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Internal Assessment Test 3 – Nov. 2018

Sub:	Energy Engineering				Sub Code:	15ME71	Branch:	Mechanical
Date:	20/11/2018	Duration:	90 min's	Max Marks: 50	Sem / Sec:	7 A & B		OBE

Answer any FIVE FULL Questions

		MARKS	CO	RBT
1	Explain with a neat sketch how geothermal energy is extracted from the earth.	[10]	CO5	L1
2	Explain the working principle of biogas production from organic waste.	[10]	CO4	L1
3	What is a gasifier? Explain any one gasifier with sketch.	[10]	CO2	L1
4	Explain the working of a double basin tidal power plant with a neat sketch.	[10]	CO6	L1
5	Explain the principle of operation of a KVIC biogas digester with a neat sketch.	[10]	CO2	L1
6	What is meant by anaerobic digestion? What are the factors which affect bio-digestion? Explain any two in brief.	[10]	CO4	L1

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Sub:	Energy Engineering					Sub Code:	15ME71	Branch:	Mech
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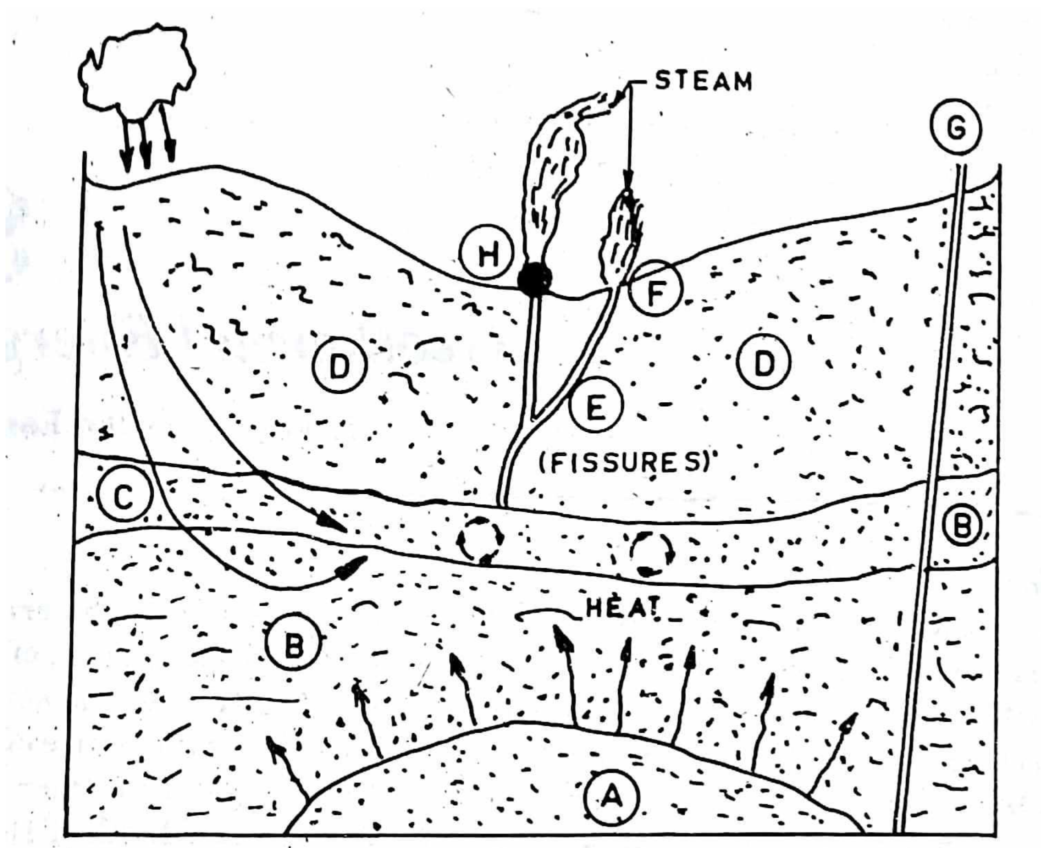
Scheme of evaluation

Q.No	Scheme	Marks
1	Sketch of geothermal field Short note extracting of geothermal energy	5 5
2	Commonly used organic wastes for biogas production Different types of micro-organisms involved Environmental conditions required	3 4 3
3	Description of gasifier Sketch of any one type of gasifier Short note on its working	4 5 3
4	Sketch of double basin power plant Principle of working	5 5
5	Sketch of KVIC biogas plant Principle of working	5 5
6(a)	Definition of anaerobic digestion Importance of anaerobic digestion for biogas production Effect of any two factors on anaerobic digestion	2 4 4

Energy Engineering (15ME71)

IAT 3 Solutions

1) Energy present as heat (i.e. thermal energy) in the earth's crust constitutes a potentially useful and an almost inexhaustible source of energy. This heat is apparent from the increase in temperature of the earth with increasing depth below the surface. The average temperature at a depth of 10 km is about 200ºC.



The figure below shows a typical geothermal field. The hot magma (molten mass) near the surface (A) solidifies into igneous rock (B). The heat of the magma is conducted upward to this igneous rock. Ground water that finds its way down to this rock through fissures in it, will be heated by the heat of the rock or by mixing with hot gases and steam emanating from the magma. The heated water will then rise convectively upward and into a porous and permeable reservoir (C) above the igneous rock. The reservoir is capped by a layer of impermeable solid rock (D) that traps the hot water in the reservoir. The solid rock, however; has fissures (E) that act as vents of the giant underground boiler. The vents show up at the surface as geysers fumaroles (F) (steam is continuously vented though fissures in the ground, these vents are called fumaroles) or hot spring (G). A well (H) taps steam from the fissures for use in a geothermal power plant.

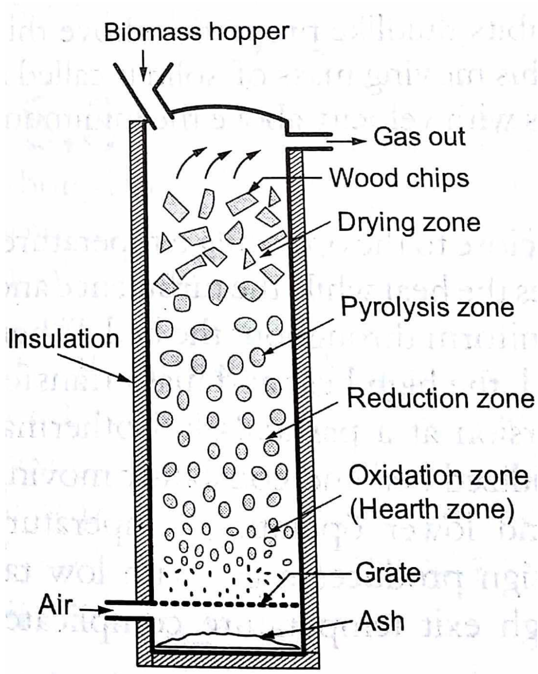
2) Biogas or methane is produced by the anaerobic decomposition of organic materials. This gas is produced from cow dung and other wastes such as cornhusks, leaves, straw, and garbage, flesh of carcasses, poultry droppings, pig dung, human excreta and sewage. Biomass, if left to decompose in open air, is acted upon by aerobic bacteria (bacteria that require oxygen for their survival and growth) to produce mainly CO_2, NH_3, etc. Thus the total carbon component completely gets oxidized to produce CO_2 and no fuel is produced. Some part of nitrogen is also lost in the form of ammonia.

Biogas is produced from wet biomass with about 90-95% water content by the action of anaerobic bacteria (bacteria that live and grow in absence of oxygen). Part of carbon is oxidized and another part reduced to produce CO_2 and CH_4. These bacteria live and grow without oxygen. They derive the needed oxygen by decomposing the biomass. The process is favored by wet, warm and dark conditions. The airtight equipment used for conversion is known as biogas plant or digestor, which is constructed and controlled to favor methane production. The conversion process is known as anaerobic fermentation (or bio-digestion). Nutrients such as soluble nitrogen compounds remain available in solution and provide excellent fertilizer and humus. The energy available from the combustion of biogas is 60-90% of the input dry matter heat of combustion. Thus the energy conversion efficiency of the process is 60-90%.

3) The word gasification implies converting a solid or liquid into a gaseous fuel without leaving any solid carbonaceous residue. Gasifier is an equipment which can gasify a variety of biomass such as stood waste, agricultural waste like stalks, and roots of various crops, maize cobs etc. The gasifier is essentially a chemical reactor where various complex physical and chemical processes take place. Biomass gets dried, heated, pyrolysed, partially oxidized and reduced, as it flows through it.
The gas produced in the gasifier is a clean burning fuel having heating vale: of about 950-1209 kcal/m^3. Hydrogen (18 – 20 %), and carbon-monoxide (18-24%) are the main constituents of the gas.

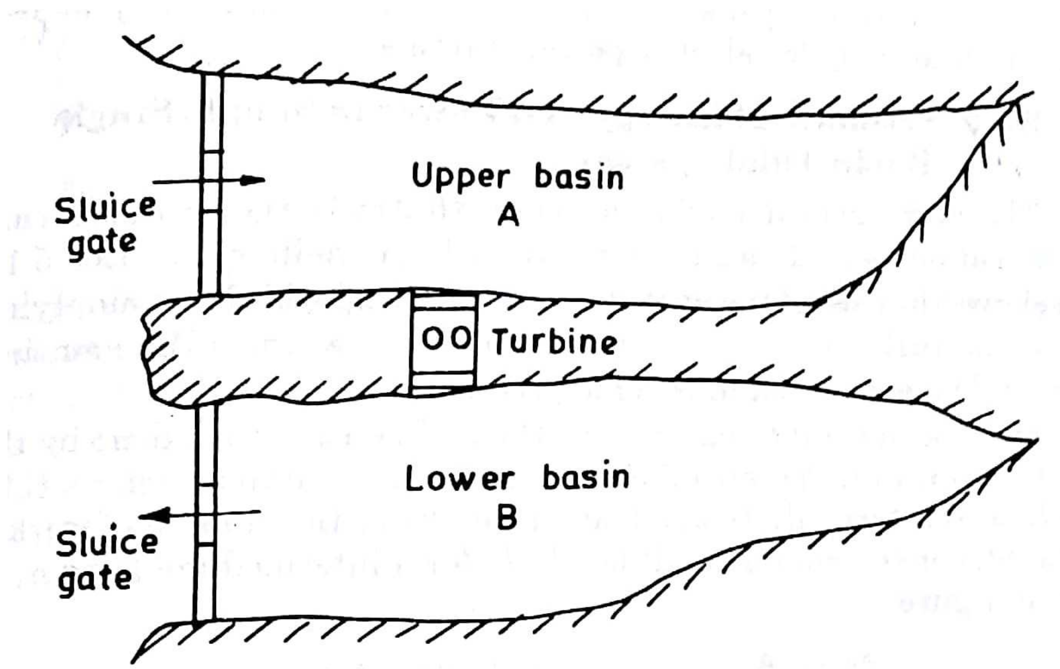
The three main designs of fixed bed gasifiers are (i) Up draught, (ii) Down draught and (iii) cross draught.

Up draught gasifiers: In up draught gasifier air enters below the combustion zone and the producer leaves near the top of the gasifier. This type of gasifier is easy to build and operate. The gas produced has practically no ash but contains tar and water vapor because of passing of gas through the unburned fuel. Hence updraught gasifiers are suitable for tar free fuels like charcoal, especially in stationary engines. The figure below shows the cross section of an upgraught gasifier.



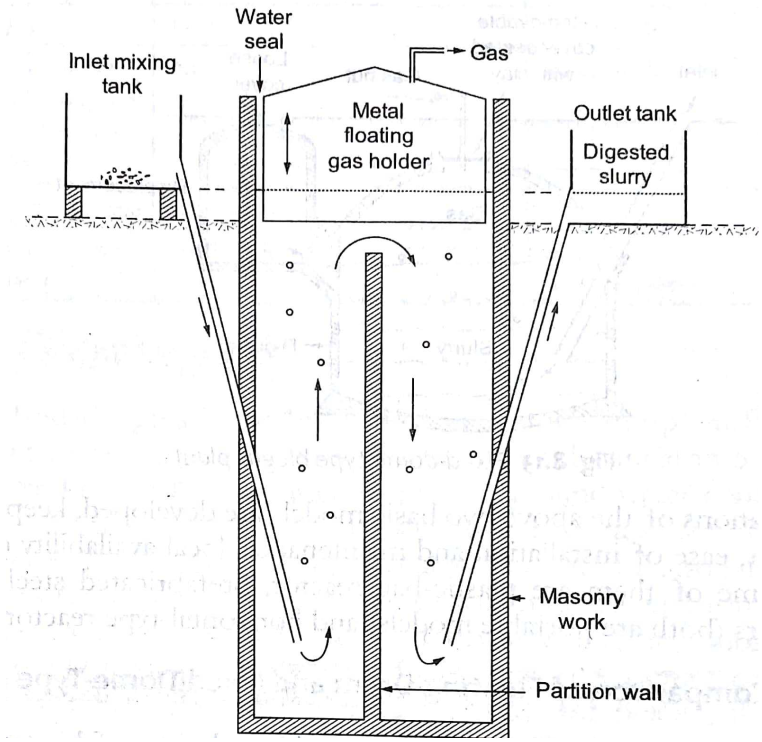
4) Double Basin Arrangement: It requires two separate but adjacent basins. In one basin called upper basin (or high. pool), the water level is maintained above that in the other, the low basin (or low pool). Because there is always a head between upper and lower basins, electricity can be generated continuously, although at a variable rate.

In this system the turbines are located in between the two adjacent basins, while the sluice gates are embodied in the dam across the mouths of the two estuaries. At the beginning of the flood tide, the turbines are shut down, the gates of upper basin A are opened and those of the lower basin B are closed. The basin A is thus filled up while the basin B remains empty. As soon as the rising water level in A provides sufficient difference of head between the two basins, the turbines are started. The water flows from A to B through the turbines, generating power. The power generation thus continues simultaneously with the filling up of the basin A. At the end of the flood tide when A is full and the water level in it is the maximum, its sluice gates are closed. When the ebb tide level gets lower than the water level in B, its sluice gates are opened whereby the water level in B, which was rising and reducing the operating head, starts falling with the ebb. This continues until the head and water level in A is sufficient to run to run the turbines. With the next flood tide the cycle repeats itself. With this twin basin system, a longer and more continuous period of generation per day is possible. The small gaps in the operation of such stations can be filled up by thermal power.



5) The figure below shows the schematic of Khadi and Village Industries commission (KVIC) biogas plant. These are for small scale biogas production and consist of slurry inlet tank, gas value, dome, outlet tank ac inlet pipe, digester, partition wall. The plant consist of digester made of masonry construction in the form a well below the ground level and the floating gas holder also called as dome, made of mild steel.

In the inlet tank, animal waste slurry containing cow dung and waste in the ratio as 1:1 to 1:1.25 is prepared. The feeding of animal waste slurry is usually done once in a day. The sludge comes out with the built up of gas pressure in the dome above the partition wall and flows out to the outlet tank through the outlet pipe. This sludge is an excellent fertilizer which can be again fed to the soil. At the top of the gas holder, the accumulated gas is drawn from the pipe through gas value. The bifurcation of the digestion chamber through the partition wall provides optimum conditions for growth of acid formers and methane formers as the pH valve requirement for these bacteria are different. Therefore, this gives a good yield of biogas. It operates naturally under constant pressure. The diameter of the digester of a gas plant ranges from 1.2 to 6m and its height varies from 3m to 6m.



6) The treatment of any slurry or sludge containing a large amount of organic matter, utilizing bacteria and other micro-organisms under anaerobic conditions is referred to as anaerobic digestion. This anaerobic digestion consists broadly of three phases:

(i) Enzymatic hydrolysis where the fats, starches and proteins contained in cellulosic biomass are broken down into simple compounds.

(ii) Acid formation where the micro organisms of facultative and anaerobic group collectively called as acid farmers, hydrolyze and ferment the simple compounds of previous step to acids and volatile solids. As a result complex organic compounds are broken down to short chemical simple organic acids. In some cases, these acids may be produced in such large quantities that the pH may be lowered to a level where a1l biological activity is arrested. This initial acid phase of digestion may last about two weeks and during this period a large amount of carbon dioxide is given off.

(iii) Methane formation where organic acids as formed above are converted into methane (CH_4) and CO_2 by the bacteria which are then strictly anaerobe. These bacteria are called methane fermentors. For spic iciest digestion these acid formers and methane fermentors must remain in a state of dynamic equilibrium. This equilibrium is a very critical factor which decides the efficiency of generation. It has been demonstrated that the methane formers are sensitive to pH changes. A pH value between 6.5 and 8 is the best for fermentation and normal gas production. If organic acids are formed at a faster rate than the tilted population of methane formers can assimilate, then the accumulated acids will reduce the pH to levels unfavorable to methane formers.

Factors affecting bio-digestion:

(i) Temperature: Methane forming bacteria work best in temperature range of 20-55ºC. Digestion at higher temperature proceeds more rapidly than at lower temperature, with gas yield rates doubling at about every 5ºC increase in temperature. The gas production decreases sharply below 20ºC and almost stops at 10ºC. It is to be noted that raising the temperature accelerates the gas production; however its methane content gets relatively reduced.

(ii) Pressure: A minimum pressure of 6-10 cm of water column, i.e., 1.2 bar (abs) is considered ideal for proper functioning of the plant, and it should never be allowed to exceed 40 - 50 cm of water column. Excess pressure inhibits release of gas from slurry. It also leads to leakage in masonry through micro-pores. Even normal gas taps and pipe joints start leaking due to excess pressure.