ME 6301- ENGINEERING THERMODYNAMICS

UNIT – III QUESTION BANK

1. A vessel of volume 0.04m^3 contains a mixture of saturated water and steam at a temperature of 250^0 C. The mass of the liquid present is 9 kg. Find the pressure, mass, specific volume, enthalpy, entropy and internal energy. **(8)**
(May/June 2003, Nov/Dec 2012)
2. A rigid tank of 0.03m^3 capacity contains wet vapour at 80 kPa. If the wet vapour mass is 12kg, calculate the heat added and the quality of the mixture when the pressure inside the tank reaches 7 Mpa. **(Nov/ Dec 2005)**
3. 3 kg of steam at 18bar occupy a volume of 0.2550m^3. During a constant volume process, the heat rejected is 1320kJ. Determine final internal energy and final initial dryness and work done. **(May/June 2008)**
4. Steam initially at 0.3Mpa, 250^{0}C is cooled at constant volume. At what temperature will the steam become saturated vapour? What is the quality at 80^{0}C.Also find what is the heat transferred per kg of steam in cooling from 250^0 C to 80^{0}C. **(12)**
(Nov / Dec 2013)
5. Ten kg of water of 45^{o}C is heated at a constant pressure of 10 bars until it becomes superheated vapour at 300^{0}C. Find the changes in volume, enthalpy, internal energy and entropy. **(May / June 2005)**
6. 2 kg of water at 200^{0}C are contained in a 20m^3 vessel. Determine the pressure, enthalpy, mass and volume of vapor within the vessel. **(8)**
(May / June 2007)
7. Steam at 30 bar and 350^0 C is expanded in a non flow isothermal process to a pressure of 1 bar. The temperature and pressure of the surroundings are 25^{0}C and 100 kPa respectively. Determine the maximum work that can be obtained from this process per kg of steam. Also find the maximum useful work. **(10)**
(May/June 2013)
8. 1 kg of steam initially dry saturated at 1.1 MPa expands in a cylinder following the law pv$^{1.13}$= C. The pressure at the end of expansion is 0.1MPa. Determine: **(i)** The final volume **(ii)** final dryness fraction **(iii)** work done **(iv)** The change in internal energy **(v)** the heat transferred. **(16)**
(Nov/Dec 2006)
9. Steam at a pressure of 15bar and 250^{0}C expands according to the law pV$^{1.25}$=C to a pressure of 1.5 bar. Evaluate the final conditions, work done, heat transfer and change in entropy. The mass of the system is 0.8kg. **(Nov/Dec 2008)**
10. In steam generator compressed water at 10 MPa, 30^{0}C enters a 30 mm diameter tube at the rate of 3 litres /sec. Steam at 9 MPa and 400^{0}C exit the tube. Find the rate of heat transfer. **(8)**
(Nov/Dec 2003, May/June 2012)
11. Steam at 0.8 MPa, 250^{0}C and flowing at the rate of 1 kg/s passes into a pipe carrying wet steam at 0.8 MPa, 0.95 dry. After adiabatic mixing the flow rate is 2.3 kg/s. Determine the properties of the steam after mixing. **(Nov/Dec 2004)**

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12. A vessel having a capacity of 0.05 m^3 contains a mixture of saturated water and saturated steam at a temperature of 245^0C. The mass of the liquid present is 10 kg. find the following

(i) The pressure,
(ii) The mass,
(iii) The specific volume
(iv) The specific enthalpy,
(v) The specific entropy, and
(vi) The specific internal energy. **(16)**

(May/June 2014)

13. Steam flows steadily through a turbine with a mass flow rate of 3 kg/sec. the steam is at 70 bar and 500^0C while entering the turbine and at 0.2 bar on leaving the turbine. The expansion process may be considered as isentropic. Determine the turbine output power. **(May/June 2004)**

14. Steam expands in a nozzle from 1 MPa, 250^0C to 10 kPa, the flow rate being 1 kg/sec. determine the velocity of steam at the exit of the nozzle and the exit area of the nozzle. The steam velocity at the inlet to the nozzle may be ignored.

(May/June 2004)

15. Two streams of steam, one at 2 MPa, 300^0C and the other at 2 MPa, 400^0C, mix in a steady flow adiabatic process. The rates of flow of the two streams are 3 kg/min and 2 kg/min respectively. Evaluate the final temperature of the emerging steam, if there is no pressure drop due to the mixing process. What would be the rate of increase in the entropy of the universe? This steam with negligible velocity now expands adiabatically in a nozzle to a pressure of 1 kPa. Determine the exit velocity of the stream and exit area of the nozzle. **(16)**

(Nov/Dec 2011)

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16. A 0.5 m^3 vessel contains 10 kg refrigerant 134a at -20°C. Determine the pressure, the total internal energy and the volume occupied by the liquid phase. **(6)**

(Nov/Dec 2010)

17. A rigid tank with a volume of 2.5 m^3 contains 15 kg of saturated liquid vapour mixture of water at 75°C. Now the water is slowly heated. Determine the temperature at which the liquid in the tank is completely vaporized. Also, show the processes on T-v diagram with respect to saturation lines**.** **(10)**

(Nov/Dec 2010)

18. Steam flows through a small turbine at the rate of 5000 kg/h entering at 15 bar, 300^0C and leaving at 0.1bar with 4% moisture. The steam enters at 80m/s at a point 2 m above the discharge and leaves at 40m/s. compute the shaft power assuming that the device is adiabatic but considering kinetic and potential energies. Calculate the diameters of the inlet and discharge tubes. **(8)**

(May/June 2010)

19. Steam expands isentropically in a nozzle from 1 MPa, 250^0C to 10 kPa. The steam flow rate is 1 kg/s. find the velocity of steam at the exit from the nozzle, and the exit area of the nozzle. Neglect the velocity of steam at inlet to the nozzle. The exhaust steam from the nozzle flows in a condenser and flows out as saturated water. The cooling water enters the condenser at 25^0C and leaves at 35^0C. Determine the mass flow rate. **(8)**

(May/June 2010)

20. In a closed vessel the 100 kg of steam at 100 kPa, 0.5 dry is to be brought to a pressure of 1000 kPa inside vessel. Determine the mass of dry saturated steam admitted at 2000 kPa for raising pressure. Also determine the final quality. **(16)**

(May/June 2011)

21. A steam power plant running on Rankine cycle has steam entering HP turbine at 20 MPa, 500^0C and leaving LP turbine at 90% dryness. Considering condenser pressure of 0.005 MPa and reheating occurring up to the temperature of 500^0C determine,

(i) The pressure at which steam leaves HP turbine

(ii) The thermal efficiency.

(iii) Work done. **(16)**

(May/June 2011)

22. In a Rankine cycle, the steam at inlet to turbine is saturated at a pressure of 35 bar and the exhaust pressure is 0.2 bar. The flow rate of steam is 9.5 kg/s. Determine (1) the pump work (2) the turbine work (3) Rankine efficiency (4) condenser heat flow (5) work ratio and (6) specific steam consumption. **(10)**

(Nov/Dec 2011)

23. Steam at a pressure of 2.5 MPa and 500°C is expanded in a steam turbine to a condenser pressure of 0.05 MPa. Determine for Rankine cycle:

(i) The thermal efficiency of Rankine cycle

(ii) Specific steam consumption.

If the steam pressure is reduced to 1 MPa and the temperature is kept same 500°C. Determine the thermal efficiency and the specific steam consumption. Neglect feed pump work, **(16)**

(Nov/Dec 2006)

24. Consider a steam power plant operating on the ideal Rankine cycle. Steam enters the turbine at 3 MPa and 623 K and is condensed in the condenser at a pressure of 10 kPa. Determine (i) the thermal efficiency of this power plant, (ii) the thermal efficiency if steam is superheated to 873 K instead of 623 K, and (iii) the thermal efficiency if the boiler pressure is raised to 15 MPa while the turbine inlet temperature is maintained at 873 K. **(16)**

(Nov/Dec 2009)

25. Consider a steam power plant operating on the ideal reheat Rankine cycle. Steam enters the high-pressure turbine at 15 MPa and 873 K and is condensed in the condenser at a pressure of 10 kPa. If the moisture content of the steam at the exit of the low-pressure turbine is not to exceed 10.4 percent, determine (i) the pressure at which the steam should be reheated and (ii) the thermal efficiency of the cycle. Assume the steam is reheated to the inlet temperature of the high-pressure turbine. **(16)**

(Nov/Dec 2009)

26. Consider a steam power plant that operates on a reheat Rankine cycle and has a net power output of 80 MW. Steam enters the high-pressure turbine at 10 MPa and 500°C and the low-pressure turbine at 1 MPa and 500°C. Steam leaves the condenser as a saturated liquid at a pressure of 10 kPa. The isentropic efficiency of the turbine is 80 percent, and that of the pump is 95 percent. Show the cycle on a T-s diagram with respect to saturation lines, and determine

(i) The quality (or temperature, if superheated) of the steam at the turbine exit,

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(ii) The thermal efficiency of the cycle, and '
(iii) The mass flow rate of the steam. **(16)**

(Nov/Dec 2010)

27. A steam boiler generates steam at 30bar, 300^0C at the rate of 2kg/s. this steam is expanded isentropically in a turbine to a condenser pressure of 0.05bar, condensed at constant pressure and pumped back to boiler.

(i) Draw the schematic arrangement of the above plant and T-S diagram of Rankine cycle.
(ii) Find heat supplied in the boiler per hour.
(iii) Determine the quality of steam after expansion.
(iv) What is the power generated by the turbine?
(v) Estimate the Rankine efficiency considering pump work.

(May/June 2004)

28. A cyclic steam power plant is to be designed for a steam temperature at turbine inlet of 633K and an exhaust pressure of 8kPa. After isentropic expansion of steam in the turbine, the moisture content at the turbine exhaust is not to exceed 15%. Determine the greatest allowable steam pressure at the turbine inlet, and calculate the Rankine cycle efficiency for these steam conditions. Estimate also the mean temperature of heat addition. **(16)**

(Nov/Dec 2007)

29. Steam at 20bar, 360^0C is expanded in a steam turbine to 0.08bar. It then enters a condenser, where it is condensed to saturated liquid water. The pump feeds back the water into the boiler.

(i) Assuming ideal processes find the net-work and the cycle efficiency per kg of steam.
(ii) If the pump and the turbine have 80% efficiency, find the percentage reduction in the net-work and cycle efficiency. **(8)**

(May/June 2012)

30. In a steam power plant operating on an ideal reheat Rankine cycle, the steam enters the high-pressure turbine at 3MPa and 400^0C. After expansion to 0.6 MPa, the steam is reheated to 400^0C and then expanded the low-pressure turbine to the condenser pressure of 10kPa. Determine the thermal efficiency of the cycle and the quality of the steam at the outlet of the low pressure turbine.

(Nov/Dec 2002)

31. In a thermal power plant operating on a Rankine cycle, superheated steam at 50 bar and 500^0C enters a turbine, the isentropic efficiency of which is 0.8. The condenser pressure is 0.05 bar and it delivers saturated liquid to a feed pump, the isentropic efficiency of which is 0.7. Determine the thermal efficiency of the power plant and the mass flow rate of steam required for 50 MW net power generation. **(8)**

(May/June 2010)

32. A reheat cycle operating between 30 and 0.04bar has a superheat and reheat temperature of 450^0C. The first expansion takes place till the steam is dry saturated and then reheat is given. Neglecting feed pump work. Determine the ideal cycle efficiency. **(Nov/Dec2003)**

33. A steam power plant operates on a theoretical reheat cycle. Steam at boiler at 150 bar, 550^0C expands through the high pressure turbine. It is reheated at a constant pressure of 40bar to 550^0C and expands through the low pressure turbine to a condenser at 0.1 bars. Draw T-s and h-s diagrams. Find :

(i) Quality of steam at turbine exhaust

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(ii) Cycle efficiency
(iii) Steam rate in kg/kWh. **(16)**

(May/June2004, May/June 2014)

34. In a reheat steam cycle, the maximum steam temperature is limited to 773K. The condenser pressure is 10kPa and the quality at turbine exhaust is 0.8778. Had there been no reheat, the exhaust quality would have been 0.7592. Assuming ideal processes, determine (i) reheat pressure (ii) the boiler pressure (iii) the cycle efficiency (iv) the steam rate. **(16)**

(Nov/Dec2007)

35. In a regenerative cycle, the steam pressure at turbine inlet is 30bar and the exhaust is at 0.04bar. The steam is initially saturated. Enough steam is bled off at the optimum pressure of 3bar to heat the feed water. Determine the cycle efficiency. Neglect pump work. **(Nov/Dec2003)**

36. In a single heater regenerative cycle the steam enters the turbine at 30bar and 400^0C and the turbine exhaust pressure is 0.10bar. The condensate is heated in a direct contact type heater which operates at 5bar. Find the efficiency and the steam rate of the cycle and the increase in mean temperature of heat addition, efficiency and steam rate as compared to the Rankine cycle. Neglect pump work. **(May/June2004)**

37. Steam enters the turbine at 3MPa and 400^0C and is condensed at 10kPa. Some quantity of steam leaves the turbine at 0.6MPa and enters open feed water heater. Compute the fraction of the steam extracted per kg of steam and cycle thermal efficiency. **(10)**

(Nov/Dec2005, Nov/Dec2012)

38. In an ideal reheat cycle, the steam enters the turbine at 30bar and 500^0C. After expansion to 5bar, the steam is reheated to 500^0C and then expanded to the condenser pressure of 0.1 bar. Determine the cycle thermal efficiency, mass flow rate of steam. Take power output as 100 MW. **(10)**

(May/June2007)

39. Steam at 50bar, 400^0C expands in a Rankine cycle to 0.34 bar. For a mass flow rate of 150 kg/s of steam, determine

(i) Power developed
(ii) Thermal efficiency
(iii) Specific steam consumption. **(8)**

(May/June 2013)

39. Steam at 480^0C, 90 bar is supplied to a Rankine cycle. It is reheated to 12bar and 480^0C. The minimum pressure is 0.07 bar. Find the work output and cycle efficiency using steam tables with and without considering pump work**.** **(16)**

(Nov / Dec 2013)

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