Paper 2: Energy Efficiency in Thermal Systems

Section A

Tick appropriate answer of the following questions on the top page. 1 x 50 =50

1. Gross and net calorific values of a fuel is the same
   A. if its carbon content is very low
   B. if its hydrogen/hydrogen compound content is zero
   C. under no circumstances.
   D. if its ash content is zero.
2. The difference of actual air supplied and the stoichiometric air required for complete combustion of fuel is called
   A. excess air C. theoretical air
   B. combustion air D. dry air
3. Combustion of 1kg of coal requires
   A. 3-4 kg of air C. 7-8 kg of air
   B. 12-13 kg of air D. 17-18 kg of air
4. In a boiler, feed water supplied per hour is 205 kg while coal fired per hour is 23 kg. The net enthalpy rise per kg of water is 145 kJ. If the calorific valve of the coal is 2050 kJ/kg then the boiler efficiency will be
   A. 56% C. 74%
   B.63% D.78%
5. Air pressure at the fuel bed is reduced below that of atmosphere by means of a fan placed at or near the bottom of the chimney to produce a draught. Such a draught is called
   A. natural draught C. forced draught
   B. induced draught D. balanced draught
6. Which one of the following is boiler accessories?
   A. economiser C. both (A) and (B)
   B. superheater D. none of these
7. The material used to control SOx in the FBC boiler is
   A. dolomite C. silica
   B. alumina D. soda ash
8. The difference between mean solid and mean gas velocity in FBC boiler is called
   A. fluidization factor C. settling velocity
   B. slip velocity D. terminal velocity
9. In FBC boilers fluidization depends largely on
   A. Particle size and air velocity
   B. particle size and bed material
   C. Size of boiler and bed material

D. Size of boiler, bed material and air velocity

10. To start a cold boiler, the bed of FBC boiler is first preheated to around
    A. 340ºC
    B. 440ºC
    C. 540ºC
    D. 740ºC
11. In FBC boilers, the percentage of bottom ash to the total ash is about
    A. 0%
    B.30-40%
    C. 60 -70%
    D. 80 -90%
12. When steam pressure reduces, which of the following increases?
    A. sensible heat
    B. enthalpy of steam
    C. saturation temperature
    D. specific volume
13. Removal of condensate from main steam line is done to prevent to
    A. steam locking
    B. air locking
    C. water hammer
    D. all of the above
14. For flash steam calculation, flash steam quantity availability depends on
    A. condensate pressure and flash steam pressure
    B. steam pressure
    C. steam enthalpy at atmospheric pressure
    D. total heat of flash steam
15. Steam mains should be run with a falling slope of ... in the direction of steam flow for effective line condensate drainage
    A. 50 mm in 30 meters
    B. 125 mm in 30 meters
    C. 250 mm in 30 meters
    D. 350 mm in 30 meters
16. For industrial process heating, the best quality of steam is
    A. dry saturated steam
    B. superheated steam
    C. wet steam
    D. high pressure steam
17. 5 m lift of condensate in steam pipe will result in back pressure of
    A. 0.05 bar
    B. 0.5 bar
    C. 5 bar
    D. 50 bar
18. Walls, roofs and combustion chambers of annealing furnaces are made of _ bricks.
    A. high duty fireclay
    B. silica
    C. mullite
    D. carborundum
19. With the increase in the alumina content, the refractoriness of high alumina refractories
    A. increases
    B. decreases
    C. remains same
    D. may increase or decrease
20. Example for basic type of refractory is
    A. Chrome
    B. chrome magnesite
    C. Alumina
    D. all the above
21. An increase in bulk density of a refractory increases its
    A. thermal conductivity
    C. resistance to slag penetration

B. heat capacity D. all of the above

22. The storage heat losses in a batch type furnace can best reduce by
    A. fire clay brick C. high alumina brick
    B. ceramic fibre D. high silica brick
23. The waste heat boiler application is not suitable in
    A. Gas turbine C. Oil fired furnaces
    B. Diesel engine D. Hot air dryers
24. Recovery of heat from dryer exhaust air is a typical application of
    A. waste heat recovery boiler C. heat wheel
    B. heat pump D. economizer
25. Regenerators utilizing waste heat are widely used in
    A. cement industry C. glass melting furnaces
    B. pulp and paper D. aluminum
26. A heat pipe can transfer up to times more—— thermal energy than copper
    A. 10 B.20
    C. 50 D.100
27. Which one is the preferred waste heat recovery system in a large gas turbine?
    A. economizer C. boiler
    B. air pre heater D. heat wheel
28. A recuperator is used mainly as a waste heat recovery system in a
    A. boiler B. compressor
    C. billet reheating furnace D. none of the above
29. Cogeneration is the simultaneous generation of
    A. heat and power C. steam and condensate
    B. mechanical energy and power D. all of the above
30. The Ranking Cycle is related to
    A. Boiler C. Condenser
    B. Steam turbine D. all of the above
31. A power plant which uses first a gas turbine followed by steam turbine for power generation is called
    A. Rankine cycle C. Brayton cycle
    B. Combined cycle D. Bottoming cycle
32. A paper plant needs steam at 3 bar and 10 bar in addition to electric power. The most suitable cogeneration choice among the following will be
    A. condensing turbine C. extraction cum back pressure turbine
    B. back pressure turbine D. bottoming cycle
33. Which type of fuel can be used in a gas turbine?
    A. light fuel oil C. diesel
    B. natural gas D. all of these
34. How is the efficiency of cogeneration measured?

A. Electrical conversion C. Both (A) and (B)
B. Thermal recovery D. none of these

35. In Cogeneration system, overall high efficiency is achieved from
A. Gas turbine C. Reciprocating engine
B. Back pressure steam-turbine D. Combined cycle

36. Which one of the following is not an example of recuperator type heat exchanger?
A. Automobile radiators C. Chemical factories
B. Condensers D. Oil heaters for an aero plane

37. In a rerolling mill furnace, the typical operating temperature is
A. About 2000°C C. above 2000°C
B. About 1200°C D. About 800°C

38. The dominant mode of heat transfer in reheating furnaces is
A. convection C. conduction
B. wall radiation D. gas radiation

39. A disadvantage of pusher type furnace is due to
A. It cannot be used in steel industry C. High installation cost
B. All round heating of stock is not possible D. High maintenance cost

40. What can happen when flame impinges on the stock in a furnace?
A. The flame can leap out C. Scale losses can increase
B. Air infiltration can occur D. None of the above

41. Which one of the following instrument is required for the performance evaluation of a furnace?
A. Infrared pyrometer C. Low pressure ring gauge
B. Flue gas analyzer D. All of the above

42. Which one of the following is not a continuous waste heat recovery equipment used in a furnace?
A. Ceramic recuperator C. Economizer
B. Metallic recuperator D. Regenerator

43. To improve the boiler efficiency, which of the following needs to be done
A. maximize O_2 in flue gas C. minimize $C0_2$ in flue gas
B. maximize $C0_2$ in flue gas D. maximize CO in flue gas

44. Which one of the following fuels, the difference between the GCV and NCV is maximum?
A. coal C. natural gas
B. furnace Oil D. hydrogen

45. When pure hydrogen is burned with theoretical air, the volume percentage of nitrogen in flue gas on dry basis will be
A. 100% C. 21%
B. 79% D. 0%

46. Deaerator is a _____ heat exchanger.
A. Shell and tube type C. Direct contact type

B. Plate type
D. Run around coil type

47. Which one of the following is used for controlling pressure in a natural draught furnace?
    A. Forced draught fan
    C. Dampers
    B. Induced draught fan
    D. Both (A) and (B)
48. In a boiler, air preheater is installed
    A. before the economizer
    C. after ESP
    B. after economizer
    D. before superheater
49. 1% of the fuel is saved in boiler fuel consumption, if the feed water temperature is increased by
    A. 4ºC
    C. 9ºC
    B. 6ºC
    D. 10ºC
50. For which fuel among the following needs temperature control during storage?
    A. coal
    C. furnace oil
    B, diesel oil
    D. kerosene

Section B: Short Question

1. In the context of FBC boiler, what is slip velocity? Whats are its advantages? 05
2. A process requires 5000 kg/h of dry saturated steam at 7 kg/cm^2 (g). For the flow velocity not exceeding 25 m/s, determine the pipe size. [Specific volume at 7 kg/cm^2 (g) is 0.24 m^3/kg]. 05
3. Assume we have a $^1/_2$ inch thick uninsulated mild steel tank storing a hot fluid. K value for mild steel is 314.4 Btu.in/ft^2.h.ºF. The tank is 10 ft in diameter and 10 ft tall. Find the R-value for the tank? 05
4. What are characteristics for the best heat-recovery opportunities? 05
5. Draw a schematic diagram of a combined cycle power plant with corresponding T-s diagram. 05
6. A cogeneration plant has an electrical output of 4MW with a back pressure turbine which has a input steam conditions to the turbine as 27 TPH with enthalpy of 3418 KJ/kg @ 64 ata and 500°C and the exit conditions of steam at the end of the back pressure turbine is 186°C, with 5 enthalpy of 2835.8 KJ/kg. After the process heating, all the condensate @ 73°C returns to the boiler. Calculate the heat to power ratio and energy utilization factor of the process. Fuel consumption of the boiler is 6.5 TPH coal at 4800 GCV. 05
7. Name three types of steam traps and also give their principle of operation? 05
8. List, all Losses in boilers 05

Section C: Long Descriptive Question

1. One kg of water is heated from 250K to 400 K at one standard atmosphere pressure. How much heat is required for this? The mean heat capacity of ice between 250 K and 273 K is 2.037 kJ/kg K, the mean heat capacity of water between 273 K and 373 K is 75.726 kJ/kmol K and the heat capacity of water vapor (kJ/kmol K) is
$C_p = 30.475 + 9.652 \times l0^{-3} T + 1.189 \times 10^{-6} T^2$,
Where, T is in K. The latent heat of fusion and vaporization of water are, respectively, 6012 kJ/kmol and 40608 kJ/kmol. 10

2. The following data have been obtained from a steel rerolling mill for melting 5 tons of steel from an ambient temperature of 30°C. Specific heat of steel = 0.18 Wh/kg°C, Latent heat for melting of steel = 40 Wh/kg. The melting point of steel = 1650°C
Total electricity consumed = 4500 kWh. Find out the furnace efficiency. 10

3. Draw a block diagram to show heat recovery from boiler blow-down. 10

4. A food containing 80% water is to be dried at 100°C down to moisture content of 10%. If the initial temperature of the food is 21°C, calculate the quantity of heat energy required per unit weight of the original material, for drying under atmospheric pressure. The latent heat of vaporization of water at 100°C and at standard atmospheric pressure is 2257 kJ/kg. The specific heat capacity of the food is 3.8 kJ/kg°C and of water is 4.186 kJ/kg°C. Find also the energy requirement/kg water removed. 10

5. Explain the main features with reference to fuel feeding system and air distribution system for a FBC boiler. 10

6. A counter flow double pipe heat exchanger using hot process liquid is used to heat water which flow at 20 m^3/hr. The process liquid enters the heat exchanger at 180°C and leaves at 130°C. The inlet and exit temperatures of water are 30°C and 90°C. Specific heat of water is 4.187 kJ/kg K. Calculate the heat transfer area if overall heat transfer coefficient is 820 W/m^2 K. What would be the percentage increase in the area if fluid flow were parallel assuming same overall heat transfer coefficient? 10