MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION
(Autonomous)
(ISO/IEC - 27001 - 2005 Certified)

Summer-17 EXAMINATION

Model Answer

Subject Title: Energy Management Subject code : 17559

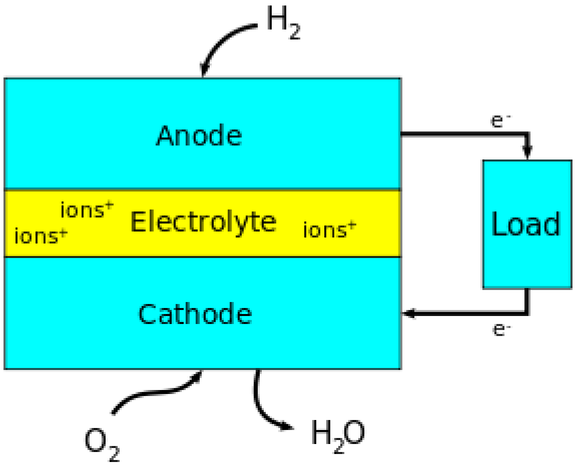
Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based one quivalent concept.

Q No.	Answer	Marks
1 A	**Attempt any three**	**12**
a)	**Primary energy** is an energy form found in nature that has not been subjected to any conversion or transformation process. The primary energy sources are derived from: the sun, the earth's heat, the wind, water (rivers, lakes, tides, and oceans), fossil fuels - coal, oil, and natural gas, biomass, and radioactive minerals. **Secondary energy** Secondary energy refers to the more convenient forms of energy which are transformed from other, primary, energy sources through energy conversion processes. Examples are electricity, which is transformed from primary sources such as coal, raw oil, fuel oil, natural gas, wind, sun, streaming water, nuclear power, gasoline etc. **OR** **Conventional Energy sources:** These sources are exhaustible after use. e.g Coal, crude oil, Gas **Non-Conventional energy sources:** These sources can renew again and again. e.g Solar, Wind, Biomass, Hydro	2 2
b)	**Energy generated from tide and ocean:** Tidal: The technology required to convert tidal energy into electricity is comparable to technology used in traditional hydroelectric power plant. The first requirement is a dam across the tidal bay. Best sites are those where a bay has a narrow openings, thus reducing the	2

	length of dam required.Gates and turbines are installed. When there is a adequate difference in the level of the water on the different sides of the dam , the gates are opened.This causes water to flow though the turbines , turning the generator to produce electricity. Electricity produced by water flowing both inwards and out of a bay. There are periods of maximum generation every 12 hrs. , with no electricity generation at the 6 hrs. mark in between. The turbines may also used pumps to pump extra water into the basin behind the dam at times when demand on electricity is low.This water can later be released when the demand on the system is very high. **From ocean:** Ocean thermal energy conversion (OTEC): Is a method for generating electricity which uses the temp. difference that exist between deep and shallow water to run heat engine. As with any heat engine, the greatest efficiency and power is produced with the largest temp. difference. This temp difference increases with decreasing latitude. Evaporation prevent the surface temp from exceeding 27 deg. C .also the subsurface water rarely falls below 5 deg. C. The earth`s ocean are continuously heated by sun. this temp difference contains a vast amount of solar energy	2
c)	**Instruments used for energy audit:** • Electrical measuring instruments- to measure current, voltage, power, PF • Combustion analyzer- For flue gas analysis • Thermometer (contact thermometer)- For temperature measurement • Infrared thermometer- For temperature measurement • Flow meter – Doppler effect, ultra sonic – for flow measurement	1 mark each for any 4

	• Leak detector- To find change in pressure • Lux meter – to measure intensity of light	
d)	**Fuel cell** Fuel cells come in many varieties; however, they all work in the same general manner. They are made up of three adjacent segments: the anode, the electrolyte, and the cathode. Two chemical reactions occur at the interfaces of the three different segments. The net result of the two reactions is that fuel is consumed, water or carbon dioxide is created, and an electric current is created, which can be used to power electrical devices, normally referred to as the load. At the anode a catalyst oxidizes the fuel, usually hydrogen, turning the fuel into a positively charged ion and a negatively charged electron. The electrolyte is a substance specifically designed so ions can pass through it, but the electrons cannot. The freed electrons travel through a wire creating the electric current. The ions travel through the electrolyte to the cathode. Once reaching the cathode, the ions are reunited with the electrons and the two react with a third chemical, usually oxygen, to create water or carbon dioxide.	**4**

		
1B	**Attempt any one**	**6**
a)	**Power factor**	
	The power factor of an AC electrical power system is defined as the ratio of the real power flowing to the load to the apparent power in the circuit, and is a dimensionless number between 0 and 1.	1
	It is calculated by following formula	
	P = √3 x V x I x PF	1
	Given : active power P = 55 kW V = 415 V , I = 80 Amp.	
	Apparent power =[√3 x V x I] / 1000 =[√3 x 415 x 80] / 1000 = 57.50 kW	2

	Power factor = active power / apparent power = 55/ 57.50 = **0.9565**	2
b)	**Modes of heat transfer** 1. Conduction 2. Convection and 3. Radiation **CONDUCTION** Conduction is the mode of heat transfer occurs from one part of a substance to another part of within the substance itself or with another substance which is placed in physical contact. In conduction, there is no noticeable movement oof molecules. You ight be think that then how this heat tranbsfer occurs? The heat transfer occurs here by the two mechanisms happen. 1. By the transfer of free electrons. (Good conductors like metals have a plenty of free electrons to make conductive heat transfer. 2. The atoms and molecules having energy will pass those energy they have with their adjacent atoms or molecules by means of lattice vibrations. **CONVECTION** Conductive heat transfer occurs within a fluid itself and it is carried out by transfer of one fraction of the fluid to the remaining portion. Hence unlike conduction, transfer of molecules occurs during convection. Since movement of particles constitutes convection, it is the macro form of heat transfer. Also convection is only [possible in fluids where the particles can moved easily and the rate of convective heat transfer depends on the rate of flow to a great extend. Convection can be of two types:	2 2

1. Natural convection: In this type of convection, the movement of particles which constitutes convection occurs by the variation in densities of the fluids. As we already know, as temperature increases, the density decreases and this variation in density will force the fluid to move through the volume. This cause convection to occur.

2. Forced Convection: The difference between natural convection and forced convection is that in forced convection, a work is done to make movement in the fluid. This is done using a pump or blower.

RADIATION

Radiation is the third mode of heat transfer. This mode of heat transfer didn't require any medium to occur. Every matter having a temperature, pressure above absolute zero will emit energy in the form of electromagnetic waves and called radiation. It is the same way the energy of the Sun reach us. The key features about radiation are it does not require any medium and also laws of reflection is applicable for radiation.

2

2 **Attempt any four** **16**

a)

Preliminary Energy Audit	**Detailed Energy audit**
It is walk through audit.	It is detailed analysis of energy consumption in plant.
It required fuel and energy consumption trend.	It required data of each and every equipment which consumes energy
It gives potential of detailed audit.	It gives detailed report and energy conservation measures.
Recommends low or no cost energy conservation measures.	It recommends all types of energy conservation measures including measure retrofitting of equipment.

One mark each

b)	**Forms of Energy** **Kinetic Energy** is energy that is in motion. Moving water and wind are good examples of kinetic energy. Electricity is also kinetic energy because even though you can't see it happen, electricity involves electrons moving in conductors. **Potential Energy** is stored energy. Examples of potential energy are oil sitting in a barrel, or water in a lake in the mountains. This energy is referred to as potential energy, because if it were released, it would do a lot of work. **Mechanical Energy** is the energy of motion that does the work. An example of mechanical energy is the wind as it turns a windmill. **Heat energy** is energy that is pushed into motion by using heat. An example is a fire in combustion chamber. **Chemical Energy** is energy caused by chemical reactions. A good example of chemical energy in fuel. **Electrical Energy** is when electricity creates motion, light or heat. An example of electrical energy is the electric coils for heating. **Gravitational Energy** is motion that is caused by gravity. An example of gravitational energy is water flowing down a waterfall.	1 mark each for any four
c)	**Direct current (DC)** is the unidirectional flow of electric charge. Direct current is produced by sources such as batteries, thermocouples, solar cells, and commutator-type electric machines of the dynamo type. Sources of direct current include power supplies, electrochemical cells and batteries, and photovoltaic cells and panels. The intensity, or amplitude, of a direct current might fluctuate with time, and this fluctuation might be periodic. In some such cases the dc has an ac component superimposed on it. **Alternating current (AC)** is the flow of electric charge periodically reverses	2

	direction. The usual waveform of alternating current in most electric power circuits is a sine wave. In certain applications, different waveforms are used, such as triangular or square waves. Audio and radio signals carried on electrical wires are also examples of alternating current. These types of alternating current carry information encoded (or modulated) onto the AC signal, such as sound (audio) or images (video). These currents typically alternate at higher frequencies than those used in power transmission.	2
d)	**Energy saving opportunities in cooling tower** • Follow manufacturer's recommended clearances around cooling towers and relocate or modify structures that interfere with the air intake or exhaust • Optimize cooling tower fan blade angle on a seasonal and/or load basis • Correct excessive and/or uneven fan blade tip clearance and poor fan balance • In old counter-flow cooling towers, replace old spray type nozzles with new square spray nozzles that do not clog • Replace splash bars with self-extinguishing PVC cellular film fill • Install nozzles that spray in a more uniform water pattern • Clean plugged cooling tower distribution nozzles regularly • Balance flow to cooling tower hot water basins • Cover hot water basins to minimize algae growth that contributes to fouling • Optimize the blow down flow rate, taking into account the cycles of concentration (COC) • limit • Replace slat type drift eliminators with low-pressure drop, self-	½ mark each for any eight

	extinguishing PVC cellular units • Restrict flows through large loads to design values	
e)	**Energy security** The basic aim of energy security for a nation is to reduce its dependency on the imported energy sources for its economic growth. India will continue to experience an energy supply shortfall throughout the forecast period. Increasing dependence on oil imports means reliance on imports from the Middle East, a region susceptible to disturbances and consequent disruptions of oil supplies. Some of the strategies that can be used to meet future challenges to their energy security are • Building stockpiles • Diversification of energy supply sources • Increased capacity of fuel switching • Demand restraint • Development of renewable energy sources • Energy efficiency • Sustainable development	4
3	**Attempt any four**	**16**
a)	**Biogas** **Working** • The feed material is mixed with water in the influent collecting tank The fermentation slurry flows through the inlet into the digester. • The bacteria from the fermentation slurry are intended to produce biogas in the digester. • The process of anaerobic digestion occurs in a sequence of stages	**2**

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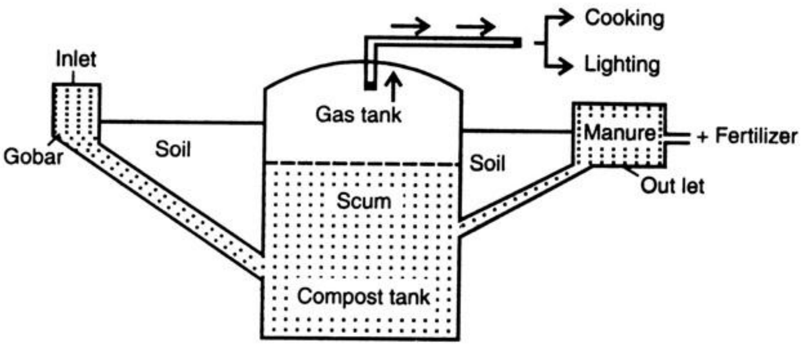
involving distinct types of bacteria.

- Hydrolytic and fermentative bacteria first break down the carbohydrates, proteins and fats present in biomass feedstock into fatty acids, alcohol, carbon dioxide, hydrogen, ammonia and sulfides.
- This stage is called “hydrolysis” (or “liquefaction”).
- Next, acetogenic (acid-forming) bacteria further digest the products of hydrolysis into acetic acid, hydrogen and carbon dioxide.
- Methanogenic (methane-forming) bacteria then convert these products into biogas.
- The combustion of digester gas can supply useful energy in the form of hot air, hot water or steam.



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<td>b)</td>
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NPSH

The quantity used to determine if the pressure of the liquid being pumped is adequate to avoid cavitation is the net positive suction head (NPSH). The net positive suction head available (NPSHA) is the difference between the pressure at the suction of the pump and the saturation pressure for the liquid being pumped.

If the available NPSH is not greater than that required by the pump many serious problems can result. The problems start with partial vaporization of the
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	liquid at the leading edges of the vanes. This phenomenon is also called CAVITATION. The vapour formed as small bubbles at the suction side collapse more or less suddenly when the liquid moves through the impeller to a high-pressure region. The formation of vapour has a marked reduction in total head and capacity of the pump. The loss in capacity is due to pumping a mixture of liquid & vapour. Water at 220C increases in volume 54000 times when vapour. Thus slight cavitation will reduce duty. Under worse situation a complete failure of pump operation can result. Excessive noise & vibration can result when a section of the impeller handles vapour and the other section handling liquid. Continued CAVITATION can result in a serious pitting and erosion of the pump parts leading to premature failure of impellers.	2
c)	**Contents of energy audit report** • Introduction • General requirements • Engineering calculation methods • Scope of report • Energy Audit Report outline • Key contacts information • Table of contents • Executive summary • Introduction • Energy consumption • Baseline period enrgy consumption • System, process or equipment description • Energy efficiency upgrades • Economic analysis	4

	• Conclusions and recommendations • Appendix	
d)	**Applications of solar energy** 1) Solar energy can be used to produce electrical energy by using photovoltaic cells. 2) Solar energy can be used to produce electrical energy by using solar collectors (Solar thermal energy) 3) Solar energy can be used for grains, fruit and vegetable drying. 4) Solar energy can be used for water heating 5) Solar energy can be used for cooking food using solar cookers.	1 mark each for any four
e)	**Features of Perform Achieve Trade (PAT)** • Specification of specific energy consumption (SEC) norm for each designated consumer in the baseline year and in the target year • Verification of the SEC of each designated consumer in the baseline year and in the target year by an accredited verification agency • Issuance of Energy Savings Certificates (ESCerts) to those designated consumers who exceed their target SEC reduction • Trading of ESCerts with designated consumers who are unable to meet their target SEC reduction after three years • Checking of compliance, and reconciliation of ESCerts at the end of the 3-year period. In case of non-compliance, a financial penalty is due.	1 mark for each for any four
4 A	**Attempt any three**	**12**
a)	**Salient features of water tube boiler** • They usually exist in larger sizes as compared to fire tube boiler designs. The size of a typical water tube boiler can go upto quite a few million pounds per hour of steam generated.	1 mark each for any

	• They are proficient in dealing with steam pressures which can be as high as 5,000 psig. • Their recovery is much quicker than their firetube counterparts. • Besides, they are designed to attain extremely high temperatures • Water tube boilers which are smaller in size can be easily prepared and made available in the form of single packaged units similar to packaged firetube boiler units. On the other hand, large sized water tube boiler units are unable to be manufactured in packaged form; hence the large sections are carried to the work site where they are finally assembled. • A typical water tube boiler system consists of several burners positioned on the walls, each having a choice of either horizontal or vertical firing. Also, temperature control option is available in many sections of the boiler. These features must be specifically considered when the boiler contains an integrated superheater whose temperature is required to be controlled for getting adequate superheated steam.	two
	Salient features of fire tube boiler • Firetube boilers are often characterized by their number of passes, referring to the number of times the combustion (or flue) gases flow the length of the pressure vessel as they transfer heat to the water. • Each pass enables the hot combustion gases to pass through the boiler tubes in the different direction. Every time, for conceiving next pass, the flue gases in the boiler make a shift of 180 degrees and go back via the shell. • A typical three-pass boiler consists of three sets of boiler tubes whereas a four-pass boiler contains the four sets. The stack outlet in case of	1 mark each for any two

	former one is normally positioned at the back end of the boiler while the latter one will have the stack outlet located at the front end. • Various types of boiler tube arrangements are available for fire tube boiler systems depending upon the number of passes made by the hot flue gases emerging from the boiler furnace till the time they get cleared out of boiler system. • In case of boilers made up of plain steel, the hot combustion gases going in to the reversal chamber are required to be cooled down to a temperature of 420°C prior to their entrance whereas in case boilers having alloy steel construction, this temperature should be at least 470°C. If the temperature of combustion gases happens to be more than recommended then problems like overheating and cracking of boiler tubes may take place. • Since a fire tube boiler system consists of a considerable quantity of water within it maintained at saturation temperature point, it usually serves as significant energy storage ground to deal with very quick short term load applications. However, this fact can pose a major limitation also since re-buildup of energy reserve would be required which may consume large time. • Nowadays, the largest shell boilers offering 1,500 boiler horsepower i.e. approximately 50,000 lbs/hr have been made available.	
b)	**Day light opening**: The actual glass size that is visible. Easily remembered, as the area of glass allowing daylight into the structure. The daylight opening is the actual opening that allows the sun’s heat and the cooling effect of glass to influence the interior ambient temperatures.	4

<table>
<tr><td></td><td>Cycle time injection molding:

<i>Injection moulding</i> of plastics, if quality is taken care of by part design, mould design . on account of zero defect moulding with out rejection and ptimized <i>cycle time</i>.
<i>The question is Out of curriculum, so due consideration should be given</i></td><td></td></tr>
<tr><td>c)</td><td>
<table>
<tr><th>Latent heat</th><th>Sensible Heat</th></tr>
<tr><td>It is the heat required to convert a solid into a liquid or vapour, or a liquid into a vapour, without change of temperature.</td><td>It is the amount of heat required to raise the temperature of substance without phase change.</td></tr>
<tr><td>Phase change</td><td>No phase change</td></tr>
<tr><td>Temperature remains constant</td><td>Temperature changes</td></tr>
<tr><td>$Q= m * \lambda$</td><td>$Q= m * Cp * \Delta T$</td></tr>
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<tr><td>d)</td><td>Conventional Energy sources
Energy that has been used from ancient times is known as conventional energy. These sources are exhaustible after use. Conventional energy sources includes oil, gas and coal. These conventional sources are usually fossil fuels. Their use leads to increased greenhouse gas emissions and other environmental damage.
Non-Conventional Energy sources
The energy sources which can renew again and again are called non-conventional energy sources. Though they are also used from ancient times,</td><td>2

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	commercial and advanced use is from last century. Energy generated by using wind, tides, solar, geothermal heat, and biomass including farm and animal waste as well as human excreta is known as non-conventional energy.	
4B	**Attempt any one**	**6**
a)	**Effect of speed variation:** A centrifugal pump is a dynamic device with the head generated from a rotating impeller. There is therefore a relationship between impeller peripheral velocity and generated head. Peripheral velocity is directly related to shaft rotational speed, for a fixed impeller diameter and so varying the rotational speed has a direct effect on the performance of the pump. All the parameters will be change if the speed is varied and it is important to have an appreciation of how these parameters vary in order to safely control a pump at different speeds. The equation relating rotodynamic pump performance parameters of flow , head and power absorbed , to speed are k/as the affinity laws: $Q \propto N$ $H \propto N^2$ $P \propto N^3$ Q = FLOW RATE H = HEAD P = POWER ABSORBED N = ROTATING SPEED As can be seen from the above laws, doubling the speed of the centrifugal pump will increase the power consumption by 8 times. Conversely a small reduction in speed will result in drastic reduction in power consumption. This form the basis for energy conservation in centrifugal pumps with varying flow requirements.	3

	Power required for pump P_1 = 75 kW, N_1= 1750 rpm Power consumption at double speed P2 = P1 x $(N_2/N_1)^3$ P2 = 75 X $(2\ N_1/N_1)^3$ [here $N_2 = 2\ N_1$] = 75 x 8 = 600 kW	3
b)	**Benchmarking Parameters** **Gross production related:** kWh/MT clinker or cement produced (cement plant) kWh/kg yarn produced (textile unit) kWh/MT , kcal/kg, paper produced (paper plant) kcal/kWh power produced (heat rate of power plant) million cal/MT urea or ammonia (fertilizer plant) kWh/MT of liquid metal output (in a foundry) **Utility related :** kW/ ton of refrigeration (on air conditioning plant) % thermal efficiency of a boiler plant % cooling tower effectiveness in a cooling tower kWh/Nm^3 of compressed air generated kWh/liter in a diesel power generation plant	6 marks for any 8 parametrs
5	**Attempt any two**	**16**
a)	**Objectives of pump performance test** To analyses pump operation data. To verify the conations related to pump performance curve To select right pump	4

	To study energy efficiency of pump at current process conditions. **System Resistance** It is the losses in pump due to various reasons like friction loss, loss due to various pipe fitting, loss due to throttling. System resistance curves can be used to graphically determine flows and pressures in process systems where there is typically one supply pressure or tank, a centrifugal pump, a control valve, and one destination tank or pressure.	4
b)	**Energy conservation act 2001** The Act empowers the Central Government and, in some instances, State Governments to: • specify energy consumption standards for notified equipment and appliances; direct mandatory display of label on notified equipment and appliances; • prohibit manufacture, sale, purchase and import of notified equipment and appliances not conforming to energy consumption standards; • notify energy intensive industries, other establishments, and commercial buildings as designated consumers; • establish and prescribe energy consumption norms and standards for designated consumers; • prescribe energy conservation building codes for efficient use of energy and its conservation in new commercial buildings having a connected load of 500 kW or a contract demand of 600 kVA and above; **direct designated consumers to -** • designate or appoint certified energy manager in charge of activities for efficient use of energy and its conservation;	6

	• get an energy audit conducted by an accredited energy auditor in the specified manner and interval of time; • furnish information with regard to energy consumed and action taken on the recommendation of the accredited energy auditor to the designed agency; • comply with energy consumption norms and standards; • prepare and implement schemes for efficient use of energy and its conservation if the prescribed energy consumption norms and standards are not fulfilled; • get energy audit of the building conducted by an accredited energy auditor in this specified manner and intervals of time. **Amendments in EC act** • in clause (a), for the words –“an auditor possessing qualifications specified under” the words –“an energy auditor accredited in accordance with the provisions of” shall be substituted; • in clause (b), for the words and figures –“established under‖ section 30”, the words and figures -” referred to in section 30” shall be substituted; • In section 9 of the principal Act, in sub-section (3), for the words “three years”, the words- “five years” shall be substituted.	2
c)	**Amount of air required** Case i) Basis : 100 kg fuel. C = 85.9 kg,H_2 = 12 Kg , O_2 = 0.7 Kg , S = 0.5 Kg , water = 0.35 Kg , N_2 = 0.5 kg , ash = 0.05 kg.	

1) $C + O_2 \rightarrow CO_2$
2) $H_2 + ½ O_2 \rightarrow H_2O$
3) $S + O_2 \rightarrow SO_2$

Foe reaction .(1)

1 kg atom of C = 1 kg mol of O_2

12 kg C = 32 kg of O2 2

Therefore, O2 theoretical required = 32/12 X 85.9

= 229.06 Kg

For reaction (2)

1 kg mol of H_2 = ½ kg mol of O_2

2 kg of H_2 = 16 kg of O_2

O2 theoretical required = 16/2 X 12

= 96 kg

For reaction (3)

1 kg atom of S = 1 kg mol of O_2

32 kg of S = 32 kg of O_2

O_2 theoretical required = 32/32 x 0.5

= 0.5 kg

Therefore, total theoretical requirement of O_2 = 229.06 +96+0.5- 0.7

=324.86 kg

Theoretical air required = 100 * 28.84/21*32 x 324.86 2

= **1394.19 kg**

=13.94 kg/kg of fuel

Case ii)

Basis : 100 kg fuel.

C = 88.4 kg,H_2 = 9.4 Kg , O_2 = 2 Kg , S = 0.2 Kg ,

1) $C + O_2 \rightarrow CO_2$
2) $H_2 + ½ O_2 \rightarrow H_2O$
3) $S + O_2 \rightarrow SO_2$

Foe reaction .(1)

1 kg atom of C = 1 kg mol of O_2

12 kg C = 32 kg of O2

Therefore, O2 theoretical required = 32/12 X 88.4

= 235.73 Kg

For reaction (2)

1 kg mol of H_2 = ½ kg mol of O_2

2 kg of H_2 = 16 kg of O_2

2

O2 theoretical required = 16/2 X 9.4

= 75.2 kg

For reaction (3)

1 kg atom of S = 1 kg mol of O_2

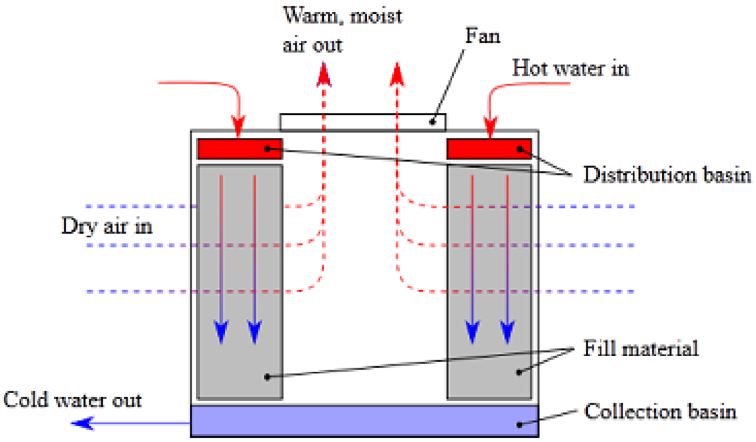
32 kg of S = 32 kg of O_2

O_2 theoretical required = 32/32 x 0.2

= 0.2 kg

Therefore, total theoretical requirement of O_2 = 235.73 +75.2+0.2-2

=309.13 kg

	Theoretical air required = 100 * 28.84/21*32 x 309.13 = **1326.68 kg** =13.27 kg/kg of fuel	2
6	**Attempt any two**	**16**
a)	**Cooling Tower** A cooling tower is a specialized heat exchanger in which air and water are brought into direct contact with each other in order to reduce the water's temperature. As this occurs, a small volume of water is evaporated, reducing the temperature of the water being circulated through the tower. **Crossflow cooling towers** In crossflow towers the water flows vertically through the fill while the air flows horizontally, across the flow of the falling water. Because of this, air does not have to pass through the distribution system, permitting the use of gravity flow hot water distribution basins mounted at the top of the unit above the fill. These basins are universally applied on all crossflow towers.  **Counterflow cooling towers** Counterflow towers are designed so that air flows vertically upward, counter to	2 4 marks for any one type with diagram

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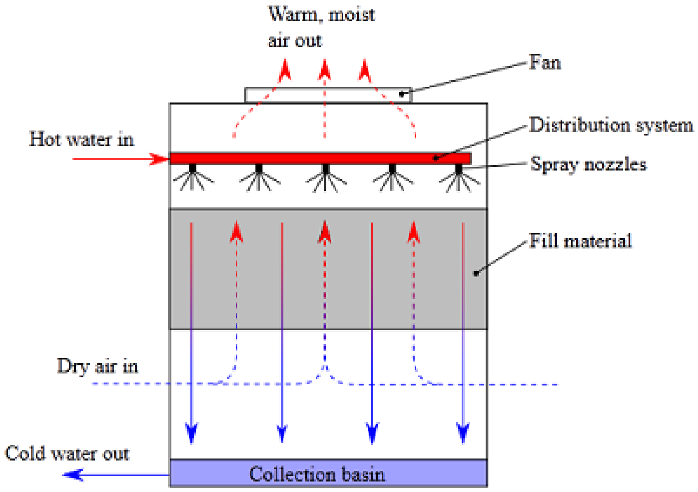
<p>the flow of falling water in the fill. Because of this vertical airflow, it is not possible to use the open, gravity-flow basins typical in crossflow designs. Instead, counterflow towers use pressurized, pipe-type spray systems to spray water onto the top of the fill. Since air must be able to pass through the spray system, the pipes and nozzles must be farther apart so as not to restrict airflow.</p>


<p>Effectiveness. This is the ratio between the range and the ideal range (in percentage), i.e. difference between cooling water inlet temperature and ambient wet bulb temperature, or in other words it is = Range / (Range + Approach). The higher this ratio, the higher the cooling tower effectiveness.</p>
<p>CT Effectiveness (%) = 100 x (CW temp – CW out temp) / (CW in temp – WB temp)</p>
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<tr>
<td>b)</td>
<td>
<p>Use of solar energy</p>
<p>Solar energy can be used in two forms.</p>

Solar thermal energy
Solar photovoltaic energy

<p>Solar Thermal Energy</p>
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	It is used for various purposes ranging from water heating, grain drying to electricity production. Solar thermal electric energy generation concentrates the light from the sun to create heat, and that heat is used to run a heat engine, which turns a generator to make electricity. The working fluid that is heated by the concentrated sunlight can be a liquid or a gas. Different working fluids include water, oil, salts, air, nitrogen, helium, etc. Different engine types include steam engines, gas turbines, Stirling engines, etc. All of these engines can be quite efficient, often between 30% and 40%, and are capable of producing 10's to 100's of megawatts of power. **Photovoltaic, or PV energy conversion** Solar PV directly converts the sun's light into electricity using solar cell. When light energy strikes the solar cell, electrons are knocked loose from the atoms in the semiconductor material. If electrical conductors are attached to the positive and negative sides, forming an electrical circuit, the electrons can be captured in the form of an electric current - that is, electricity. **Examples (Any six)** Applications of solar energy 1. Solar energy can be used to produce electrical energy by using photovoltaic cells. 2. Solar pump used for pumping water for agricultural use. 3. Solar energy can be used to produce electrical energy by using solar collectors (Solar thermal energy) 4. Solar energy can be used for grains, fruit and vegetable drying. 5. Solar energy can be used for water heating 6. Solar energy can be used for cooking food using solar cookers.	4

7. Solar distillation for water purification
8. Solar space heating for maintaining temperature in buildings.

c)

Performance assessment of H.E.

Step A: 2

Monitoring and reading of steady state parameters of the H.E. under evaluation are tabulated as below:

parameters	units	inlet	Outlet
Hot fluid flow	Kg/h		
Cold fluid flow	Kg/h		
Hot fluid temp.	Deg. C		
Cold fluid temp.	Deg. C		
Hot fluid P	Bar g		
Cold fluid P	Bar g		

Step B:physical properties of stream can be tabulated as: 2

parameters	unit	Inlet	outlet
Hot fluid density	Kg/h		
Cold fluid density	Kg/h		
Hot fuid viscosity	MPas		
cold fuid viscosity	MPas		

Hot fuid them. coductivity	kW/(mK)		
Cold fuid ther. conductivity	kW/(mK)		
Hot fuid heat capacity	KJ/Kg.K		
Cold fuid heat capacity	KJ/Kg.K		

Step c:

Calculate the thermal parameters of H.E. & compare with the design data: 2

parameters	Unit	Test date	Design data
Heat duty	kW		
Hot fluid side P drop	Bar		
Cold fluid side P drop	Bar		
Temp. Range hot fluid	Deg. C		
Temp. Range cold fluid	Deg. C		
Capacity ratio , R	-		
Effectiveness , S	-		
Corrected LMTD	Deg. C		

H.T.Coeff. , U	KW/(m^2.K)		

Step D:

1) heat duty , Q = Q_s + Ql

Qs = sensible heat , Ql = latent heat

For sensible heat

Qs = (m x Cp x dT)hf

Qs =(m x Cp x dT)cf

For latent heat

Ql = (m x latent heat)hf

Ql = (m x latent heat)cf

2) Hot fluid side P drop , (dP)hf = Pi –Po

3) Cold fluid side P drop , (dP)cf = Pi –Po

4) Temp. Range hot fluid , dT = Ti - To

5) Temp. Range cold fluid , dt = ti – to

6) Capacity ratio , R = (Ti- To) / (to – ti)

7) Effectiveness , S = (to- ti) / (Ti –ti)

8) LMTD:

LMTD for counter current flow

LMTD for co-current flow

Correction factor for LMTD,

$$F = \frac{(R + 1)^{1/2} \text{ X } \ln [(1 - S R) / (1 - S)]}{(1 - R) \text{ x } \ln \{ 2 - S [R + 1 - (R + 1)^{1/2}] / \ 2 - S [R + 1 + (R + 1)^{1/2} \}}$$ 2

9) Corrected LMTD = F x LMTD

10) Overall heat transfer coeff. , U = Q / (A x Corrected LMTD)