Important Questions
Applied Thermodynamics EME-401, (Semester IV, 2ⁿᵈ year)

(26 April 2013)

UNIT-1 (Thermodynamic Relations, Fuels and Combustion)

1. Define Helmholtz and Gibbs Functions and hence derive the Maxwell Relations, using 'mathematical conditions' for exact differentials.

2. Define 'Clapeyron Equation' and it significance. Determine h_{fg} of R12 refrigerant at -10°C using the Clapeyron equation. Take:

   $P_{sat\ at\ -5°C}$= 260.96 kPa

   $P_{sat\ at\ -10°C}$= 182.60 kPa

   $V_{g\ at\ -10°C}$= 0.0765 m³/kg

   $V_{f\ at\ -10°C}$= 0.00070 m³/kg

   R= 0.06876 kJ/kg.K

   $H_{fg\ at\ -10°C}$ =156.3kJ/kg from steam tables

3. Describe Joule-Thomson Coefficient, showing the importance of 'Inversion Curve' in brief. Explain what is the maximum the inversion temperature?

4. Define the following terms:

   a. Adiabatic Flame temperature

   b. Isothermal compressibility

5. What do you mean by combustion? Explain fuel and its types. Differentiate between proximate and ultimate analysis.

6. Describe the Bomb Calorimeter and its significance.

7. Describe Orsat apparatus, differentiate between dry and wet analysis of combustion.

8. Explain the terms 'excess air', 'air fuel ratio', 'flash point', 'fire point', 'lean' and 'rich' mixture.

9. What do you understand by heat of reaction, when it is positive and when negative? Differentiate it with enthalpy of formation.

10. Determine the air fuel ratio of C_3H_8 with 150 percent theoretical air supplied.

11. The volumetric composition of the dry products of combustion of an hydrocarbon fuel C_xH_y gives : CO_2 12.1%, O_2 3.8%, CO 0.9% and N_2 83.2%. Determine :

   a. Chemical composition of fuel,

   b. The air fuel ratio, and

   c. Percentage of excess air used.

12. Describe the Bomb Calorimeter. Determine the HCV and LCV of coal for which the following observations are made in bomb calorimeter:

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a. Mass of coal sample =1 gm
b. Mass of water in calorimeter =2.5 gm
c. Initial Temperature of water =20°C
d. Max. recorded Temperature of water =22.6°C
e. Water equivalent of apparatus =750 gm
f. Cooling correction =+0.018°C
g. H_2 Content in coal =5%

UNIT-2 (Boilers, Condenser)

13. Define boiler and give the classification of boilers? Distinguish between fire-tube and water-tube boilers, giving at least 2 names of each type.

14. Explain the working of water level indicator and high steam low water safety valve, comparing with the fusible plug.

15. Explain boiler draught and describe its types. Why it is required? What are the advantages and disadvantages of Artificial over Natural Draught?

16. Explain the parts of a steam power plant with neat sketch.

17. Derive the expression for the natural draught required for disposing the flue gases through a chimney of height H, in N/m^2.

18. Explain how the escape of water and steam is prevented from water level indicator, in case of steam generator, if the glass tube gets damaged?

19. Draw a neat labeled sketch of a simple fire tube boiler, and explain its working in brief

20. Define the terms 'Equivalent Evaporation' and 'Boiler Efficiency'.

21. Describe the type of artificial draught. Compare the induced, forced and balanced draught. Prove that the power required for induced draught fan is more than that of forced draught fan. Indicate the location of induced, forced and balanced draught fans using the neat sketches.

22. Explain the working of fire tube and water tube boilers, in reference with Lancashire, Locomotive and 'Babcock and Wilcox boiler', with neat sketches.

23. What is the basic difference between boiler mountings and accessories? Draw a neat labeled sketch of a 'dead weight' or a 'spring loaded' safety valve, fusible plug and explain its working in brief.

24. What is the purpose of condenser? Give the classification of condenser. What do you mean by condenser performance measurement, how it is measured? What are different types of condensers and their working? How the air leakage into a condenser affects its working? What are different methods to detect the air leakage into the condenser?

25. Explain, in brief, the functions and uses of air pre-heater, feed-water heater and super-heater in steam boilers.

26. In a boiler artificial draught is used at **150°C**, with a chimney of height **60m**.Temperature of hot gases inside chimney is **300°C** and air requirement per kg of fuel burnt is **19 kg**. The atmospheric temperature may be assumed to be **17°C**. Specific heat of hot gases may be assumed as **1.0032kJ/kg-K.** Fuel used has a HCV of **32604kJ/kg.** Evaluate draught produced in mm of water, efficiency of chimney and extra heat carried away by flue gases per kg of fuel.

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27. What are the considerations to be made for a better deign of a condenser? During the trail on a condenser it is noted to have vacuum of **67** cm of Hg while barometer reading is **75** cm of Hg. The mean condenser temperature is **40°C** and temperature of hot well is **35°C**. Circulating water flows at **1000 kg/min** for giving condensate at the rate of **50 kg/min**. Temperature of cooling water at inlet and exit are **10°C** and **25°C**. Determine:

     a. Vacuum corrected to standard barometer reading of 76 cm of Hg
     b. Vacuum efficiency of condenser
     c. Under-cooling of condensate
     d. Condenser efficiency
     e. State of steam entering condenser
     f. Mass of air per m^3 of condenser volume
     g. Mass of air per kg of uncondensed steam

UNIT-3 (Steam Engines, Steam & Gas Nozzle)

28. Explain the function of steam nozzles, and their types. Derive the expression for the calculation of steam velocity at the exit of nozzle with the help of steady flow energy equation.

29. Draw a labeled sketch of hypothetical and actual indicator diagrams for a simple steam engine and define the term, 'Diagram factor'.

30. Explain Saturation curve, diagram factor and missing quantity of steam engines. How the steam condensation (or missing quantity) may be minimized?

31. Why the work out-put is not getting doubled in case to double acting steam engine?

32. What do you understand by saturation curve and missing quantity and how the missing quantity and steam condensation can be reduced in case of steam engines?

33. What in mean effective pressure and explain the working of steam engine.

34. Explain the working of steam engine with a neat sketch. Why the hypothetical indicator diagram differs from actual indicator diagram for steam engines, explain with neat sketch?

35. Explain the following for a steam engine with suitable diagram:

     a. Missing quantity
     b. Heat balance sheet
     c. Simple steam engine plant

36. A single cylinder double acting steam engine is supplied with dry and saturated steam at **11.5 bar** and exhaust occurs at **1.1 bar.** The cut-off occurs at **40%** of stroke. If the stroke equals **1.25 times** the cylinder bore and engine develops **60 kW** at **90 rpm**, determine the bore and stroke. Assume hyperbolic expansion and a diagram factor of **0.70**. Also calculate the theoretical steam consumption per hour.

37. Discuss the phenomenon of super saturation in the nozzles and significance of Wilson line, with a neat sketch.

38. What is the classification of nozzles depending upon the back pressure? Discuss the OFF design operation of nozzles. What is the over expansion and under expansion in flow through nozzles.

39. What do you understand by Choked Flow in a nozzle? Also discuss it's significance. Obtain the

expression for the maximum discharge through a convergent- divergent nozzle having isentropic expansion with negligible inlet velocity.

40. Explain the phenomenon of super-saturation in case of steam nozzle. Indicate the process on h-s diagram.

41. Derive the formulae for maximum discharge through a convergent-divergent nozzle making suitable assumptions.

42. What is the effect of friction in nozzle? Indicate the process on h-s OR T-s diagram.

43. Explain the coefficient of discharge and critical velocity in nozzles.

44. A steam nozzle has steam entering at **6 bar**, **300 ºC** and expansion occurs upto steam pressure of **1.5 bar**. Determine the nozzle efficiency for mass flow rate of **5 Kg/s** and nozzle exit area of **6.8 cm²**.

45. In a nozzle steam expands from **12 bar** and **300ºC** to **6 bar** with flow rate of **5 kg/s**. Determine throat and exit area if exit velocity is **500 m/s** and velocity at inlet to nozzle is negligible. Also find coefficient of velocity at exit. Coefficient of velocity is the ratio of actual velocity of fluid at nozzle exit to the velocity at exit considering isentropic flow through nozzle.(You may need three interpolations, practice to solve using Steam table and Mollier Chart)

46. A nozzle is supplied with steam at 0.7 MPa and 275ºC. Determine temperature and velocity at throat considering no losses. If diverging portion of nozzle is 6 cm long and throat diameter of 0.5 cm, determine the angle of cone in nozzle so that steam leaves nozzle at 0.1 MPa. Assume heat utilization in diverging portion to be 85%. Solve using mollier diagram.

47. Steam enters a nozzle in a dry saturated condition and expands from a pressure of **2 bar** to a pressure of **1 bar**. It is observed that super-saturated flow is taking place and the steam flow reverts to a normal flow at **1 bar**. What is the degree of under-cooling,, increase of entropy and the loss in the available heat drop due to irreversibility? Indicate the process on h-s diagram.

48. What is meant by compounding of steam turbines and what are the different methods of compounding? Explain, with the help of neat sketch, in brief. What is the basic purpose of governing of steam turbines?

49. How do you classify Gas Turbines? Draw the P-V and T-S diagrams for a simple Constant Pressure Open Cycle and close cycle Gas Turbines.

50. What do you understand by the degree of superheat and degree of sub cooling?

UNIT-4 (Vapour Power Cycle, Steam Turbine)

51. Compare Carnot and Rankine power cycles. Why it is necessary to modified Rankine cycle for steam engines?

52. What are the methods used to improve the performance of Rankine cycle, discuss the effect of :
    a) Pressure of steam at inlet to the turbine
    b) Temperature of steam at inlet to turbine
    c) Pressure at the end of expansion
    d) Temperature of feed water at inlet to the boiler

53. Discuss the different losses in the operation of turbines and preventive steps to be taken.

54. What is reheat factor explain with h-s diagram. Comment on "The internal efficiency of a turbine with multiple stages is always more than that of single stage turbine".

55. What are the different controls incorporated into steam turbines for its proper operation.

56. What do you understand by regeneration? How the ideal regenerative cycle is made practicable?

57. What is bleeding and how does it affect the cycle efficiency? Draw the layout of a steam power plant operating on Rankine cycle with three bleed heaters.

58. Discuss the following, using neat sketches:
    a. Reheat cycle
    b. Regenerative cycle and de-aerator
    c. Co-generation
    d. Binary vapour cycle
    e. Combined cycle

59. Why water is generally used as working fluid in the steam power plants, mention the limitations of water as working fluid in the steam power plants.

60. An impulse steam turbine of **180 kW** has steam flowing at rate of **165 kg/min** and leaving axially. Steam turbine blade speed is **175 m/s** and it leaves nozzle at **400 m/s**. For the blade velocity coefficient of **0.9**, find nozzle angle, blade angles at inlet and exit, axial thrust and diagram efficiency.

61. Discuss the OFF design operation of convergent –divergent nozzle and differentiate between over expanding and under expanding nozzles.

62. Discuss the effect of friction on the nozzle performance with help of h-s diagram.

63. Define Critical pressure ratio for nozzle of the steam turbine. Obtain analytically its value in terms of the index of expansion.

64. Discuss the effect of inlet Pressure and Temperature of steam of Rankine cycle. Write the advantages of reheating of the steam.

65. Explain the difference between impulse and reaction turbine.

66. Define the stage efficiency and speed ratio of the steam turbine.

67. What are the different controls incorporated into steam turbines for its proper operation.

68. What do you understand by governing of steam turbines and explain the different types of governing methods for steam turbines with neat diagram?

69. Draw the velocity diagram of a velocity compounded impulse and 50% reaction turbine stage. Show the calculation for the finding out the tangential force, axial force, blade efficiency and stage efficiency for both the impulse and reaction turbine.

70. Define the following terms:
    a. State point locus
    b. Reheat factor

UNIT-5 (Gas Turbine, Jet Propulsion)

71. Explain in brief the various methods of improving the efficiency of a gas turbine working on a simple Brayton cycle with the help of neat sketches.

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72. What is the classification of gas turbines? Differentiate between closed and open cycle gas turbines, with neat sketches of gas flow and T-S diagram

73. Discuss the significance of reheating, inter-cooling and regeneration on the performance of gas turbine.

74. State the merits and demerits of the closed cycle gas turbine over open cycle.

75. What is the principle of jet propulsion? Classify the jet propulsion engines. Explain the working of turbo jet engines.

76. What is the working principle of turbo prop engines, explain with neat sketch. Differentiate between the turbo prop and turbo jet engines.

77. With the help of neat sketches explain:
    a. Turboprop engines
    b. Rocket engine.

78. What is the principle of rocket propulsion and what are the different types of rocket engines.

79. Differentiate between the working of solid and liquid fuel rocket engines, with neat sketches.

***** Good Luck *****

***** HARD WORK HAS NO SUBSTITUTE *****

Practice as much numerical problems as possible and of different types.