(vii) For the same compression ratio and heat addition:
(a) $\eta_{Otto} > \eta_{Diesel} > \eta_{Dual}$ (b) $\eta_{Diesel} > \eta_{Dual} > \eta_{Otto}$
(c) $\eta_{Diesel} > \eta_{Otto} > \eta_{Dual}$ (d) $\eta_{Otto} > \eta_{Dual} > \eta_{Diesel}$

(viii) For a Parson's reaction turbine , the degree of reaction is
(a) 75 % (b) 50% (c) 80 % (d) 90 %.

(ix) The ratio of exit pressure to inlet pressure for maximum mass flow rate of initially superheated steam per unit area through a nozzle is
(a) 0.955 (b) 0.58 (c) 0.5457 (d) 0.6.

(x) Steam turbines are governed by
(a) throttle control (b) nozzle control
(c) by-pass control (d) all of these.

Group - B

2. (a) Why is an ideal regenerative cycle not practicable?
The use of regenerative feedwater heating increases the capital cost but reduces the operating cost of a steam power plant-Explain.

(b) Steam at a pressure of $15\ bar$ and $250°C$ is expanded through a turbine at first to a pressure of $4\ bar$. It is then reheated at constant pressure to the initial temperature of $250°C$ and is finally expanded to $0.1\ bar$. Estimate the work done per kg of steam flowing through the turbine. Also calculate the amount of heat supplied during the process of reheat. Compare the work output when the expansion is direct from $15\ bar$ to $0.1\ bar$ without any reheat. Assume all processes to be isentropic.

(2+2) + (3+3+2) = 12

3. (a) In a boiler, the steam produced per hour at a pressure of $750\ kN/m^2$ is $5400\ kg$. The feedwater temperature is $41.5°C$. The dryness fraction of steam at exit is 0.98. The amount of coal burnt per hour is $670\ kg$. The calorific value of coal is $31000\ kJ/kg$. Determine the boiler efficiency and equivalent evaporation.

(b) What is boiler efficiency? Show that the overall plant efficiency is a product of five component efficiencies.
What is a supercritical steam cycle?

(3+2) + (2+3+2) = 12

Spring Constant =1 bar/mm
Speed of the engine =400 rpm
load on brake=370 N
Spring balance reading =50 N
Dia of the brake drum=1.2m
Fuel Consumption = 2.8kg/hr (Calorific value =41800 kJ/kg)
Diameter of the cylinder = 160 mm
Stroke =200 mm.
Rope diameter=20mm
Calculate:
(i) Indicated mean effective pressure (ii)Brake power & brake mean effective pressure (iii) Brake fuel consumption (iv) Brake thermal efficiency and (v) Indicated thermal efficiency

(b) Write short notes on (i) Octane Number and (ii) Cetane Number.

(8) + (2+2) = 12

B.TECH/EE/4TH SEM /ELEC 2203/2016
2016

THERMAL POWER ENGINEERING
(ELEC 2203)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternatives for the following: **10 × 1 = 10**

(i) The heat rate of a steam power plant cycle is equal to (η_R is the cycle efficiency):
(a) η_R (b) $1/\eta_R$ (c) $1/\eta_R^2$ (d) none of the above.

(ii) Compression ratio of diesel engines is of the order
(a) 5-7 (b) 7-10 (c) 14-20 (d) 10-12.

(iii) Which of the following ideal cycles has the same efficiency as an ideal Carnot cycle?
(a) Otto cycle (b) Diesel cycle
(c) Stirling cycle (d) Brayton cycle.

(iv) Maximum efficiency of a De- Laval turbine with nozzle angle α1, is given by
(a) $\sin^2 \alpha_1$ (b) $\cos^2 \alpha_1$
(c) $\tan^2 \alpha_1$ (d) $\cot^2 \alpha_1$.

(v) Natural circulation type of boiler works on the principle of
(a) differential density of hot and cold water
(b) differential density of hot and cold gases at chimney
(c) natural draught system with chimney
(d) none of these.

(vi) Octane number of iso-octane is
(a) 0 (b) 60 (c) 30 (d) 100.

Group - C

4. (a) A steam turbine discharges $5000\ kg$ of steam per hour at $40°C$ and 0.85 dryness fraction. The estimated air leakage is $15\ \frac{kg}{hr}$. The temperature at the suction of the air pump is $32°C$ and the condensate temperature is $35°C$. Find the: (i) vacuum gauge reading, (ii) capacity of air pump, (iii) loss of condensate in kg/hr, (iv) quantity of cooling water required if the rise in temperature of cooling water is limited to $10°C$.

(b) An unknown hydrocarbon fuel C_xH_y is allowed to react with air (79% N_2, 21% O_2). An analysis made of a representative sample of the product gases (dry basis) yields the following results: $CO_2 = 12.1\%,\ O_2 = 3.8\ \%,\ and\ CO = 0.9\ \%$. Determine: (a) the chemical equation of the actual reaction, (b) composition of the fuel, (c) air-fuel ratio during the test, (d) excess or deficiency of air used.

(1+2+2+1) + (3+1+1+1) = 12

5. (a) The following readings were taken during a test on a surface condenser:
Mean condenser temperature = $35°C$
hot well temperature = $30°C$
condenser vacuum = 69 cm Hg
barometer reading = 76 cm Hg
The mass rate of condensate collected = $16\ kg/min$.
The cooling water enters at $20°C$ and leaves at $32.5°C$, its mass flow rate being $37500\ kg/hr$. Calculate:
(a) mass of air present per cubic metre of condenser,
(b) quality of steam at condenser inlet,
(c) vacuum efficiency,
(d) condenser efficiency.

(b) What is a fabric filter? What is meant by the term 'air-to-cloth' ratio? What are the different types of fabric filters?

(2+2+1+1) + (2+2+2) = 12

Group - D

6. (a) Draw p-V and T-s diagram of a dual cycle and mark and describe all the processes in that cycle. Why this cycle is also called limited pressure cycle?

B.TECH/EE/4TH SEM /ELEC 2203/2016

Group - C

4. (a) A steam turbine discharges $5000\ kg$ of steam per hour at $40°C$ and 0.85 dryness fraction. The estimated air leakage is $15\ \frac{kg}{hr}$. The temperature at the suction of the air pump is $32°C$ and the condensate temperature is $35°C$. Find the: (i) vacuum gauge reading, (ii) capacity of air pump, (iii) loss of condensate in kg/hr, (iv) quantity of cooling water required if the rise in temperature of cooling water is limited to $10°C$.

(b) An unknown hydrocarbon fuel C_xH_y is allowed to react with air (79% N_2, 21% O_2). An analysis made of a representative sample of the product gases (dry basis) yields the following results: $CO_2 = 12.1\%,\ O_2 = 3.8\ \%,\ and\ CO = 0.9\ \%$. Determine: (a) the chemical equation of the actual reaction, (b) composition of the fuel, (c) air-fuel ratio during the test, (d) excess or deficiency of air used.

(1+2+2+1) + (3+1+1+1) = 12

5. (a) The following readings were taken during a test on a surface condenser:
Mean condenser temperature = $35°C$
hot well temperature = $30°C$
condenser vacuum = 69 cm Hg
barometer reading = 76 cm Hg
The mass rate of condensate collected = $16\ kg/min$.
The cooling water enters at $20°C$ and leaves at $32.5°C$, its mass flow rate being $37500\ kg/hr$. Calculate:
(a) mass of air present per cubic metre of condenser,
(b) quality of steam at condenser inlet,
(c) vacuum efficiency,
(d) condenser efficiency.

(b) What is a fabric filter? What is meant by the term 'air-to-cloth' ratio? What are the different types of fabric filters?

(2+2+1+1) + (2+2+2) = 12

Group - D

6. (a) Draw p-V and T-s diagram of a dual cycle and mark and describe all the processes in that cycle. Why this cycle is also called limited pressure cycle?

ELEC 2203 3

(b) A compression ignition engine has a compression ratio of 10 and 2/3 rd of heat of combustion is liberated at constant volume and the remainder at constant pressure. The pressure and temperature at the beginning of suction stroke are 1 bar and 27° C and the maximum pressure is 40 bar. Find the temperatures at the end of compression and expansion, if it follows the law $pV^{1.35}$=constant. Take γ=1.4.

(3+1) + 8 = 12

7. (a) Show that the condition for maximum efficiency of a 50 % reaction turbine is given by

$\eta_{max} = \frac{2\cos^2 \alpha_1}{1+\cos^2 \alpha_1}$ where α_1 is the angle at which the steam enters the blade.

(b) In a reaction turbine, the fixed blades and the moving blades are of the same shape but reversed in direction. The angles of the receiving tips are 35° and of the discharging tips 20° .Find the power developed per pair of blades for a steam consumption of 2.5 kg/s, when the blade speed is 50 m/s.If the heat drop per pair is 10.04 kJ/kg, find the efficiency of the pair.

7 + 5 = 12

Group - E

8. (a) Show that the maximum discharge of steam through the nozzle takes place when the ratio of steam pressure at the throat to the inlet pressure is given by,

$$\frac{p_2}{p_1} = \left(\frac{2}{n+1}\right)^{\frac{n}{n+1}}$$

(b) Dry saturated steam enters a steam nozzle at a pressure of 15 bar and is discharged at a pressure of 2.0 bar. If the dryness fraction of discharge steam is 0.96, what will be the final velocity of the steam? Neglect the initial velocity of the steam.

6 + 6 = 12

9. (a) During the testing of Engine , a single cylinder 4-stroke diesel engine gave the following results while running on full load:
Area of the indicator diagram=300mm²
Length of the Indicator Diagram= 40 mm

B.TECH/EE/4TH SEM /ELEC 2203/2016

(b) A compression ignition engine has a compression ratio of 10 and 2/3 rd of heat of combustion is liberated at constant volume and the remainder at constant pressure. The pressure and temperature at the beginning of suction stroke are 1 bar and 27° C and the maximum pressure is 40 bar. Find the temperatures at the end of compression and expansion, if it follows the law $pV^{1.35}$=constant. Take γ=1.4.

(3+1) + 8 = 12

7. (a) Show that the condition for maximum efficiency of a 50 % reaction turbine is given by

$\eta_{max} = \frac{2\cos^2 \alpha_1}{1+\cos^2 \alpha_1}$ where α_1 is the angle at which the steam enters the blade.

(b) In a reaction turbine, the fixed blades and the moving blades are of the same shape but reversed in direction. The angles of the receiving tips are 35° and of the discharging tips 20° .Find the power developed per pair of blades for a steam consumption of 2.5 kg/s, when the blade speed is 50 m/s.If the heat drop per pair is 10.04 kJ/kg, find the efficiency of the pair.

7 + 5 = 12

Group - E

8. (a) Show that the maximum discharge of steam through the nozzle takes place when the ratio of steam pressure at the throat to the inlet pressure is given by,

$$\frac{p_2}{p_1} = \left(\frac{2}{n+1}\right)^{\frac{n}{n+1}}$$

(b) Dry saturated steam enters a steam nozzle at a pressure of 15 bar and is discharged at a pressure of 2.0 bar. If the dryness fraction of discharge steam is 0.96, what will be the final velocity of the steam? Neglect the initial velocity of the steam.

6 + 6 = 12

9. (a) During the testing of Engine , a single cylinder 4-stroke diesel engine gave the following results while running on full load:
Area of the indicator diagram=300mm²
Length of the Indicator Diagram= 40 mm

ELEC 2203 4