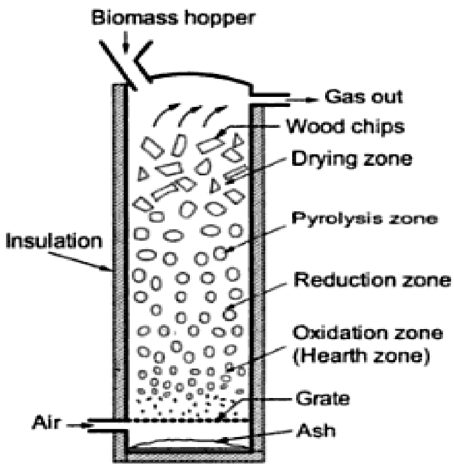
CMR INSTITUTE OF TECHNOLOGY, BENGALURU
(Approved by AICTE, New Delhi, Accredited by NAAC with A+ and Affiliated to VTU)

Department of Electrical and Electronics Engineering

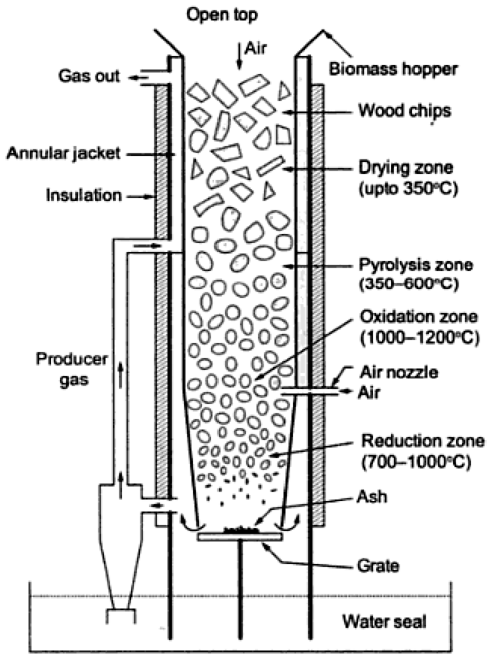
15EE563 - Renewable Energy Sources (V Semester - Open Elective)

Academic year 2018-19

Solutions to IAT-II

1	With neat diagram, analyze the principle of operation of updraft and downdraft gasifier in biogas generation.
Ans:	**Updraft Gasifier:**  **Working Principle:** • The air intake is at the bottom and the gas leaves at the top. Near the grate at the bottom the combustion reactions occur, which are followed by reduction reactions somewhat higher up in the gasifier. • In the upper part of the gasifier, heating and pyrolysis of the feedstock occur as a result of heat transfer by forced convection and radiation from the lower zones. • The tars and volatiles produced during this process will be carried in the gas stream. Ashes are removed from the bottom of the gasifier. • The major advantages of this type of gasifier are its simplicity, high charcoal burn-out and internal heat exchange leading to low gas exit temperatures and high equipment efficiency, as well as the possibility of operation with many types of feedstock (sawdust, cereal hulls, etc.). • Major drawbacks result from the possibility of "channelling" in the equipment, which can lead to oxygen break-through and dangerous, explosive situations and the necessity to install automatic moving grates, as well as from the problems associated with disposal of the tar-containing condensates that result from the gas cleaning operations. The latter is of minor importance if the gas is used for direct heat applications, in which case the tars are simply burnt.

Updraft Gasifier:



Working Principle:

- A solution to the problem of tar entrainment in the gas stream has been found by designing co-current or downdraught gasifiers, in which primary gasification air is introduced at or above the oxidation zone in the gasifier.
- The producer gas is removed at the bottom of the apparatus, so that fuel and gas move in the same direction, as schematically shown in Fig.
- On their way down the acid and tarry distillation products from the fuel must pass through a glowing bed of charcoal and therefore are converted into permanent gases hydrogen, carbon dioxide, carbon monoxide and methane.
- Depending on the temperature of the hot zone and the residence time of the tarry vapours, a more or less complete breakdown of the tars is achieved.
- The main advantage of downdraught gasifiers lies in the possibility of producing a tar-free gas suitable for engine applications.
- In practice, however, a tar-free gas is seldom if ever achieved over the whole operating range of the equipment: tar-free operating turn-down ratios of a factor 3 are considered standard; a factor 5-6 is considered excellent.
- Because of the lower level of organic components in the condensate, downdraught gasifiers suffer less from environmental objections than updraught gasifiers.
- A major drawback of downdraught equipment lies in its inability to operate on a number of unprocessed fuels. In particular, fluffy, low density materials give rise to flow problems and excessive pressure drop, and the solid fuel must be pelletized or briquetted before use. Downdraught gasifiers also suffer from the problems associated with high ash content fuels (slagging) to a larger extent than updraught gasifiers.
- Minor drawbacks of the downdraught system, as compared to updraught, are somewhat lower efficiency resulting from the lack of internal heat exchange as well as the lower heating value of the gas. Besides this, the necessity to maintain uniform high temperatures over a given cross-sectional area makes impractical the use of downdraught gasifiers in a power range above about 350 kW (shaft power).

2(a) Distinguish between different types of Fixed bed gasifiers in thermochemical energy conversion.

Ans:

	Downdraft	Updraft	Cross-flow
Operations	Biomass is introduced from the top and moves downward. Oxidizer (air) is introduced at the top and flows downward. Producer gas is extracted at the bottom at grate level.	Biomass is introduced from the top and moves downward. Oxidizer is introduced at the bottom and flows upward. Some drying occurs. Producer gas is extracted at the top.	Biomass is introduced from the top and moves downward. Oxidizer is introduced at the bottom and flows across the bed. Producer gas is extracted opposite the air nozzle at the grate.
Advantages	▪ Tars and particulate in the producer gas are lower	▪ Can handle higher-moisture biomass. ▪ Higher temperatures can destroy some toxins and slag minerals and metal. ▪ Higher tar content adds to heating value.	▪ Simplest of designs. ▪ Stronger circulation in the hot zone. ▪ Lower temperatures allow the use of less expensive construction materials.
Disadvantages	▪ Feed size limits ▪ Scale limitations ▪ Low heating value gas ▪ Moisture-sensitive	▪ Feed size limits ▪ High tar yields ▪ Scale limitations ▪ Low heating value gas	▪ More complicated to operate. ▪ Reported issues with slagging. ▪ High levels of carbon (33%) in the ash.

2(b) Discuss about the major applications of biomass gasifiers.

Ans:

1. Motive power
2. Direct heating applications
3. Electrical Power generation
4. Chemical production

3 Analyze various processes involved in Anaerobic digestion for the biogas production.

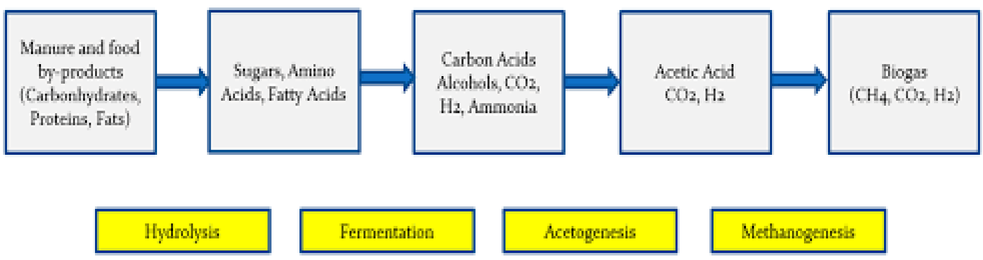
Ans: The four key stages of anaerobic digestion

nvolve hydrolysis, acidogenesis, acetogenesis and methanogenesis.

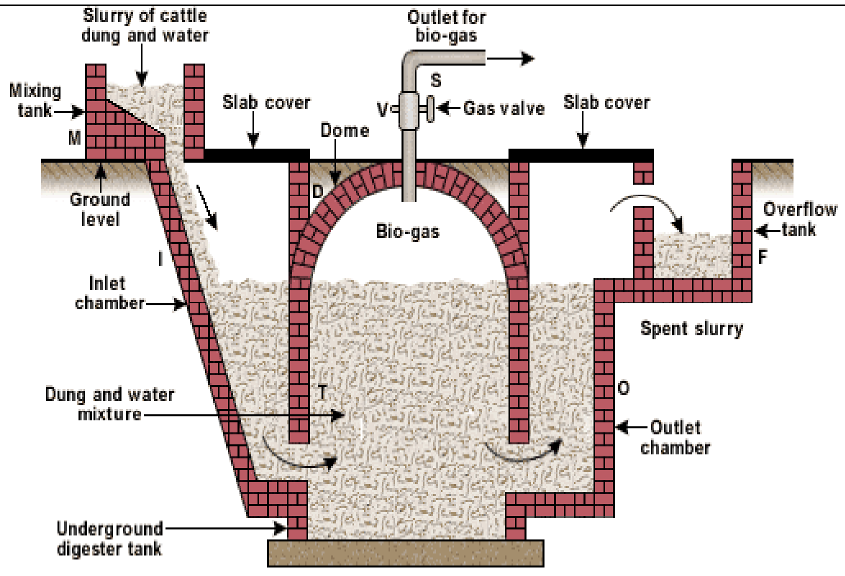
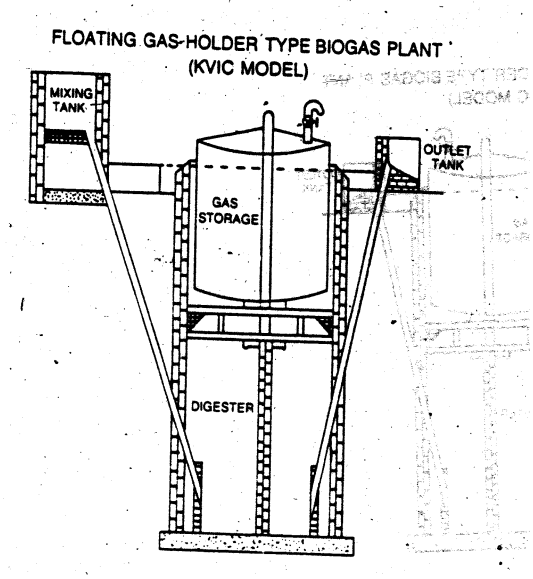
The overall process can be described by the chemical reaction, where organic material such as glucose is biochemically digested into carbon dioxide (CO_2) and methane (CH_4) by the anaerobic microorganisms.

$$C_6H_{12}O_6 \rightarrow 3CO_2 + 3CH_4$$

Block digram:



	Processes: • **Hydrolysis** In most cases, biomass is made up of large organic polymers. For the bacteria in anaerobic digesters to access the energy potential of the material, these chains must first be broken down into their smaller constituent parts. These constituent parts, or monomers, such as sugars, are readily available to other bacteria. The process of breaking these chains and dissolving the smaller molecules into solution is called hydrolysis. Therefore, hydrolysis of these high-molecular-weight polymeric components is the necessary first step in anaerobic digestion. Through hydrolysis the complex organic molecules are broken down into simple sugars, amino acids, and fatty acids. Acetate and hydrogen produced in the first stages can be used directly by methanogens. Other molecules, such as volatile fatty acids (VFAs) with a chain length greater than that of acetate must first be catabolised into compounds that can be directly used by methanogens. • **Acidogenesis** The biological process of acidogenesis results in further breakdown of the remaining components by acidogenic (fermentative) bacteria. Here, VFAs are created, along with ammonia, carbon dioxide, and hydrogen sulfide, as well as other byproducts. The process of acidogenesis is similar to the way milk sours. • **Acetogenesis** The third stage of anaerobic digestion is acetogenesis. Here, simple molecules created through the acidogenesis phase are further digested by acetogens to produce largely acetic acid, as well as carbon dioxide and hydrogen. • **Methanogenesis** The terminal stage of anaerobic digestion is the biological process of methanogenesis. Here, methanogens use the intermediate products of the preceding stages and convert them into methane, carbon dioxide, and water. These components make up the majority of the biogas emitted from the system. Methanogenesis is sensitive to both high and low pHs and occurs between pH 6.5 and pH 8. The remaining, indigestible material the microbes cannot use and any dead bacterial remains constitute the digestate.
4	With neat schematic diagram, explain the working principle of fixed dome type biogas plants.
Ans:	**Working Principle:** ✓ Invented in China in 1930's. ✓ Underground brick masonry compartment (fermentation chamber) with a dome on the top for gas at the storage. ✓ Fermentation chamber and gas holder are combined as one unit. ✓ Movement and weight of digested the slurry decides the gas pressure. ✓ *Variable gas pressure* (0-90 cm water column) ✓ Less expensive and requires less maintenance than floating drum type.

	 Fixed-dome type bio-gas plant.
5	Illustrate with neat sketches the working of KVIC biogas plant and analyze the factors affecting the biogas generation.
Ans:	 **Factors affecting the bio-gas production:** 1. Cost 2. Simplicity in design 3. Durability 4. Suitability for use with available raw inputs **5.** Inputs and outputs use frequency
6(a)	Analyze how the hydrogen energy can be stored by various storage schemes.
Ans:	Processes involved in storage: 1. Compressed gas storage tank 2. Liquid hydrogen storage tank

	3. Materials-based storage Storage schemes: Based on the process mentioned above, the hydrogen energy can be stored in the following methods. 1. Compression 2. Liquefied Hydrogen 3. Metal Hydrides
6(b)	Discuss about the advantages and disadvantages of hydrogen energy.
Ans:	Advantages of hydrogen energy (i). Easy storage (ii). High efficiency (iii). Pollution free (iv). Wide applications (v). Economical Disadvantages of hydrogen energy (i). Its low availability in pure H_2form in the environment. (ii). Difficulty in handling, storing and transportation of H_2. (iii). Requirement of energy for the production of H_2.
7(a)	Derive an expression for finding an energy availability in tidal source.
Ans:	The energy available from barrage is dependent on the volume of water. The potential energy contained in a volume of water is expressed as below. $E=1/2\ Apgh^2$ Where, h is the vertical tidal range, A is the horizontal area of the barrage basin, ρ is the density of water = 1025 kg per cubic meter (seawater varies between 1021 and 1030 kg per cubic meter) and g is the acceleration due to the Earth's gravity = 9.81 meters per second squared.
7(b)	Explain with neat diagram, the working of twin-basin system for tidal energy.
Ans:	Twin basin System has two basins at two different levels and sluice gates are provided in the dam. • Upper basin is filled during high tide and lower basin is emptied during low tide. Therefore, it creates a permanent head for turbine to operate continuously. • Power generation is continuous. • The peak power demands can be met by pumping water by other means from lower basin to upper basin.

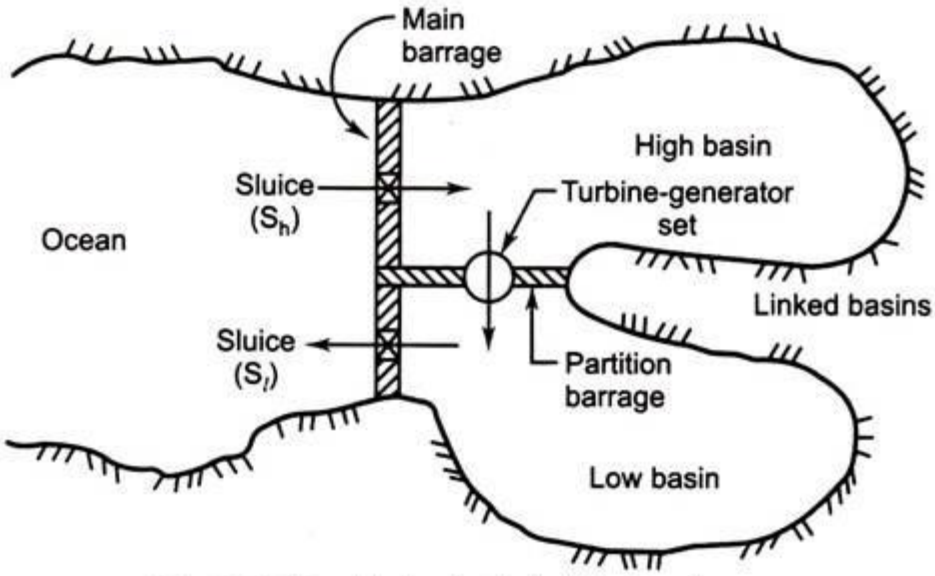


Fig. 8.10. Double-basin, linked-basin scheme.
