VTU B.E/B.TECH QUESTION PAPER SET

CBCS
SEMESTER IV

APPLIED THERMODYNAMICS

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CBCS Scheme

USN | | | | | | | | | | |

15ME43

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, June/July 2018
Applied Thermodynamics

Time: 3 hrs. Max. Marks: 80

Note: **1.** ***Answer any FIVE full questions, choosing one full question from each module.***
2. ***Use of thermodynamics data handbook is permitted.***

Module-1

1 a. Derive an expression for mean effective pressure in an air standard Otto cycle. **(08 Marks)**

b. Compression ratio of an air standard dual cycle is 8. Air is at 100 kPa, 300 K at the beginning of the compression process. The temperature of air at the end of constant pressure heat addition process is 1300 K. The net heat transfer to the cycle is 480 kJ/kg. Determine:
i) Heat added during constant volume per kg of air
ii) Air standard cycle efficiency and
iii) m.e.p. **(08 Marks)**

OR

2 a. For a simple gas turbine cycle, the optimum pressure ratio for maximum work output of cycle is given by

$$r_p = \left\{ \eta_C \eta_T \frac{T_3}{T_1} \right\}^{\frac{\gamma}{2(\gamma-1)}}$$

where η_C and η_T are the isentropic efficiency of compressor and turbine respectively, T_3 and T_1 = maximum and minimum temperature of the cycle respectively, $\gamma = C_p/C_v$ **(08 Marks)**

b. Determine the network output and thermal efficiency of an ideal gas turbine cycle having two stages of compression with perfect intercooling, two stages of expansion with perfect reheating between the stages and an ideal regenerator. The overall pressure ratio of the cycle is 4 and the maximum temperature of the cycle is 900°C. Assume that the atmospheric temperature is 15°C and the cycle is designed for maximum work output. Draw the schematic and T-S diagrams for the cycle. **(08 Marks)**

Module-2

3 a. Why is Carnot cycle not practicable for steam power plant? Explain briefly with the help of T-S diagram. **(06 Marks)**

b. Discuss the effect of (i) Boiler pressure and (ii) Superheat on the performance of a Rankine cycle. **(06 Marks)**

c. A steam power plant operates on a theoretical reheat cycle. Steam at boiler with 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 and find:
i) Quality of steam at turbine exit
ii) Cycle efficiency
iii) Steam rate in kg/KW.h **(04 Marks)**

OR

4 a. With the help of flow and h-s diagram, derive an expression for cycle efficiency and also fo mass of steam bled in a practical regenerative steam cycle with one open feed water heater. **(08 Marks)**

b. Steam at 30 bar, 350°C is supplied to a steam turbine in a practical regenerative cycle an the steam is bled at 4 bar. The bled steam comes out as dry saturated steam and heats th feed water in an direct contact type feed water heater to its saturated liquid state. The rest o the steam in the turbine expands to condenser pressure of 0.1 bar. Assuming the turbin efficiency to be same before and after bleeding; determine:
i) The turbine efficiency
ii) Steam quality at the condenser inlet
iii) Mass of steam bled per kg of boiler steam
iv) Cycle efficiency. **(08 Marks)**

Module-3

5 a. With neat sketch, explain the Orsat's apparatus used for exhaust gas analysis. **(06 Marks)**

b. The products of combustion of an unknown hydrocarbon C_xH_y have the followin composition as measured by an Orsat apparatus: CO_2 = 8.0%, CO = 0.9%, O_2 = 8.8% an rest is N_2. Determine:
i) Composition of the fuel
ii) The air-fuel ratio
iii) Percentage of excess air
iv) Dew point temperature of the products if the total pressure is 1.0 bar. **(10 Marks)**

OR

6 a. Explain the principle of conducting Morse test on IC engines for determining frictiona power. **(04 Marks)**

b. List the factors affecting the detonation. **(02 Marks)**

c. A 4-cylinder 2-stroke petrol engine has a bore of 57 mm and stroke of 90 mm. Its rate speed is 2800 rpm and is tested at this speed against a brake which has a torque arm o 0.356 m. The net brake load is 155 N and the fuel consumption is 6.74 lit/h. The specifi gravity of the petrol is 0.735 and it has a calorific value of 44200 kJ/kg. A Morse test i carried out and the cylinders are cut-out in order 1, 2, 3, 4 with corresponding brake load 111, 106.5, 104.2 and 111.3 N respectively. Calculate for this speed :
i) The engine torque
ii) Brake mean effective pressure
iii) Brake thermal efficiency
iv) BSFC
v) Mechanical efficiency
vi) Indicated thermal efficiency. **(10 Marks)**

Module-4

7 a. A vapour compression plant uses R-12 and is to develop 5 tonnes of refrigeration. Th condenser and evaporator temperatures are to be 40°C and −10°C respectively. Determine:
i) The refrigerant flow rate in kg/s
ii) Heat rejected in the condenser in KW
iii) COP
iv) Power required to drive the compressor **(06 Marks)**

b. An air refrigeration system working on Reversed Brayton Cycle with 15 tonnes capacity ha its pressure range 1 bar to 10 bar. Air enters the compressor at −5°C and enters the expande at 25°C. Assuming the isentropic efficiency of expander and compressor each has 85% find: i) COP ii) Air flow rate and iii) Power required. **(06 Marks)**

c. What are the desirable properties of good refrigerant? **(04 Marks)**

OR

8 a. With a neat sketch explain the working of air conditioning system for hot and dry summer condition. Show the processes on psychrometric chart. **(08 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 = 0.3 m^3/min/person
Seating capacity of office = 60
The required condition is achieved first by heating and then by adiabatic humidifying. Determine:
i) Heating capacity of the coil in KW and surface temperature required if the by-pass factor of the coil is 0.4.
ii) The capacity of the humidifier. **(08 Marks)**

Module-5

9 a. Derive the condition for minimum work required by a two stage air compressor with perfect intercooling between stages. Assume the compression follows the law $PV^n = C$ for stage-1 and for the stage-2 follows $PV^m = C$. Reduce this equation when n = m. **(08 Marks)**

b. A single stage, double acting air compressor, required to deliver 14 m^3 of air per minute measured at 1.013 bar and 15°C. The delivery pressure is 7 bar and speed is 300 rpm. Take the clearance volume as 5% of swept volume with the compression and expansion index, n = 1.3. Calculate:
i) the bore and stroke of the cylinder assuming L = 1.2 D
ii) Delivery temperature
iii) Indicated power required. **(08 Marks)**

OR

10 a. Prove that maximum flow rate of steam per unit area through a nozzle occurs when the ratio of pressure at throat to the inlet pressure is equal to $\left(\frac{2}{n+1}\right)^{\frac{n}{n-1}}$ where n = isentropic index of expansion. **(08 Marks)**

b. An adiabatic steam nozzle is to be designed for a discharge rate of 10 kg/s of steam from 10 bar and 400°C to a back pressure of 1 bar. The nozzle efficiency is 0.92 and the frictional loss is assumed to take place in the diverging portion of the nozzle only. Calculate: i) Velocity of steam at throat and exit of the nozzle, ii) Throat and exit area. Assume index of expansion = 1.3. **(08 Marks)**

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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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15ME43

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

Applied Thermodynamics

Time: 3 hrs. Max. Marks: 80

Note: 1. ***Answer any FIVE full questions, choosing ONE full question from each module.***
2. Use of Thermodynamic Data handbook / Steam tables / Mollier chart are permitted.

Module-1

1 a. What is an Air Standard efficiency? Derive an expression for Air Standard efficiency of a Diesel cycle. **(08 Marks)**

b. An engine of 250mm bore and 375mm stroke works on Otto cycle. The clearance volume is $0.00263 m^3$. The initial pressure and temperature are 1 bar and 50^0C. If the maximum pressure is limited to 25 bar, find the following i) The air standard efficiency of cycle ii) The mean effective pressure for the cycle. **(08 Marks)**

OR

2 a. Discuss briefly any two methods employed for improvement of thermal efficiency of open cycle gas turbine plant. **(06 Marks)**

b. State the working difference between Turbo Jet and Turbo – prop engines. **(04 Marks)**

c. A gas turbine has a pressure ratio of 6 and a maximum cycle temperature of 600^0C. The Isentropic efficiencies of compressor and turbine are 0.82 and 0.85 respectively. Calculate the power output in kilowatts of an electric generator geared to the turbine when the air enters the compressor at 15^0C at the rate of 15 kgs. Take $C_p = 1.005$ kJ/kg K and $\gamma = 1.4$ for compression process and $C_p = 1.11$ kJ.kg K and $\gamma = 1.333$ for the expansion process. **(06 Marks)**

Module-2

3 a. Describe the different processes of Rankine cycle. Derive also an expression for its efficiency. **(08 Marks)**

b. A simple Rankine cycle works between 28 bar and 0.06 bar, the initial condition of steam is being dry saturated. Calculate the cycle efficiency, work ratio and specific steam consumption. **(08 Marks)**

OR

4 a. Explain with the help of neat T – S diagram and block diagram a practical regenerative cycle and also derive and expression for its thermal efficiency with one open feed water heater. **(08 Marks)**

b. A turbine is supplied with steam at a pressure of 32 bar and a temperature of 410^0C. If the steam is reheated at 5.5 bar to a temperature of 395^0C and then expanded isentropically to a pressure of 0.08 bar, what will be the dryness fraction at the exit of turbine and thermal efficiency of the cycle? **(08 Marks)**

Module-3

5 a. Define the following : i) Stoichiometric air fuel Ratio ii) Excess air iii) Enthalpy of Reaction iv) Enthalpy of Formation. **(08 Marks)**

b. The following is the volumetric analysis of the dry exhaust from an I.C. Engine $CO_2 = 8.9\%$, $CO = 8.2\%$, $H_2 = 4.3\%$, $CH_4 = 0.5\%$, $N_2 = 78.1\%$. If the Fuel used is Octane C_8H_{18}. Determine the air Fuel Ratio on mass basis. **(08 Marks)**

OR

6 a. Explain the phenomenon of knocking in SI engine. What are the different factors which influence the knocking? **(08 Marks)**

b. During a 60 minute trail of a single cylinder four stroke engine the following observations were recorded. Bore = 0.3m , Stroke = 0.45m , Fuel consumption = 11.4kg , Calorific value = 42000 kJ/kg , IMEP = 6 bar , Net load on brake = 1500N , Speed = 300 rpm , Brake drum diameter = 1.8m , Rope diameter = 20mm , Quantity of Jacket cooling water = 600kg , Rise in temperature of Jacket cooling water = 55^0C, Quantity of air = 250 kg Exhaust gas temperature = 420^0C , Ambient temperature = 20^0C , C_p for gases = 1kJ/kg K. Find IP, BP, mechanical efficiency and draw heat balance sheet on minute basis. **(08 Marks)**

Module-4

7 a. Discuss the effect of following on the performance of a vapour compression system : i) Effect on suction pressure ii) Effect of super heating iii) Effect of subcooling. **(08 Marks)**

b. A refrigeration system of 10.5 tonnes capacity at an evaporator temperature of -12^0C and a condenser temperature of 27^0C is needed in a food storage locker. The Refrigerant Ammonia is sub cooled by 6^0C before entering the expansion valve. The vapour is 0.95 dry as it leaves the evaporator coil. Find C.O.P and power required in KW. **(08 Marks)**

OR

8 a. Define Specific humidity and derive an expression for the specific humidity. **(08 Marks)**

b. It is required to design an air conditioning plant for a small office for following conditions : Outdoor condition = 14^0C DBT and 10^0C WBT, Required conditions = 20^0C DBT and 60% RH ; Amount of air circulated = $0.3 m^3$/min/person , Seating capacity = 60. The required condition is achieved first by heating and then by adiabatic humidifying. Determine i) Heating capacity of coil in KW and its surface temperature if the by pass factor of coil is 0.4 ii) Capacity of the humidifier. **(08 Marks)**

Module-5

9 a. Define volumetric efficiency of an air compressor and derive an expression for volumetric efficiency. **(08 Marks)**

b. An air compressor takes in air at 1 bar and 20^0C and compresses it according to law $PV^{1.2}$ = constant. It is then delivered to a receiver at a constant pressure of 10 bar. Determine i) Temperature at the end of compression ii) Work done iii) Heat transferred during the compression per kg of air. **(08 Marks)**

OR

10 a. What is the effect of friction on the flow through a steam nozzle? Explain with the help of h – s diagram. **(08 Marks)**

b. Steam is expanded in a set of nozzles from 10 bar 200^0C to 5 bar. Neglecting the initial velocity, find the minimum area of the nozzle required to allow a flow of 3kg/s under the given conditions. Assume that expansion of steam to be isentropic. **(08 Marks)**

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CBCS SCHEME

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15ME43

Fourth Semester B.E. Degree Examination, Dec.2019/Jan.2020
Applied Thermodynamics

Time: 3 hrs. Max. Marks: 80

Note:* 1. *Answer any FIVE full questions, choosing ONE full question from each module.
2. Use of Thermodynamics data handbook is permitted.

Module-1

1 a. With suitable assumptions, P-V and T-S diagrams, derive an expression for the air standard efficiency of a diesel cycle in terms of compression ratio and cut off ratio. **(10 Marks)**

b. A certain quantity of air at a pressure of 1 bar and temperature of 70°C is compressed isentropically until the pressure is 7 bar in an Otto cycle engine. 465 kJ of heat per kg of air is now added at constant volume. Determine: (i) Compression ratio of the engine (ii) Temperature at the end of compression (iii) Temperature at the end of heat addition. **(06 Marks)**

OR

2 a. Derive an expression for optimum pressure ratio for maximum specific work output for an ideal gas turbine cycle. **(06 Marks)**

b. A gas turbine unit has a pressure ratio of 6:1. The maximum cycle temperature is 610°C. The isentropic efficiencies of compressor and turbine are 0.8 and 0.82 respectively. Calculate the power output in KW of an electric generator geared to the turbine when the air enters the compressor at 15°C at the rate of 16 kg/s. Take C_p = 1.005 kJ/kgK and γ = 1.4 for compression, combustion and expansion processes. **(10 Marks)**

Module-2

3 a. With a neat schematic diagram, P-V and T-S diagrams, explain the working of Rankine cycle. Derive the thermal efficiency expression for the same. **(08 Marks)**

b. A 40 MW steam power plant working on Rankine cycle operates between boiler pressure of 40 bar and condenser pressure of 0.1 bar. The steam leaves the boiler and enters the steam turbine at 400°C. The isentropic efficiency of the turbine is 85%. Determine: (i) The cycle efficiency (ii) The quality of exhaust steam from the turbine (iii) Steam flow rate in kg/hr considering pump work. **(08 Marks)**

OR

4 a. With a schematic diagram and T-S diagram, explain the working of regenerative vapour cycle with open feed water heaters. Derive the thermal efficiency expression for the same. **(08 Marks)**

b. A steam power plant operates on a reheat cycle. Steam in boiler at 150 bar, 550°C expands through high pressure turbine. It is reheated at a constant pressure of 40 bar to 550°C and expands through low pressure turbine to a condenser at 0.1 bar. Find: (i) Quality of steam at turbine exhaust (ii) Cycle efficiency (iii) Steam rate in kg/KWhr **(08 Marks)**

Module-3

5 a. Define the following:
i) Stoichiometric air ii) Excess air iii) Enthalpy of formation
iv) Internal energy of combustion v) Combustion efficiency **(10 Marks)**

b. Find the stoichiometric air fuel ratio for the combustion of Propane (C_3H_8) on molar and mass basis. **(06 Marks)**

OR

6 a. Explain how the frictional power of a multi cylinder engine is determined using Morse Test. **(06 Marks)**

b. During a test on a single cylinder 4-stroke cycle oil engine, the following observations were made: Bore = 30 cm, Stroke = 45 cm, duration of trial = 1 hour, total fuel consumption = 7.6 kg/hr, Speed = 200 rpm, Calorific value of fuel = 45000 kJ/kg, MFP = 6 bar, Net brake load = 1470 N, Brake drum diameter = 1.8 m, Rope diameter = 3 cm, Mass of cooling water circulated = 550 kg/hr, water enters at 15°C and leaves at 60°C, exhaust gas temperature = 300°C, ambient temperature = 20°C. Calculate: (i) Indicated power and brake power (ii) Mechanical efficiency. Draw the heat balance sheet on minute basis. Take mass of air = 360 kg/hr, C_{pg} = 1.1 kJ/kgK. **(10 Marks)**

Module-4

7 a. With a neat sketch, explain the working of a vapour absorption refrigeration system. **(06 Marks)**

b. An air refrigeration plant is to be designed according to the following specifications: Pressure of air at compressor inlet = 101 kPa, pressure of air at compressor outlet = 404 kPa, pressure loss in the inter cooler = 12 kPa, pressure loss in the cold chamber = 3 kPa, temperature of air at compressor inlet = 6°C, temperature of air at turbine inlet = 27°C, compressor and turbine efficiency = 0.85. Determine: (i) COP (ii) Power required to produce one TR (iii) Air circulation rate/TR. **(10 Marks)**

OR

8 a. Define the following terms:
(i) Specific humidity (ii) Relative humidity
(iii) Degree of saturation (iv) Dry bulb temperature. **(08 Marks)**

b. Following data refers to an air conditioning system to be designed for an industrial process for hot and wet climate:
Outside conditions = 30°C DBT, 75% RH
Required inside conditions = 20°C DBT, 60% RH
Amount of free air circulated = $20m^3$/min
The required condition is to be achieved first by cooling and dehumidifying and then by heating. Find: (i) Capacity of the cooling coil in TR (ii) Capacity of the heating coil in KW (iii) Amount of water vapour removed per hour. **(08 Marks)**

Module-5

9 a. Derive an expression for the volumetric efficiency of a reciprocating air compressor. **(08 Marks)**

b. A single stage single acting compressor delivers 0.6 kg/min of air at 6 bar. The temperature and pressure at the end of suction stroke of the compressor are 100 mm and 150 mm respectively. The clearance is 3% of the swept volume. Assuming the index of compression and expansion to be 1.3, find: (i) Volumetric efficiency of the compressor (ii) power required if the efficiency of the motor is 0.85 (iii) speed of the compressor. **(08 Marks)**

OR

10 a. Explain the following types of flows in a nozzle: (i) Frictionless adiabatic flow (ii) Frictional adiabatic flow (iii) Super saturated flow **(06 Marks)**

b. The inlet condition to a steam nozzle is 10 bar and 250°C. The exit pressure is 2 bar. Assuming isentropic expansion and negligible inlet velocity, determine: (i) throat area (ii) exit velocity (iii) exit area of the nozzle. Assume the index of expansion for super heated steam at inlet = 1.3 and mass flow rate of steam = 0.2 kg/s. **(10 Marks)**

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CBCS SCHEME

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15ME43

Fourth Semester B.E. Degree Examination, Aug./Sept. 2020
Applied Thermodynamics

Time: 3 hrs. Max. Marks: 80

Note: 1. ***Answer any FIVE full questions, choosing ONE full question from each module.***
2. ***Use of thermodynamic data book and steam table is permitted.***

Module-1

1 a. Define :
(i) Compression ratio.
(ii) Mean effective pressure.
(iii) Expansion ratio.
(iv) Cut-off ratio. **(08 Marks)**

b. Derive an equation of Air-standard efficiency of diesel cycle with PV and TS diagrams. **(08 Marks)**

OR

2 a. With a neat sketch, explain the working operation of rocket engine. **(06 Marks)**

b. A simple gas turbine plant operating on the brayton cycle has air entering the compressor at 100 KPa and 27°C. The pressure ratio is 9.0 and maximum cycle temperature is 727°C. What will be the percentage change in efficiency and net work output if the expansion in the turbine is divided into two stages each of pressure ratio 3.0 with intermediate reheating to 727°C. Assume compression and expansion are ideal isentropic. **(10 Marks)**

Module-2

3 a. List out the comparison of Rankine cycle and Carnot cycle. **(06 Marks)**

b. What is reheating? With a schematic diagram and PV and TS diagrams, explain the working of reheat cycle and derive an equation of efficiency of the same. **(10 Marks)**

OR

4 a. In a single heater regenerative cycle the steam enters the turbine at 30 bar, 400°C and the exhaust pressure is 0.10 bar. The feedwater heater is a direct contact type which operates at 5 bar. Find (i) The efficiency (ii) steam rate of the cycle. Neglect pump work done. **(12 Marks)**

b. Draw the schematic diagram of Rankine cycle with PV and TS diagrams. **(04 Marks)**

Module-3

5 a. Calculate the theoretical Air-Fuel Ratio [AFR] for the combustion of C_8H_{18} . **(08 Marks)**

b. Define the following:
(i) Combustion efficiency.
(ii) Enthalpy of formation.
(iii) Adiabatic flame temperature.
(iv) Excess air. **(08 Marks)**

OR

6 a. In a test on a three cylinder four stroke I.C.engine with 22 cm bore and 26 cm stroke the following observation were made during a trial period one hour:
Fuel consumption = 8 kg ; Air consumed = 300 kg; Ambient temperature = 30°; Calorific value = 45,000 kJ/kg ; Net load on brake = 1.5 kN; Brake drum dia = 1.8 m;
Rope diameter = 3 cm; Mass of cooling water = 550 kg; Inlet and outlet temperature of water = 27°C and 55°C rescpectively. Exhaust gas temperature = 310°C; Cp = for exhaust gas = 1.1 $\frac{kJ}{kgK}$. Calculate IP, BP, η_m, η_{IT} and draw heat balance sheet in $\frac{kJ}{min}$ and %. **(12 Marks)**

b. What is detonation and explain the factors affecting detonation. **(04 Marks)**

Module-4

7 a. Sketch and explain the Vapor-Compression refrigeration system. With PV and T-S diagram. **(08 Marks)**

b. Compare vapour compression and vapour absorption refrigeration system. **(08 Marks)**

OR

8 a. Define the following:
(i) DBT.
(ii) Relative humidity.
(iii) Specific humidity.
(iv) Degree of saturation. **(08 Marks)**

b. Moisture air at 35°C has a dew point of 15°C. Calculate the relative humidity, specific humidity and enthalpy. **(08 Marks)**

Module-5

9 a. Derive an equation for minimum work by two stage compressor with perfect inter cooling. **(08 Marks)**

b. Air at 1 bar and 27°C is compressed to 7 bar by a single stage reci-procating air compressor according to the law $PV^{1.3} = C$. The free air delivered is 1 m^3/min. Speed of compressor 300 rpm. Stroke to bore ratio 1.5 : 1, Mechanical efficiency 85% and motor efficiency 90% determine,
(i) Indicated power and isothermal efficiency.
(ii) Cylinder dimensions.
(iii) Power of the motor. **(08 Marks)**

OR

10 a. Define critical pressure ratio for maximum discharge and obtain the expression of critical pressure ratio. **(08 Marks)**

b. Steam approaches.a nozzle with a velocity of 250 m/s, 3.5 bar absolute pressure and dryness fraction 0.95. If the back pressure is 2 bar, assuming flow to be isentropic, find the final condition and drop in enthalpy of steam. Also find the exit velocity and the area at exit of the nozzle if the flow rate is 2700 kg/hr. **(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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CBCS SCHEME

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17ME43

Fourth Semester B.E. Degree Examination, Dec.2019/Jan.2020
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 thermodynamics data hand book is permitted.***

Module-1

1 a. Show the compression ratio (r_c) for maximum work should be per kg of air in an Otto cycle between upper and lower limits of absolute temperature T_3 and T_3 is given $r_C = \left(\frac{T_3}{T_1}\right)^{\frac{1}{2(\gamma-1)}}$ and also show that $T_2, T_4 = (T_1\ T_3)^{1/2}$ **(10 Marks)**

b. Compression ratio of diesel cycle is 14 and cut off ratio is 2.2 at beginning of cycle, air is 0.98 bar and 100°C. Find: (i) The temperature and pressure at salient points (ii) Air standard efficiency. **(10 Marks)**

OR

2 a. With a neat sketch, explain the working of Ramjet. **(10 Marks)**

b. In an open cycle gas turbine plant, air enters the compressor at 1 bar and 27°C. The pressure after compression is 4 bar. The isentropic efficiencies of the turbine and the compressor are 85% and 80% respectively. Air fuel ratio is 80:1 calorific value of the fuel used is 42000 kJ/kg. Mass flow rate of air is 2.5 kg/sec. Determine the power output from the plant and the cycle efficiency. Assume the value of Cp = 1.005 kJ/kgK and $\gamma = 1.4$. **(10 Marks)**

Module-2

3 a. Discuss with the help of T-S diagram the effect of Boiler pressure, condenser pressure and super heat on the performance of a Rankine cycle. **(10 Marks)**

b. A 40 MW steam power plant working on Rankine cycle operator between boiler pressure of 40 bar and condenser pressure of 0.1 bar. Steam leaves the boiler and enters the turbine at 400°C. The isentropic efficiency of steam turbine is 84%. Determine:
i) Efficiency ii) Quality of exhaust iii) Steam flow rate in kg/hr. **(10 Marks)**

OR

4 a. A steam power plant operates on a theoretical reheat cycle. Steam at boiler outlet 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 T-S and h-s diagrams. Find:
(i) Quality of steam at turbine exhaust
(ii) Cycle efficiency
(iii) Steam rate in kg/KWh. **(10 Marks)**

b. With the help of neat diagram, explain the working of regenerative Rankine cycle and derive the efficiency of the cycle. **(10 Marks)**

Module-3

5 a. Explain the following terms with reference to a combustion process:
(i) Adaibatic flame temperature
(ii) Enthalpy of formation
(iii) Stoichiometric air
(iv) Enthalpy of combustion
(v) Combustion efficiency **(10 Marks)**

b. Methane (CH_4) 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
(iii) Percent theoretical air **(10 Marks)**

OR

6 a. Explain the following:
(i) Heat balance sheet
(ii) Morse test **(10 Marks)**

b. A single cylinder 4-stroke diesel engine give the following results while running on full load, area of indicator diagram = 300 mm^2, length of diagram = 40 mm. The spring constant = 1 bar/mm, speed of the engine = 400 rpm, load on the brake = 370 N, spring balance reading = 50 N, diameter of brake drum = 1.2 m, fuel consumption = 2.8 kg/hr, calorific value fuel = 41800 kJ/kg, diameter of cylinder = 160 mm, stroke = 200 mm. Calculate IP, BP, Brake mean effective pressure, brake specific fuel consumption, brake thermal efficiency, indicator thermal efficiency. **(10 Marks)**

Module-4

7 a. With a neat sketch, describe clearly the working of a Bell-Coleman cycle. **(06 Marks)**

b. Write a brief note on properties of refrigerants. **(04 Marks)**

c. For food-storage purpose, a refrigeration plant of 10.5 TR is required at an evaporation temperature of –12°C and condenser temperature of 27°C. The refrigerant is ammonia. It is sub-cooled by 6°C before entering the expansion valve. The vapour is 0.95 dry as it leaves the evaporator coil. The compression is adiabatic using p-h chart. Calculate:
(i) Condition of vapour at outlet of the compressor
(ii) Condition of vapour at entrance to evaporator
(iii) CoP
(iv) Power required in KW.
Neglect throttling and clearance effect. **(10 Marks)**

OR

8 a. Define the following:
(i) Dry bulb temperature (ii) Dew point temperature
(iii) Relative humidity (iv) Specific humidity
(v) Degree of saturation **(10 Marks)**

b. An air-conditioning plant is to be designed for a small office for winter conditions. Outdoor condition = 10°C DBT and 8°C WBT. Required indoor conditions = 20°C DBT and 60% RH. Amount of air circulation = 0.3 m^3/min/person seating capacity of the office = 50. The required condition is achieved first by heating and then by adiabatic humidifying. Find the followings:
(i) Heating capacity of the coil in KW and the surface temperature required if the bypass factor of the coil is 0.32
(ii) The capacity of the humidifier. **(10 Marks)**

Module-5

9 a. Define the following with respect to a compressor:
i) Isothermal efficiency ii) Adiabatic efficiency iii) Mechanical efficiency
iv) Overall efficiency v) Volumetric efficiency **(10 Marks)**

b. An air compressor takes in air at 1 bar and 20°C and compresses the same according to the law $PV^{1.2} = C$. It is the delivered to a receiver at a constant pressure of 10 bar.
Determine:
(i) Temperature at the end of compression
(ii) Work done and heat transferred during compression per kg of air R = 0.287 kJ/kgK. **(10 Marks)**

OR

10 a. Prove the maximum flow rate of steam per unit area through a nozzle occurs when the ratio of pressure at throat to the inlet pressure is equal to $P_2/P_1 = \left(\frac{2}{n+1}\right)^{\frac{n}{n-1}}$ where n is polytropic index of expansion. **(10 Marks)**

b. 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 frictionless. Determine: (i) Exit velocity of steam (ii) Ratio of cross-section area at exit and at throat. Assume the index of adiabatic expansion to be 1.135. **(10 Marks)**

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CBCS SCHEME

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17ME43

Fourth Semester B.E. Degree Examination, Aug./Sept. 2020
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. State any 2 assumptions for Air Standard Cycle and obtain air standard efficiency expression for diesel cycle. **(10 Marks)**

b. An air standard limited pressure cycle has a compression ratio of 15 and compression begins at 0.1 MPa, 40°C. The maximum pressure is limited to 6 MPa and the heat added is 1.675 MJ/kg. Compute (i) The heat supplied at constant volume per kg of air (ii) The heat supplied at constant pressure per kg of air (iii) The cycle efficiency (iv) The cut-off ratio (v) The M.E.P of the cycle. **(10 Marks)**

OR

2 a. With the help of line diagram and T-S diagram, explain intercooling and reheating in gas turbine cycles. **(10 Marks)**

b. A gas turbine working on Brayton cycle receives air at 1 bar and 27°C . The air is compresed adiabatically to 6.2 bar with efficiency of the compressor being 88%. The fuel has a heating value of 44180 kJ/kg and the fuel air ratio is 0.017 kg fuel/kg air. The efficiency of the turbine is 90%. Calculate (i) Compressor work (ii) Turbine work and (iii) Thermal efficiency. **(10 Marks)**

Module-2

3 a. Explain the types of feed water heater using flow and T-S diagram. **(10 Marks)**

b. A turbine is supplied with steam at a pressure of 32 bar and temperature of 410°C. The steam then expands isentropically to a pressure of 0.08 bar. Find the dryness fraction at the end of expansion and thermal efficiency of the cycle.
If the steam is reheated at 5.5 bar to a temperature of 400°C and then expanded isentropically to a pressure of 0.08 bar, what will be the dryness fraction and thermal efficiency of the cycle. **(10 Marks)**

OR

4 a. Discuss the effect of condenser pressure and Boiler pressure in Rankine cycle. **(08 Marks)**

b. Write any two desirable characteristics of the working fluid used in vapour power cycle. **(02 Marks)**

c. A 40 MW steam power plant working on Rankine cycle operates between boiler pressure of 4 MPa and condenser pressure of 10 KPa. The steam leaves the boiler and enters the steam turbine at 400°C. The isentropic efficiency of the steam turbine is 85%.
Determine (i) The cycle efficiency (ii) The quality of exhaust steam from the turbine and (iii) the steam flow rate in kg per hour. Consider pumpwork. **(10 Marks)**

Module-3

5 a. Define stoichimetric air, actual air, excess air and combustion efficiency. **(08 Marks)**

b. Calculate the air-fuel ratio for burning of propane (C_3H_8) with 130 percent theoretical air. **(08 Marks)**

c. Explain Detonation in SI engine. **(04 Marks)**

OR

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

b. In a test on a 3-cylinder, 4-stroke IC engine with 22 cm bore and 26 cm stroke, the following were the observations during a trail period of one hour.
Fuel consumption = 8 kg, Calorific value = 45000 kJ/kg
Total revolutions of the Crankshaft = 12000
Mean effective pressure = 6 bar
Net load on brake = 1.5 kN
Brake drum diameter = 1.8 m, Rope diameter = 3 cm
Mass of cooling water = 550 kg
Inlet temperature of water = 27°C
Exit temperature of water = 55°C
Air consumed = 300 kg, Ambient temperature = 30°C
Exhaust gas temperature = 310°C
Specific heat of gases = 1.1 kJ/kg K
Calculate (i) Indicated and brake power (ii) Mechanical efficiency
(iii) Indicated thermal efficiency
Also draw a heat balance sheet on minute and percent basis. **(12 Marks)**

Module-4

7 a. Explain any two factors affecting the performance of a simple vapour compression system. **(06 Marks)**

b. With a neat sketch, explain steam jet refrigeration. **(06 Marks)**

c. A simple vapour compression plant produces 5 tonnes of refrigeration. The enthalpies of the working fluid at inlet to the compressor, at exit of compressor and at exit from the condenser are 183.19 KJ/kg, 209.41 KJ/kg and 74.59 KJ/kg respectively. Estimate (i) The refrigerant flow rate (ii) COP of the plant (iii) Power required to drive the compressor and (iv) the rate of heat rejection in the condenser. Assume that vapour is dry saturated at the end of compression. **(08 Marks)**

OR

8 a. Explain the following: (i) Adiabatic mixing of air (ii) Heating and Humidification (iii) Cooling and dehumidification. **(12 Marks)**

b. The dry and the wet bulb temperature of atmosphere air at 1 atm (101.325 KPa) pressure are measured with a sling psychrometer and determined to be 25 and 15°C respectively. Determine (i) Specific humidity (ii) Relative humidity (iii) The enthalpy of air (iv) DPT. Use properties of table only. **(08 Marks)**

Module-5

9 a. Derive an expression for workdone with clearance volume. **(08 Marks)**

b. A single acting air compressor has a cylinder bore of 15 cm and a piston stroke of 25 cm. The crank speed is 600 rpm. Air taken from atmosphere (1 bar and 27°C) is delivered at 11 bar. Assuming that both the compression and expansion processes are according to the law $PV^{1.25}$ = constant and the clearance is 5%. Determine (i) Power required to drive the compressor, assuming mechanical efficiency as 80% (ii) The time required to deliver 1 m^3 of air as measured at compressor outlet conditions, (iii) Volumetric efficiency. **(12 Marks)**

OR

10 a. Explain the shapes of nozzle. **(06 Marks)**

b. In a 2-stage air compressor, the work output is found to be 350 KJ/kg of air. It is used to compress 1 kg of free air from 1 bar pressure and 32°C initial temperature. The value of n = 1.3 and R = 0.287 KJ/kgK. Find the intermediate pressure. **(06 Marks)**

c. Obtain an expression for volumetric efficiency of compressor. **(08 Marks)**

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