 0.4 bar. Calculate Carnot and Rankine efficiency of the cycle neglect the pump work. **(08 Marks)**

OR

4 a. What do you mean by Regenerative cycle? With help of neat diagram, explain the working of a regenerative Rankine cycle and derive the efficiency of the cycle. **(08 Marks)**

b. Consider a regenerative vapour power cycle with open feed water heater. Steam enters the turbine at 9 MPa and 350°C and expands to 0.9 MPa where some of the steam is extracted and passed to the open feed water heater operating at 0.9 MPa. The remaining steam expands through the remaining part of the turbine to the condenser pressure of 0.01 MPa. Saturated liquid exits the open feed water heater at 0.9 MPa. If the net power output of the cycle is 120 MW. Determine

(i) Thermal efficiency (ii) Mass flow rate of steam entering the turbine. **(08 Marks)**

Module-3

5 a. Explain the following terms with reference to a combustion process:

(i) Enthalpy of formation (ii) Adiabatic flame temperature

(iii) Enthalpy of combustion (iv) Heat of reaction **(08 Marks)**

b. Methane is burned with atmospheric air. The analysis of the products on a dry basis is as follows:

CO_2 = 10%, O_2 = 2.37%, CO = 0.53%, N_2 = 87.10%

(i) Determine the combustion equation.

(ii) Calculate the air fuel ratio on mass basis.

(iii) Percent theoretical air. **(08 Marks)**

OR

6 a. Explain the combustion phenomenon in C.I. engine. (08 Marks)

b. A single cylinder 4 stroke diesel engine gave the following results while running on full load. Area of indicator card = 300 mm^2, Spring constant = 1 bar/mm, Length of the diagram = 40 mm, Speed of the engine = 450 rpm, Load on the brake = 370 N, Spring balance reading = 50 N, Diameter of the brake drum = 1.2 m, Diameter of the cylinder = 160 mm, Stroke of the piston = 200 m, C.V of the fuel = 41800 KJ/kg.
Calculate (i) IMEP
(ii) BP and brake mean effective pressure
(iii) BSFC (Brake Specific Fuel Consumption)
(iv) Brake thermal and indicated thermal efficiency. (08 Marks)

Module-4

7 a. With the help of a neat sketch, explain a simple vapour absorption cycle. (05 Marks)

b. Explain the various factors affecting the performance of a vapour compression system. (04 Marks)

c. A vapour compression refrigerator uses methyl chloride (R-40) and operates between temperature limits of −10°C and 45°C. At the entry to the compressor, the refrigerant is dry and after compression it acquires a temperature of 60°C. Find the C.O.P of the refrigerator. (07 Marks)

OR

8 a. Define the following terms:
(i) Dry bulb temperature (DBT).
(ii) Wet bulb temperature (WBT)
(iii) Specific humidity.
(iv) Relative humidity. (08 Marks)

b. Atmospheric air at 101.325 KPa has 30°C DBT and 15°C DPT. Without using the psychromatic chart, using the property values from the tables. Calculate
(i) Partial pressure of air and water vapour.
(ii) Specific humidity
(iii) Relative humidity.
(iv) Vapour density and enthalpy of moist air. (08 Marks)

Module-5

9 a. Obtain expression for volumetric efficiency of a single stage air compressor in terms of pressure ratio, clearance and 'n' the polytropic index. (06 Marks)

b. What are disadvantages of a single stage air compressor? (02 Marks)

c. A two stage air compressor with perfect intercooling takes in air at 1 bar 27°C. The law of compression in both the stages is $PV^{1.3}$ = constant. The compressed air is delivered at 9 bar. Calculate for unit mass flow rate of air the minimum workdone and the heat rejected to the intercooler. Compare the values if the compression is carried out in single stage compressor with after cooler. (08 Marks)

OR

10 a. Mention the types of nozzles. Explain any one. (04 Marks)

b. Derive an expression for steam velocity coming out from a nozzle. (04 Marks)

c. Dry saturated steam at a pressure of 11 bar enters a convergent-divergent nozzle and leaves at a pressure of 2 bar. If the flow is adiabatic and frictionless, determine
(i) The exit velocity of steam.
(ii) Ratio of cross section at exit and that at throat. (08 Marks)
Assume the index of adiabatic expansion is 1.135.

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15ME43

Fourth Semester B.E. Degree Examination, Dec.2018/Jan.2019
Applied Thermodynamics

Time: 3 hrs. Max. Marks: 80

Note: 1. ***Answer FIVE full questions, choosing one full question from each module.***
2. Use of steam table/Mollier chart/Psychrometric chart is permitted.

Module-1

1 a. Derive an expression of Air-standard efficiency of otto cycle with neat sketch of P-V and T-S diagrams. **(06 Marks)**

b. With a neat sketch, explain the working of Ram jet. **(05 Marks)**

c. Calculate the percentage loss in the ideal efficiency of a diesel engine with compression ratio 14 if the fuel cut-off is delayed from 5% to 8%. **(05 Marks)**

OR

2 a. With a neat block diagram and T-S diagram, explain how 'regeneration' increases thermal efficiency of gas turbine plant. **(06 Marks)**

b. Define Air-standard efficiency. **(02 Marks)**

c. A Gas turbine unit has a pressure ratio 6 : 1 and maximum cycle temperature of 610°C. The isentropic efficiencies of the compressor and turbine are 0.80 and 0.82 respectively. Calculate the power output when the air enters the compressor at 15°C at the rate of 16 kg/s. Take $C_p = 1.005$ KJ/kgK and $\gamma = 1.4$ for compression and $C_p = 1.11$ kJ/kgK and $\gamma = 1.333$ for expansion processes. **(08 Marks)**

Module-2

3 a. With the help of corresponding flow and T-S diagrams explain briefly the working of a practicle regenerative Rankine cycle with one open feed water heater. Derive also an expression for its thermal efficiency. **(08 Marks)**

b. A simple Rankine cycle works between the boiler pressure of 3 MPa and condenser pressure of 4 KPa. The steam is dry saturated before the throttling in the turbine. Determine (i) Rankine cycle efficiency (ii) Work ratio (iii) Specific steam consumption. **(08 Marks)**

OR

4 a. Discuss the effect of, (i) Boiler pressure (ii) Condenser pressure (iii) Super heat on the performance of a Rankine cycle. **(08 Marks)**

b. A steam power plant operates on a theoretical reheat cycle. Steam at boiler at 150 bar, 550°C expands through the high pressure turbine. It is reheated at a constant pressure of 40 bar to 550°C and expands through the low pressure turbine to a condenser at 0.1 bar. Draw h-s diagram. Find (i) Quality of steam at turbine exhaust (ii) Cycle efficiency (iii) Steam rate in $\frac{kg}{hr.KW}$ **(08 Marks)**

Module-3

5 a. Explain the following: (i) Stoichiometric air (ii) Enthalpy of formation. **(04 Marks)**

b. Explain the method of finding friction power using Morse test. **(04 Marks)**

c. A Solid fuel contains by weight, carbon 71%, hydrogen 4%, oxygen 9%, Sulphur 3%, Nitrogen 1% and the remainder is ash. Determine the minimum quantity of air required for complete combustion of 1 kg of fuel. If the actual air supplied is 1.3 times the minimum required for complete combustion, estimate the percentage gravimetric composition of dry gases. **(08 Marks)**

OR

6 a. Classify the IC engines. **(04 Marks)**

b. Define : (i) BSFC (ii) Indicated thermal efficiency. **(04 Marks)**

c. In a trial of a single cylinder oil engine working on dual cycle, the following observations were made:

Oil consumption = 10.2 kg/h ; Calorific value of fuel = 43890 kJ/kg

Air consumption = 3.8 kg/min; Speed = 1900 rpm

Torque on the brake drum = 186 N-m; Quantity of cooling water used = 15.5 kg/min

Temperature rise = 36°C; Exhaust gas temperature = 410°C

Room temperature = 20°C; 'C_p' of exhaust gases = 1.17 kJ/kgK

Calculate Brake thermal efficiency and draw heat balance sheet on minute basis. **(08 Marks)**

Module-4

7 a. With a neat sketch, explain the working of Bell – Coleman air refrigeration cycle. **(06 Marks)**

b. Show the following processes on psychometric chart: (i) Sensible heating and cooling (ii) Cooling and dehumidification **(04 Marks)**

c. In a simple vapour compression cycle, following are the properties of the refrigerant R-12 at various points:

Compressor inlet : $h_2 = 183.2$ KJ/kg; $V_2 = 0.0767$ m^3/kg

Compressor discharge : $h_3 = 222.6$ KJ/kg; $V_3 = 0.0164$ m^3/kg

Compressor exit : $h_4 = 84.9$ KJ/kg; $V_4 = 0.00083$ m^3/kg

The piston displacement volume for compressor is 1.5 litres per stroke and its volumetric efficiency is 80%. The speed of the compressor is 1600 rpm. Find (i) Power rating of the compressor (KW) (ii) Refrigerating effect (KW) **(06 Marks)**

OR

8 a. Define (i) Dry bulb temperature (ii) Wet bulb temperature (iii) Dew point temperature (iv) Relative humidity. **(04 Marks)**

b. State the properties of good refrigerant. **(04 Marks)**

c. An air conditioning system is designed under the following conditions:

Outdoor conditions = 30°C DBT and 75% RH

Required indoor conditions = 22°C DBT and 70% RH

Amount of free air circulated = 3 m^3/sec

Coil dew point temperature = 14°C

The required condition is achieved first by cooling and dehumidification and then by heating. Calculate (i) the capacity of the cooling coil in tones.

(ii) the capacity of the heating coil in KW.

(iii) the amount of water vapour removed in kg/s. **(08 Marks)**

Module-5

9 a. What are the advantages of multistage compression? **(04 Marks)**

b. What do you mean by a supersaturated flow? Explain with the help of h-s diagram. **(06 Marks)**

c. A single stage double-acting air compressor is required to deliver 14 m^3 of air per minute at 1.013 bar and 15°C. The delivery pressure is 7 bar and the speed 300 rpm. Take the clearance volume as 5% of the swept volume with the compression and expansion index n = 1.3, calculate (i) Swept volume of cylinder (ii) Indicated power. **(06 Marks)**

OR

10 a. Derive an expression for the condition for minimum work input required for two stage compressor with perfect intercooling. **(08 Marks)**

b. A multistage compressor is to be designed to elevate the pressure from 1 bar to 120 bar, such that the stage pressure ratio will not exceed 4. Determine (i) Number of stages (ii) Minimum power required (iii) Intermediate pressures (iv) Exact pressure ratio. It is required to compress 15 m^3/min of free air. Take n = 1.2 **(08 Marks)**

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17ME43

Fourth Semester B.E. Degree Examination, June/July 2019
Applied Thermodynamics

Time: 3 hrs. Max. Marks: 100

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. Use of Thermodynamic data hand book is permitted.

Module-1

1 a. Draw neat P-V and T-S diagram of air standard dual cycle and derive an expression for air standard efficiency in terms of compression ratio, explosion ratio and cut-off ratio. Under what conditions the dual cycle becomes Otto and Diesel cycle. **(10 Marks)**

b. An air standard diesel cycle has a compression ratio 16. The temperature before compression is 27°C and the temperature after expansion is 627°C. Compute:
i) Cut-off ratio
ii) The net work output per unit mass of air
iii) Thermal efficiency
iv) Mean effective pressure in bar. **(10 Marks)**

OR

2 a. Explain with schematic diagram and T-S diagram Brayton cycle with i) Regenerator and ii) Inter-cooler and write equation for the thermal efficiency. **(10 Marks)**

b. Derive an expression for optimum pressure ratio and maximum pressure ratio for maximum work output in terms of minimum temperature, maximum temperature of Brayton cycle and what is the relation between the two. **(10 Marks)**

Module-2

3 a. With the help of schematic diagram, T-S diagram and h-s diagram, explain regenerative vapour power cycle with one open feed water heater and derive an expression for its thermal efficiency. **(10 Marks)**

b. A simple Rankine cycle works between the boiler pressure of 30bar and condenser pressure of 0.04Bar. The supply steam to the turbine is drysaturated, determine Rankine cycle efficiency. If the supply steam to the turbine is superheated by 66°C, what is the effect on the Rankine efficiency? **(10 Marks)**

OR

4 a. With the help of schematic diagram and T-S diagram explain binary vapour power cycle. List the properties of an ideal binary fluid. **(10 Marks)**

b. A reheat cycle operating between 30 bar and 0.04 bar pressure. The temperature of steam supplied from boiler is 450°C. The first stage of expansion takes place till the steam is dry saturated and then reheated to 450°C and then expanded in second in stage.
Determine:
i) Reheat pressure
ii) Quality of exhaust steam
iii) Ideal cycle efficiency
iv) Steam Rate
v) Back-pressure ratio. **(10 Marks)**

Module-3

5 a. List the methods used for finding out indicated power of an internal combustion engine. Explain the method applicable to multi-cylinder engine. **(08 Marks)**

b. The products of combustion of an unknown hydrocarbon C_xH_y have the following composition as measured by an Orsat's apparatus:
$CO_2 = 8\%$, $CO = 0.9\%$, $O_2 = 8.8\%$, $N_2 = 82.3\%$. Determine:
i) The composition of fuel
ii) A:F ratio
iii) The percentage excess air used. **(12 Marks)**

OR

6 a. Explain the following terms with reference to a combustion process:
i) Enthalpy of formation
ii) Adiabatic flame temperature
iii) Combustion efficiency
iv) Stoichiometric air. **(08 Marks)**

b. A gas engine working on constant volume cycle gave the following results during a one hour test run:
Cylinder diameter : 24cm, stroke 48cm, effective diameter of brake drum 1.25m, net load on the brake 1236N, Average speed 226.7 RPM, Average explosions per minute 77, MEP 7.5 bar, gas used 13m^3 at 15°C and 771 mm of mercury pressure, calorific value of gas 22000 kJ/m^3 at NTP. Cooling water used 625kg, rise in temperature of cooling water 35°C. Determine, mechanical efficiency, brake thermal efficiency indicated thermal efficiency, also draw up a heat balance sheet for the engine on percentage basis. Take NTP conditions as 760mm of mercury and 0°C. **(12 Marks)**

Module-4

7 a. With the help of schematic diagram and appropriate psychrometric diagram explain summer air conditioning system for hot and dry outdoor condition. **(10 Marks)**

b. A vapor compression plant uses R-12 and is to develop 5 tonnes of refrigeration. The condenser and evaporator temperature are to be 40°C and -10°C respectively. The vapor is dry saturated at compressor inlet and there is no under cooling. Determine:
i) Refrigerant flow rate in kg/sec
ii) The compressor discharge temperature
iii) The pressure ratio
iv) COP of the plant. **(10 Marks)**

OR

8 a. Explain the following with the help of P-h and T-S diagram the effect of under cooling the liquid refrigerant and super heating the vapor refrigerant on the performance of VCR cycle. **(10 Marks)**

b. It is required to design an air conditioning plant for a office room with the following conditions:
Outdoor conditions – 14°C DBT and 10°C WBT
Required conditions – 20°C DBT and 60% RH
Amount of air circulation – 0.30m^3/min/person
Seating capacity of office – 60 persons.
The required condition is achieved by heating and then by adiabatic humidification. Determine: i) Heating capacity of the coil in KW and surface temperature required if the bypass factor of the coil is 0.4 ii) The capacity of the humidifier. Also draw the flow diagram. **(10 Marks)**

Module-5

9 a. Obtain an expression for the volumetric efficiency of a single stage air compressor in terms of pressure ratio, clearance and 'h' the exponent of expansion and compression. Why intercooling is necessary in multistage compression? **(10 Marks)**

b. A singe stage single acting air compressor has cylinder bore of 15cm and Piston stroke of 25cm. The crank speed is 600rpm. The air taken from the atmosphere is at 1 bar and 27°C and delivered at 11 bar. Assuming both expansion and compression processes are according to the law $PV^{1.25}$ = constant and clearance is 5%. Determine: i) Power required to drive the compressor, assuming mechanical efficiency as 80%; ii) What will be change in power required to drive the compressor if clearance is 10% with other conditions remaining same. **(10 Marks)**

OR

10 a. What is critical pressure ratio? Derive an expression for pressure ratio which gives maximum discharge through the nozzle. **(10 Marks)**

b. The steam expands from 3 bar to 1 bar in a nozzle. The initial velocity is 90m/s and initial temperature is 150°C. Determine the exit velocity of steam:

i) If expansion is isentropic in nozzle

ii) The nozzle efficiency is 95%. **(10 Marks)**

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