Regn No: ___________________

Name : ___________________
(To be written by the candidate)

17th NATIONAL CERTIFICATION EXAMINATION
FOR
ENERGY MANAGERS & ENERGY AUDITORS – September, 2016

PAPER – 2: Energy Efficiency in Thermal Utilities		
Date: 24.09.2015	**Timings: 1400-1700 HRS**	**Duration: 3 HRS**

General instructions:

- *Please check that this question paper contains **8** printed pages*
- *Please check that this question paper contains **64** questions*
- *The question paper is divided into three sections*
- *All questions in all three sections are compulsory*
- ***All parts of a question should be answered at one place***

1.	Which zone of Cupola furnace prevents the oxidation of stock? a) Combustion zone b) Melting zone c) **Reduction zone** d) Preheating zone
2.	Which trap is preferred in flash vessels during condensate recovery? **a) Float trap** b) Thermodynamic trap c) Thermostatic trap d) All of the above
3.	Which trap is preferred in discharge of condensate recovery from process equipment? **a) Float trap** b) Thermodynamic trap c) Thermostatic trap d) All of the above

4.	Which property of the liquid fuel determines the requirement of preheating of fuel? **a) Viscosity** b) Density c) Moisture d) Calorific value
5.	Which of these is not true of 'critical point' of steam/water mixture? a) the temperature at critical point is 374.15^{o}C b) the pressure at critical point is 221.2 bar c) saturated liquid and saturated vapour lines meet at critical point **d) enthalpy of evaporation is maximum at critical point**
6.	Which of the following is not required for determining economic thickness of insulation in a steam line? a) Cost of fuel b) Boiler efficiency **c) Quantity of Steam** **d)** Calorific value of fuel
7.	Which of the following is considered in the calculation of 'Evaporation ratio'? a) calorific value of fuel b) latent heat of steam **c) fuel quantity** d) all of the above
8.	Which of the following is a temperature dilutant in fuel combustion? a) Moisture content b) Ash content **c) Nitrogen content** d) Sulphur content
9.	Which of the following insulation material can be used at high temperature (1200°C)? a) Calcium silicate b)Mineral wool **c) Ceramic fibre** d**)** All of the above
10.	Which of the following fuels has the least viscosity? a) Furnace Oil b) Diesel

	c) Kerosene **d)** Crude Oil
11.	Which of the following factor is critical for FBC boilers? a) Pressure of Fluidisation air b) Critical fluidisation Velocity c) Size of fuel particles d) **All of the above**
12.	Which of the following depends on physical properties of fluids as well as geometry of the heat exchanger? **a) Overall heat transfer coefficient** b) Fouling coefficient c) LMTD (Log Mean Temperature Difference) d) Effectiveness
13.	Which fuel among the following has the maximum moisture content? a) Anthracite coal **b) Lignite** c) Bituminous coal d) Rice husk
14.	Which Boiler utilises a combination of suspension burning & grate burning? **a) Spreader stoker Boiler** b) Pulverised Fuel Boiler c) Chain grate Boiler d) FBC Boiler
15.	Which causes alkaline hardness **a) bicarbonates of Ca and Mg** c) Chlorides of Mg and Ca b) Silicates d) nitrates of Ca and Mg
16.	Water logging of 2 m lift of condensate at trap discharge will result in back pressure of

	____ a) 0.02 kg/cm^2 **b) 0.2 kg/cm^2** c) 2 kg/cm^2 d) 20 kg/cm^2
17.	Velocity of steam in steam pipe is directly proportional to; a) number of bends in pipe **b) specific volume of steam** c) length of pipe d) diameter of the pipe
18.	The working media in a thermo-compressor is a) electricity b) compressed air c) high temperature oil **d) steam**
19.	The turbine heat rate is expressed as a) kWh/kCal b) kg/kCal **c) kCal/kWh** d) none of the above
20.	The major limitation of metallic recuperator is ------- a) limitation of handling CO_x, NO_x etc. **b) limitation of reduced life for handling temperature more than 1000^oC** c) manufacturing difficulty of the required design d) none of the above
21.	The insulation used for temperatures more than 350^oC a) Polyurethane b) polystyrene **c) Calcium silicate** d)magnesia
22.	The heat loss in a furnace depends on a) Emissivity of walls b) Conductivity of refractory c) Wall thickness d) **All of the above**
23.	The head loss due to friction in a pipe is a) directly proportional to the diameter b) directly proportional to the gravitational constant c) inversely proportional to the velocity d) **directly proportional to the square of velocity**

24.	The Furnace efficiency decreases with **a) Increase in flue gas temperature** b) Decrease in excess air c) Decrease in surface losses d) All of the above
25.	The effectiveness of insulation with ingress of moisture would a) increase **b) decrease** c) may increase or decrease depending on temperature and thickness of insulation d) remain unaffected
26.	The cost of coal handling increases with increase in a) Fixed carbon content **b) Ash content** c) Volatile matter d) Sulphur content
27.	The ability of the material to absorb & radiate heat is ______. **a) Emissivity** b) Porosity c) Thermal conductivity d) Bulk density
28.	Sulphur percentage in furnace oil a) **sets lower flue gas temperature limit** b) improves viscosity c) does not add to heat value d) forms soot above
29.	Select the odd one among the following a) Condenser b) Distillation tower c) Evaporator d) **Economiser**
30.	Scale losses in reheating furnaces will a) **Increase with increase in both excess air and Temperature** b) Decrease with decrease in both excess air and Temperature

	c) Have no relation with excess air and Temperature d) Increase with CO in combustion gases
31.	Indirect method of Boiler efficiency estimation doesn't include ____. a. Radiation loss **b. Blow down loss** c. Stack (flue gas) loss d. Unburnt loss
32.	In an FBC boiler with low ash fusion coal, if the bed temperature exceeds 950°C, the result is: a) Low steam temperature **b) clinker formation** c) Melting of lime stones d) Ash carry over
33.	In a turbine, the thermodynamic process taking place is a) contraction **b) expansion** c) condensation d) all the above
34.	In a CFBC boiler the capture and recycling of bed material is accomplished by a) Bag filter b) Settling chamber c) **Cyclone** d) Scrubber system
35.	In a boiler Air preheater is installed a) Before the economizer **b) after economizer** c) after ESP d) Before superheater
36.	Ideal furnace for melting & alloying of special steels is a**) induction furnace** b) Cupola furnace c) rotary hearth d) recirculating bogie furnace
37.	Hardness of the Boiler feed water can be removed by ____ process. a) De-aeration **b) Ion-exchange** c) Sand bed filters d) All of the above

38.	Enthalpy of Evaporation of any vapour at its Critical Point will be a) Maximum **b) Zero** c) Less than zero d) Unpredictable
39.	Electrical energy consumption for coal sizing will be maximum for a) stoker fired boiler b) AFBC boiler c) CFBC boiler **d) pulverised coal boiler**
40.	Draft caused due to difference in density of the flue gas inside the furnace & density of air outside the furnace is ____. a) Forced draft b) Induced draft c) Balanced draft **d) Natural draft**
41.	Corrosion in stack, Air Pre-Heater, Economizer is mainly influenced by _____ **a) Sulphur content in fuel** b) Ash content in fuel c) Moisture content in fuel d) All of the above
42.	Controlled wetting of coal (during the coal preparation) would result in a) reduction in flue gas exit temperature b) decrease in the percentage of unburnt carbon c) improper combustion d) **increase in the fines of coal**
43.	Bottoming cycle cogeneration is characterised by **a) Heat first power later** b) Only Heat c) Power First and Heat Later d) Only Power
44.	Automatic air vents in steam system operates on the principle of _____ .

	a) Thermodynamic **b) Thermostatic** c) Mechanical d) All of the above
45.	As the pressure increases from 1kg/cm2 to 8 kg/cm2, the values of enthalpy of steam and enthalpy of evaporation respectively a) Increases & remains the same **b) increases & decreases** c) Decreases & increases d) decreases & remains the same
46.	Arrange the following fuels by their GCV in decreasing order- (p)Rice husk, (q) Diesel, (r) Grade-C Coal, (s)Hydrogen **a) s-q-r-p** b) p-q-r-s c) r-s-q-p d) q-r-s-p
47.	An increase in bulk density of a refractory increases its a) Volume stability b) Heat capacity c) Resistance to slag penetration d) **All of the above**
48.	A rise in conductivity of boiler feed water indicates a) drop in the total dissolved solids in boiler water b) more steam generation c) **rise in the total dissolved solids in boiler water** d) greater purity of feed water
49.	1% of the fuel is saved in boiler fuel consumption, if the feed water temperature is increased by a) 4^0C b) 9^oC **c) 6^oC** d) 10^oC
50.	_____ is required for the simple estimation of flame temperature of the fuel. **a) Ultimate analysis** b) Proximate analysis c) Size of the coal d) All of the above

-------- End of Section - I ---------

Section - II: SHORT DESCRIPTIVE QUESTIONS

S-1	Calculate pressure drop in meters when pipe diameter is increased from 250 mm to 350 mm for a length of 100 meters. The water velocity is 2 m/s in the 250 mm diameter pipe, and friction factor is 0.005 in both cases
Ans	Pressure drop = $(4\ f\ L\ V^2) / (2\ g\ D)$ Pressure drop with 250 mm = $(4 \times 0.005 \times 100 \times 2^2) / (2 \times 9.81 \times 0.25)$ = 1.63 m Velocity is inversely proportional to square of Diameter $V_1 / V_2 = D_2^2 / D_1^2$ Velocity in pipe of 350 mm dia = (0.25 x 0.25 x 2) / (0.35 x 0.35) = 1.02 m/s Pressure drop with 350 mm = 4 x 0.005 x 100 x 1.02 / (2 x 9.81 x 0.35) = 0.29 m Pressure drop reduction = 1.6 – 0.3 = 1.3 m
S-2	A 50 kg/hr of methane is burnt with 10% excess air in a heat treatment furnace. The flue gas temperature at the outlet of furnace is 400^0C.It is proposed to reduce the flue gas temperature to 150^0C by installing a waste heat recovery device to preheat water to 80^0C. Additional information: Specific heat of flue gas=0.24 kCal/kg^{0}C Heat exchanger efficiency=95%, water inlet temperature=30^0C, water outlet temperature=80^0C. 1-What is the total weight of flue gas generated? 2- How much quantity of heat is available in flue gas for recovery ? 3- How much quantity of water can be heated?
Ans	(1) $CH_4 + 2O_2 = 2H_2O + CO_2$ (12+4) +2(32) = 2(2+16) +(12+32) 16 kg of methane require 64 kg of O_2 50 kg of methane require (64/16)*50 = 200kg of O_2 Therefore, Air (Theoretical) required = (100/23)*200 = 869.5 kg Excess Air @ 10% = 86.95 kg Therefore, Total flue gas = total theoretical air+ Excess air + fuel burnt = 869.5+86.9+50 = 1006.4 kg 2) Heat recovered from flue gas: mcpΔt 1006.4* 0.24*(400-150) = 60384kCal/hr.

	(3) Quantity of water: $mcp\Delta t$ = 60384kCal/hr. , m = 60384*.95/80-30 = 1147kg/hr. ***or*** <u>LONG CALCULATION:</u> CO_2 produced = (44/16)*50= 137.5 kg H_2O produced = (36/16)*50= 112.5 kg Nitrogen in theoretical air = 869.5*77/100= 669.5kg Total flue gas = CO_2 +H_2O +N_2+Excess air 137.5+112.5+669.5+86.95 = 1006.4 kg. (2) Heat recovered from flue gas: $mcp\Delta t$ 1006.4* 0.24*(400-150) = 60384kCal/hr. (3) Quantity of water: $mcp\Delta t$ = 60384kCal/hr. , m = 60384*.95/80-30 = 1147kg/hr.
S-3	a) Explain why de-superheating is done after pressure reduction in PRVs? b) Why correction factor is required for estimation of LMTD?
Ans	a) A reduction in steam pressure through a pressure reducing valve (PRV) is an isenthalpic process. Saturated steam when reduced to a lower pressure results in super heated steam. Since process requires only saturated steam, de-superheating is often required, to compensate for superheat gained in PRV application due to isenthalpic expansion. b) In multi pass shell and tube heat exchangers, the flow pattern is a mixture of co-current and counter current flow, as the two streams flow through the exchanger in the same direction on same passes and in the opposite on others. For this reasons, the mean temperature differences is not equal to the logarithmic mean. However it is convenient to retain the LMTD by introducing a correction factor, F which is appropriately termed as the LMTD correction factor.
S-4	A gas turbine of 20 MW Capacity was running with Naphtha as its fuel. In order to reduce emissions, the firm has decided to replace Naphtha fuel with Natural Gas. The cost of power generation using Naphtha was Rs 9.2 per unit. If the efficiency of the Gas Turbine remains at 35%, calculate the percentage reduction in cost of generating electricity after switching to Natural gas. GCV of Natural gas = 10800 kCal/kg Cost of Natural Gas = Rs 36000/ton
Ans	Gas turbine output = 20 * 1000 = 20,000 KW = 20000 * 860 Kcal/hr = 1,72,00,000 Kcal/hr Efficiency of gas turbine = 35 % Heat input to the GT = 17200000 / 0.35 = 4,91,42,857 Kcal/hr Natural gas consumption = 49142857 / 10800 = 4550 kg/hr (or) 4.55 Tons/hr

	Cost of generation of electricity = 4.55 * 36000 = Rs. 1,63,800 Cost of one unit of electricity generated = 163800 / 20000 = Rs 8.2 per KW % Savings in cost of electricity = (9.2 – 8.2) / 9.2 x 100 = 10.8 %
S-5	In a paper industry, 1.5 Tons/hr of saturated steam at 8 bar is used for preheating 25 Tons/hr of Soda liquor in a heat exchanger. Soda liquor enters the heat exchanger at 55°C and the specific heat of the liquor is 0.38 Kcal/Kg°C. Calculate the exit temperature of the soda liquid leaving the heat exchanger & the LMTD of the exchanger with the following data from steam table, <table><tr><th rowspan="2">Pressure, bar</th><th rowspan="2">Temperature, °C</th><th colspan="3">Enthalpy kcal/kg</th></tr><tr><th>Water</th><th>Evaporation</th><th>Steam</th></tr><tr><td>8.0</td><td>170</td><td>170</td><td>490</td><td>660</td></tr></table>
Ans	Heat lost by saturated steam = 1.5 * 1000 * 490 = 7,35,000 Kcal/hr Heat gain by soda liquor = 735000 Kcal/hr m * Cp * ($T_1 – T_2$) = 735000 ($T_1 – T_2$) = 735000 / (25*1000*0.38) Temperature difference = 77.4 °C Exit temperature of Soda liquor = 77.4 + 55 = 132.4 °C Exit temperature of Soda liquor = 132.4 °C <u>LMTD of Counter flow:</u> LMTD calculation = ((170-55)-(170-132.4)) / ln ((170-55)/(170-132.4)) = 69.2°C LMTD of the heat exchanger is 69.2°C
S-6	Two identical oil fired boilers of capacity 100 TPH are operated in a refinery. They have a full load efficiency of 90%. The part load efficiencies at 70% and 40% load are 75% and 65% respectively. For meeting 140 TPH requirement of steam, which one of the case would you prefer to run and estimate the % savings in the preferred case. The enthalpy of steam generated is 550 Kcal/kg and feed water

	enters the boiler at 50°C in all the cases. Calorific value of the fuel oil is 10,000 Kcal/hr. Case 1: both the boilers operated at 70 TPH capacity each. Case 2: one at full load capacity and other at 40% capacity.
Ans	Case-1: Amount of Fuel energy required when both the boilers are run at 70% load i.e, at 70 TPH load Enthalpy change = (550 – 50) = 500 Kcal/kg = (2 * 70 * 1000 * 500)/ (0.75 * 10000) = 9333 Kg/hr (or) 9.33 Tons/hr Case-2: Amount of Fuel required when one boilers is running at full load at 100 TPH and other at part load of 40 TPH Enthalpy change= (550 – 50) = 500 Kcal/kg = (100 * 1000 * 500) / (0.9*10000) + (40 * 1000 * 500) / (0.65*10000) = 5555 + 3077 = 8632.5 Kg/hr (or) 8.632 Tons/hr Fuel required for Case 2 is less & hence Case 2 is preferred % Fuel Savings = (9.33 – 8.63) / 9.33 x 100 = 7.5 %
S-7	A cogeneration plant has an electrical output of 5 MW with a back pressure turbine which has a input steam conditions to the turbine as 32 TPH with Enthalpy of 3418 KJ/kg @ 64 ata and 500^{o}C and the exit conditions of steam at the end of the back pressure turbine is 186^{o}C, with enthalpy of 2835.8 KJ/kg. After the process heating, all the condensate @ 73^{0}C returns to the boiler. Calculate the Heat to power Ratio and Energy Utilization factor of the process. Fuel consumption of the boiler is 8.2 TPH Coal at 4800 GCV.
Ans	Heat to power Ratio = 32*((2835.8/4.18)-73)/(5*860) = 4.5 Energy Utilization Factor = (32* ((2835.8/4.18)-73) + 5*860))/(8.2*4800) = 68.7%
S-8	List down any five good practices in Furnaces for energy efficiency
Ans	a) Improve capacity Utilisation b) Minimise Excess air c) Minimise heat loss due to radiation, walls and openings d) Adopt Waste heat recovery e) Ensure Complete combustion

	f) Maintain Furnace in slightly positive pressure g) Adopt Variable frequency drives for fans h) Optimise cycle time. i) Emissivity Coatings

Section - III: LONG DESCRIPTIVE QUESTIONS Marks: 6 x 10 = 60

(i) Answer all SIX questions
(ii) Each question carries **Ten** marks

<table>
<tr><td>L-1</td><td>A chilled water vapour compression system is used for air conditioning control room of process plant . The chilled water flow rate is 10.5 liters/ Sec the temperature difference across the evaporator is 4^0C .

High pressure condensate from process is available at 12 bar and 2.5 tph. The condensate is to be flashed to low pressure steam at 2.5 bar in a flash vessel. Find out the quantity of flash steam that can be generated .The flash steam is to be used for operating a vapour absorption system to replace the existing vapour compression system.

Calculate the potential annual cost savings with the following data

• Sensible heat of high pressure condensate = 194.58 kcal /kg
• Sensible heat of low pressure steam = 139.55 kcal /kg
• Latent heat of low pressure steam = 512.89 kcal /kg
• Electricity cost = Rs 7 / kWh
• Specific power consumption for the vapour compression system = 1.1 kW /TR
• Specific steam consumption of the Vapour absorption system = 5 kg/TR
• Specific power consumption for Vapour absorption system = 0.2 kW/TR
• Investment for flash recovery system and vapour absorption system = Rs 40 lakh.

Number of operating hours = 6000 hrs</td></tr>
<tr><td>Ans</td><td>TR of the existing vapour compression system = (10.5x3600 x 4)/ 3024 = 50 TR

Flash steam available = S1- S2/L2 =((194.58 – 139.55)/ 512.89) x 100= 10.7%

Quantity of flash steam = 0.107 x 2500 = 268.2 kg/hr

TR with VAR = 268.2 / 5 = 53.65 TR

Savings

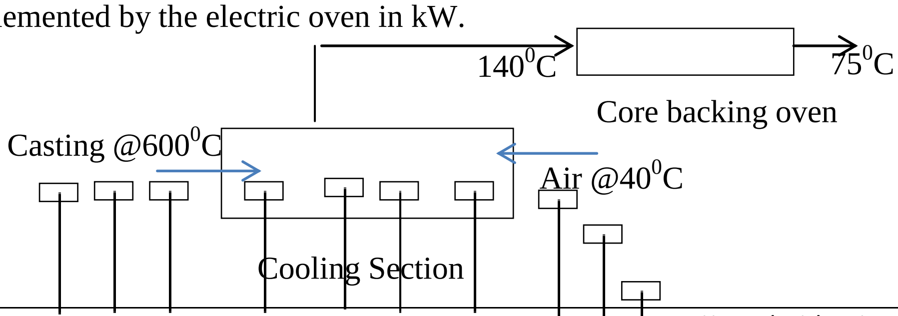
Cost of operating vapour compression system = 50 x 1.1 x 6000 x Rs 7 = Rs 23.1 lakh</td></tr>
</table>

	Cost of operating VAR = 0.2 x 50 x 6000 x 7 = Rs 4.2 lakh Net savings = 23.1 – 4.2 = 18.9 lakhs Payback period = 40 / 18.9 = 2.1 yrs = 25 months
L-2	A textile plant is using furnace oil as fuel for firing in the boiler, generating steam on an average of 30T/hr. The unit has decided to take advantage of ECerts under PAT and accordingly decided to switch over to natural gas as fuel. The boiler feed water temperature is 60^{o}C and the enthalpy of steam is 660 kCal/kg. The other data are as under: <u>Furnace oil</u> GCV of furnace oil; 10200kCal/kg Cost of furnace oil: Rs 20000/T %Carbon in furnace oil: 84 Efficiency of furnace oil: 82% <u>Natural Gas</u> Gross Calorific value of Natural gas: 9500kCal/ (Sm^3) Density of natural gas: 0.8kg/Sm^3 Cost of natural gas: Rs.20/Sm^3 % carbon in natural gas: 74 Annual operating hrs.: 8000 Efficiency of natural gas boiler: 86% Calculate the followings: (a) Which fuel is cheaper? (b) Reduction in GHG emissions?
Ans	<u>Fuel oil fired boiler</u> Kg of CO_2/kg of oil = 0.84*44/12 = 3.08 Heat output of boiler = 30000*(660-60) = 18 million kCal/hr. Heat input to boiler = 18/0.82 = 21.95 million kCal/hr Furnace oil consumption = 21.95*10^6/ 10200 = 2.152T/hr. CO_2 emission with furnace oil = 2,152* 3.08 = 6.628T/hr. <u>Gas fired Boiler</u> Kg of CO_2/kg of gas = 0.74*44/12 = 2.71 Heat input to boiler = 18/0.86 = 20.93 million kCal/hr Natural gas consumption = 20.93* 10^6/9500 = 2203 Sm^3/hr = 2203*0.8/1000 = 1.7624T/hr. CO_2 emission with natural gas= 1.7624*2.71 = 4.776T/hr. Annual cost of furnace oil = 2.152*8000*20000 = Rs.34.432 Crore Annual cost of natural gas = 2203*20*8000 = Rs. 35.248 Crore Fuel oil fired boiler is cheaper than gas fired boiler by Rs. (35.248- 34.432)=Rs.81.6 lakhs

Annual CO_2 reduction = (6.628-4.776)*8000 = 14816 T/y

L-3 In a foundry industry, casting are heated to 600^0C in pusher type Heat Treatment furnace at the rate of 1 Ton / hr . The castings after heat treatment are cooled down to $50\ ^0$ C by blowing ambient air @ $40\ ^0$ C through blowers in the cooler section. The temperature of hot air is 140 ^{0}C leaving the cooler section. Specific heat of air is 0.23 kcal/kg ^oC and of casting is 0.12 kcal/kg ^oC.

There is a continuous core baking oven nearby using 50KW electrical heater with 90% efficiency. There is proposal to utilize the hot air from the cooling section of the furnace for core baking oven. The hot air will enter the oven at $140\ ^0C$ and leaving at $75\ ^0$ C . The efficiency of the oven using hot air will be 80%. Evaluate if the heat available in the hot air is adequate to meet the heat requirement of the oven . If not calculate the additional heat to be supplemented by the electric oven in kW.



Ans

Heat requirement in the electric oven = 50 kW x 860 ((kcal/hr)/kW) = 43,000 kcal /hr

Efficiency of the electric core baking oven = 90%

Total heat required for the core drying = 43000 x 0.9 = 38700 kcal/hr

Heat given by the casting to cooling air = 1000 kg/hr x 0.12 kcal/kg ^oC x (600 -50)

= 66000 kcal /hr

Quantity of casting cooling air required = 66000 / 0.23 x (140-40) = 2870 kg /hr

Heat available = 2870 x 0.23 x (140-75) = 42907 kcal/hr

Efficiency of the oven using hot air = 80%

Amount of heat required for hot air oven = 38700 / 0.8 = 48375 kcal / hr

Additional heat required = 48375 - 42907 = 5468 kcal/hr

Capacity of electrical heater (same efficiency)

	required for additional heat = 5468 / (860x0.9) = 7.06 kW
L-4	An oil fired Boiler is generating 100 TPH of steam at 85% efficiency, operating 330 days in a year. Management has installed a water treatment plant at Rs. one crore investment for reducing the TDS in boiler feed from 450 ppm to 150 ppm. The maximum permissible limit of TDS in the boiler is 3000 ppm and make up water is 10%. Temperature of blow down water is 175°C and boiler feed water temperature is 45°C. Calorific value of Fuel oil is 1200 Kcal/kg. Calculate the payback period if the cost of fuel is Rs.20000 per ton.
Ans	Blow down % = Feed water TDS * % make up water * 100 / (maximum permissible TDS in boiler water – Feed water TDS) Initial blow down = 450 * 10 / (3000 – 450) Initial blow down = 1.76 % Improved blow down = 150 * 10 / (3000 – 150) Improved blow down = 0.53 % Reduction in blow down = 1.76 – 0.53 Reduction in blow down = 1.24 % Reduction in blow down = 1.24 * 100 * 1000 / 100 Reduction in blow down = 1238 kg/hr Specific heat of water is 1 kcal/kg°C Heat savings = m * Cp * (T_1 – T_2) = 1238 * 1 * (175 – 45) Heat savings = 160991 kcal/hr Fuel Oil saving = 160991 / (1200 * 0.85) = 157.83 kg/hr = 157.83 * 24 * 330 / 1000 = 1250.01 MT / annum Fuel Oil – cost savings = 1250.01 * 20000 = Rs. 250 lakh

	Investment on water treatment plant = Rs. 1 Crore Payback period = 1 / 0.25 Payback period = 0.4 years (or) 5 months
L-5	a) Explain the process of Mechanical de-aeration and chemical de-aeration b) How does an energy auditor assess the performance of steam trap during energy audit?
Ans	**a)** **Mechanical de-aeration** Mechanical de-aeration for the removal of these dissolved gases is typically utilized prior to the addition of chemical oxygen scavengers. Mechanical de-aeration is based on Charles' and Henry's laws of physics. Simplified, these laws state that removal of oxygen and carbon dioxide can be accomplished by heating the boiler feed water, which reduces the concentration of oxygen and carbon dioxide in the atmosphere surrounding the feed water. Mechanical de-aeration can be the most economical. They operate at the boiling point of water at the pressure in the de-aerator. They can be of vacuum or pressure type. The vacuum type of de-aerator operates below atmospheric pressure, at about 82°C, can reduce the oxygen content in water to less than 0.02 mg/litre. Vacuum pumps or steam ejectors are required to maintain the vacuum. The pressure-type de-aerators operates by allowing steam into the feed water through a pressure control valve to maintain the desired operating pressure, and hence temperature at a minimum of 105°C. The steam raises the water temperature causing the release of O_2 and CO_2 gases that are then vented from the system. This type can reduce the oxygen content to 0.005 mg/litre. Where excess low-pressure steam is available, the operating pressure can be selected to make use of this steam and hence improve fuel economy. In boiler systems, steam is preferred for de-aeration because: • Steam is essentially free from O_2 and CO_2 • Steam is readily available • Steam adds the heat required to complete the reaction. **Chemical de-aeration** While the most efficient mechanical deaerators reduce oxygen to very low levels (0.005 mg/litre), even trace amounts of oxygen may cause corrosion damage to a system. Consequently, good operating practice requires removal of that trace oxygen with a chemical oxygen scavenger such as sodium sulfite or hydrazine. Sodium sulphite reacts with oxygen to form sodium sulphate, which increases the TDS in the boiler water and hence increases the blow down requirements and make-up water quality. Hydrazine reacts with oxygen to form nitrogen and water. It is invariably used in high pressures boilers when low boiler water solids are necessary, as it does not increase the TDS of the boiler water. **Ref page no 47**

	b) Steam trap performance assessment is basically concerned with answering the following two questions: • Is the trap working correctly or not? • If not, has the trap failed in the open or closed position? Traps that fail 'open' result in a loss of steam and its energy. Where condensate is not returned, the water is lost as well. The result is significant economic loss, directly via increased boiler plant costs, and potentially indirectly, via decreased steam heating capacity. Traps that fail 'closed' do not result in energy or water losses, but can result in significantly reduced heating capacity and/or damage to steam heating equipment. **The three performance test methods of steam traps are** **1. Visual testing,** **2. Sound Testing** **3. Temperature testing** **Ref page no 95**
L-6	Answer the following: (a) Explain why dry saturated steam is preferred over wet or superheated steam for industrial process heating. (b) Why should one use dry saturated steam at the lowest possible pressure for indirect steam heating? (c) What are the two major advantages of direct injection of steam for heating of liquid? (d) Why drain points are required in a steam system? (e) What is flash steam?
Ans	a) Dry saturated steam is the preferred choice because: • Wet steam has a lower heat content than dry steam. • Superheated steam gives up heat at a slower rate than saturated steam. • Dry steam alone condenses quickly, thereby providing a higher heat transfer rate. b) The latent heat of steam increases with reduction of steam pressure and it is only the latent heat that is transferred during indirect heating applications. c) • No condensate recovery system is necessary • The heating is quick, and the sensible heat in the steam is also used up along with the latent heat, making the system thermally more efficient. d) The drain points help in removing water in pipes due to condensation of steam. e) Flash steam is produced when condensate at a high pressure is released to a lower pressure.

…………. End of Section – III …………..