Q.5 i. Define Volumetric efficiency of Reciprocating air compressor and also give expression for same when index of compression and expansion are same. **2**

ii. A single acting, two stage reciprocating air compressor with complete inter-cooling delivers 10.5 kg/min. of air at 16 bar. The compressor takes air at 1 bar 27 ^{o}C. The compression and expansion follow the law $pV^{1.3}$ = const. Calculate **8**
(a) Power required to drive the compressor,
(b) Isothermal efficiency and
(c) FAD

OR iii. Derive the relation for either minimum compression work or optimum intermediate pressure for a Multi-stage compressor. Also justify need of multi-staging in an air compressor. **8**

Q.6 i. Air is flowing isentropically through a nozzle at 27 ^{o}C and 0.8 bar with a velocity of 120 m/sec. Calculate stagnation enthalpy and stagnation temperature. **2**

ii. Steam enters a convergent-divergent nozzle at 2 Mpa, 400 ^{o}C with a negligible velocity and mass flow rate of 2.5 kg/sec. and it exits at a pressure of 300 kPa. The flow is isentropic between nozzle entrance and throat and overall nozzle efficiency is 93 % Determine throat and exit areas. **8**

OR iii. Derive the formulae for all property (temperature, pressure and density) relations for an isentropic flow through a duct at stagnation condition and also at throat. **8**

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Enrollment No.....

Faculty of Engineering

End Sem (Even) Examination May-2018

ME3CO09 Energy Conversion - I

Programme: B.Tech. Branch/Specialisation: ME

Duration: 3 Hrs. **Maximum Marks: 60**

Note: (a) All questions are compulsory. Internal choices, if any, are indicated. Answers of Q.1 (MCQs) should be written in full instead of only a, b, c or d.
(b) Use of Steam table is permitted.

Q.1 i. For the same draught produced, the power of induced draught fan as compared to force draught fan is **1**
(a) Less (b) Same (c) Not predictable (d) More

ii. For maximum discharge of hot gases through the chimney, the height of hot gas column producing draught is **1**
(a) Twice the height of chimney
(b) Equal to the height of chimeny
(c) Half of the height of chimeny
(d) None of these

iii. Rankine efficiency of steam power plant **1**
(a) Improves in summer as compared to that in winter
(b) Is unaffected by climatic conditions
(c) Improves in winter as compared to that in summer
(d) None of these

iv. With Reheat-Regenerative Rankine cycle **1**
(a) Quality of exhausted steam is improved
(b) Net work output of cycle increases
(c) Specific steam consumption decreases
(d) All of these

v. An evaporative type condenser has **1**
(a) Steam in tubes surrounded by water
(b) Water in tubes surrounded by water
(c) Both (a) and (b)
(d) None of these

vi. In a high-level jet condenser, the condenser shell is installed at a height of **1**
(a) More than 5.5m (b) More than 10.336 m
(c) Less than 10.336 m (d) None of these

vii. With suction pressure being atmospheric, increase in delivery pressure with fixed clearance volume **1**
(a) Increases the volumetric efficiency
(b) Does not change the volumetric efficiency
(c) Decreases the volumetric efficiency
(d) First increases the volumetric efficiency and then decrease it

viii. With increasing the clearance volume, the ideal work for compressing 1 kg of air **1**
(a) Increases (b) First increases then decreases
(c) Decreases (d) Remains same

ix. If the exit pressure from a nozzle is less than critical pressure, it is **1**
(a) Divergent nozzle
(b) Convergent nozzle
(c) Convergent-divergent nozzle
(d) None of these

x. At critical pressure ratio for a nozzle, the velocity at outlet will be **1**
(a) More than the sonic velocity
(b) Equal to the sonic velocity
(c) Less than the sonic velocity
(d) None of these

Q.2 i. Why high capacity and high pressure boilers are water tube boilers only? **2**

ii. A boiler produces 2500 kg of steam per hr. at a pressure of 12 bars abs. from feed water at 30 ^{o}C. The coal having calorific value of 30400 kJ/kg is used at rate of 275 kg/hr. This steam is sampled by means of a throttling calorimeter in which the pressure is 1.05 bars abs. & temperature after throttling is 110 ^{o}C. Determine the dryness fraction of steam before throttling and efficiency of boiler. **8**

OR iii. The following data were refer to a boiler plant consisting of an economiser, boiler and super heater: Mass of water evaporated per hour = 5940 kg, mass of coal burnt per hour = 675 kg, LCV of coal = 31600 kJ/kg, pressure of steam at boiler stop valve = 14 bar, temperature of feed water entering the economiser = 32 ^{o}C, temperature of feed water leaving the economiser = 115 ^{o}C, dryness fraction of steam leaving the boiler and entering the super heater =0.96, temperature of steam leaving super heater = 260 ^{o}C, specific heat of superheated steam = 2.33. Determine: **8**
(i) Percentage of heat in coal utilised in economiser, boiler and super heater and (ii) Overall thermal efficiency of boiler plant.

Q.3 i. Define work ratio and specific steam consumption along with SI units. **2**

ii. The steam at 30 bar, 400 ^{o}C is supplied to a turbine and is expanded isentropically to a pressure of 3 bars, where some of steam is extracted for a surface heater, in which the feed water is heated to 130 ^{o}C. The remaining steam from feed water is cooled in a drain cooler to 27 ^{o}C. The feed water before entering the feed heater is used as coolant in drain cooler. The cooled drain water is then mixed with condensate at 0.04 bar. Determine 1) Mass of steam used for feed water heating per kg of steam entering the turbine and 2) Thermal efficiency of given cycle. **8**

OR iii. A steam turbine is fed with steam having an enthalpy of 3100 kJ/kg. It moves out of turbine with an enthalpy of 2100 kJ/kg. Feed heating is done at a pressure of 3.2 bar with steam enthalpy of 2500 kJ/kg. The condensate from a condenser with an enthalpy of 125 kJ/kg enters into feed water heater. The quantity of bled steam is 11200 kg/h. Find mass of bled steam from feed heater and power developed by turbine. Assume that water leaving the feed water heater is saturated liquid at 3.2 bars and the heater is direct mixing type. Neglect pump work. **8**

Q.4 i. Discuss the effect of air leakage upon the performance of condenser. **2**

ii. During a trial on a condenser, the following data were recorded: **8**
Barometer reading = 760 mm of Hg, Vacuum in condenser = 718 mm of Hg, Temperature of hot well = 29 ^{o}C, Inlet temperature of cooling water = 15 ^{o}C, Outlet temperature of cooling water = 24 ^{o}C, Mass of steam condensed = 1760 kg/hr, Mass of water circulated = 1550 kg/min, Calculate
(a) Under cooling of condensate,
(b) Quality of exhaust steam
(c) Condenser efficiency

OR iii. The steam is supplied to a steam turbine at 3 MPa, 300 ^{o}C. The expansion of steam is carried out isentropically to a condenser vacuum of 713 mm of Hg. The barometer reads 758 mm of Hg. The condenser temperature is 20 ^{o}C and rise in temperature of cooling water is 12 ^{o}C. Determine **8**
(a) Quality of steam entering to the condenser and
(b) Quantity of cooling water circulated per kg of steam. Assume no air is present in the condenser.

Marking Scheme
ME3CO09 Energy Conversion – I

Q.1	i.	For the same draught produced, the power of induced draught fan as compared to force draught fan is (d) More		**1**
	ii.	For maximum discharge of hot gases through the chimney, the height of hot gas column producing draught is (b) Equal to the height of chimeny		**1**
	iii.	Rankine efficiency of steam power plant (c) Improves in winter as compared to that in summer		**1**
	iv.	With Reheat-Regenerative Rankine cycle (d) All of above		**1**
	v.	An evaporative type condenser has (a) Steam in tubes surrounded by water		**1**
	vi.	In a high-level jet condenser, the condenser shell is installed at a height of (b) More than 10.336 m		**1**
	vii.	With suction pressure being atmospheric, increase in delivery pressure with fixed clearance volume (c) Decreases volumetric efficiency		**1**
	viii.	With increasing clearance volume, the ideal work for compressing 1 kg of air (d) Remain same		**1**
	ix.	If the exit pressure from a nozzle is less than critical pressure, it is (c) Convergent-divergent nozzle		**1**
	x.	At critical pressure ratio for a nozzle, the velocity at outlet will be (b) Equal to sonic velocity		**1**
Q.2	i.	High capacity and HP boilers are water tube boilers		**2**
	ii.	Full marks for each correct answer		**8**
		Dryness fraction of steam before throttling = x = 0.955	4 marks	
		efficiency of boiler = 76.87 %	4 marks	
OR	iii.	(i) Percentage utilised for economiser= 9.66% (346.9 kJ/kg of LCV)		**8**
			2 marks	
		Percentage utilised for boiler= 65.7% (2362.6 kJ/kg of LCV)	2 marks	
		Percentage utilised for super heater= 6.34% (227.8 kJ/kg of LCV)	2 marks	
		(ii) Overall thermal efficiency of boiler plant= 81.79 %	2 marks	
Q.3	i.	Definition work ratio with SI units	1 mark	**2**
		Specific steam consumption along with SI units	1 mark	
	ii.	Schematic or given cycle on p-v/T-s/h-s diagram	2 marks	**8**
		(a) Mass of steam used for feed water heating per kg of steam entering the turbine = m_1 = 0.20 kg/kg of steam and	3 marks	
		(b) Thermal efficiency of given cycle = 37.9 %	3 marks	
OR	iii.	Schematic or given cycle on p-v/T-s/h-s diagram	2 marks	**8**
		Mass of bled steam from feed heater = m = 0.226 kg	3 marks	
		Power developed by turbine = P = 12521.5 kW	3 marks	
Q.4	i.	Discuss the effect of air leakage upon the performance of condenser.		**2**
	ii.	Fully labelled diagram	1 mark	**8**
		(a) Under cooling of condensate = 5.91853 ^{o}C	1 mark	
		(b) Quality of exhaust steam = x = 0.81302	3 marks	
		(c) Condenser efficiency = 45.184 %	3 marks	
OR	iii.	Fully labelled diagram or p-v/T-s as per given data	2 marks	**8**
		(a) quality of steam entering to the condenser = x = 0.77	3 marks	
		(b) quantity of cooling water circulated per kg of steam = 38.37 kg/kg of steam	3 marks	
Q.5	i.	Define Volumetric efficiency	1 mark	**2**
		Give expression	1 mark	
	ii.	Given cycle on p-v/t-s/h-s diagram	2 marks	**8**
		(a) Power required to drive the compressor = 49.23 kW	2 marks	
		(b) Isothermal efficiency = 84.8 %	2 marks	
		(c) FAD = 9.04 m^3/min	2 marks	
OR	iii.	Derive the relation	6 marks	**8**
		Also justify need	2 marks	
Q.6	i.	Stagnation enthalpy = 308.87 kJ/kg	1 mark	**2**
		Stagnation temperature = 307.2 K	1 mark	
	ii.	Fully labelled diagram as per given data	2 marks	**8**
		(a) throat area = A_t = 10.33 cm^2	3 marks	
		(b) exit areas = A_e = 18.17 cm^2	3 marks	
OR	iii.	Property relations at stagnation condition	4 marks	**8**
		Property relations at throat condition	4 marks	

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