BIOMASS

Biomass is an organic matter produced by plants, both terrestrial and aquatic & their derivatives. It includes forest crops & residues, crops grown on energy farms and animal manure. It can also be considered a form of solar energy as the latter is used indirectly to grow these plants by photosynthesis.

Solar energy → Photosynthesis → Biomass → Energy generation.

Biomass Conversion:

1. Direct Combustion: Domestic refuse can be dried and burnt to provide heat. Fuels derived from biomass (Bio fuels) are easily handled & burnt, whereas raw biomass is often wet & of inconsistent quality. Solid biofuels - wood, straw, refuse.
Liquid biofuels - Alcohols, vegetable oil.
Gases biofuels - Production of biogas from dung and agricultural wastes is now extensive in some developing countries. Biogas is a mixture of methane and CO_2 with traces of hydrogen sulphide.

2. Thermochemical conversion: It takes 2 forms: gasification and liquefaction. Gasification takes place by heating the biomass with limited oxygen to produce low heating value gas or by reacting it with steam

and oxygen at high Pressure and temperature to produce medium heating value gas. The latter may be used as fuel directly or used in liquefaction by converting it to methanol (CH_3OH), or ethanol (CH_3CH_2OH) or it may be converted to high heating value gas.

3. Biochemical Conversion: It takes 2 forms: Anaerobic digestion and fermentation. Anaerobic digestion involves the microbial digestion of biomass.

Wet Processes:

Fermentation: is the breakdown of complex molecules in organic Compound under the influence of a ferment such as yeast, bacteria, enzymes etc. Fermentation is a well established & widely used technology for the conversion of grains & sugar crops into ethanol. One tonne of sugar will produce upto 520 litres of alcohol, a tonne of grain, 350 litres and a tonne of wood, an estimated 260 to 540 litres. After fermentation, residue from grains and other feed stuffs contains high Protein content and is a useful cattle feed supplement.

Anaerobic digestion: Biogas is produced by the bacterial decomposition of wet sewage sludge, animal dung or green Plants in the absence of oxygen. The natural decay Process, Anaerobic ~~digesti~~ decomposition, can be speeded up by using a thermally insulated air tight tank with a stirrer unit and heating system. The gas collects in the digester tank above slurry & can be piped off continuously. At optimum temp (35°C) complete decomposition of animal or human faces takes around 10 days. The residue left after digestion is valuable fertilizer. It is also rich in protein and could be dried and used as animal feed supplement.

<u>Chemical reduction</u>: It involves pressure - cooking animal wastes or plant cellulosic slurry with an alkaline catalyst in the presence of CO at temp. b/w 250°C and 400°C.

<u>Dry Processes</u>:

<u>Pyrolysis</u>: A wide range of energy rich fuels can be produced by roasting dry wood matter like straw and wood chips. The material is fed into a reactor vessel in a Pulverised form and heated in the absence of air. (Air cause Pyrolysis Products to ignite). As the temp. rises the cellulose and lignin break down to simpler substances which are driven off leaving a char residue behind. This Process is used to produce charcoal.

<u>Lequefaction</u>: Liquid yields are maximized by rapid heating of the feed~~back~~ stock to comparatively low temp. The vapours are condensed from the gas stream and these separate into a 2 phase liquor: the aqueous phase contains a soup of water soluble organic materials like acetic acid, acetone and methanol (wood alcohol); the non-aqueous phase consists of oils & tars.

Gasification: Pyrolysis of wet biomass produces fuel gas & very little Liquid. An alternative technique for maximising gas yields is to blow small quantities of air into the reactor vessel and to inc. temp. over 1000°c. This causes part of the feed to burn. This gas can either be burnt or converted into substitute natural gas (methane) or methanol by Std. catalytic Processes.

Steam - gasification: Methane is produced directly from woody matter by treatment at high temp. & Pressure with hydrogen gas.

Hydrogenation: Under less severe condn. of temp. & Pressure (300 - 400°c and 100 atm), CO & steam react with cellulose to produce heavy oils which can be separated and refined to Premium fuels.

Types of Biomass fuels :

1. **Solids** : Three solid biofuels are being burnt on an inc. scale in many countries to provide useful heat.

→ **wood** : In the form of cut logs, wood chips and saw dust is currently used for domesting heating and to provide heat in the timber and furniture industries. Wood though it is bulky fuel, has low ash and sulphur content and burns easily. It requires four volumes of air-dried wood to deliver an equivalent amount of heat to that from one volume of coal.

→ **straw** : Various sizes of straw - baled or chopped, compressed straw are burn to provide heat for crop drying and space and water heating.

→ **Municipal refuse** : It is far from ideal fuel and messy to handle. It has low and variable energy content on avg. only about $\frac{1}{3}$ that of coal. It is dried, sorted and shredded and can then be burn to provide heat. However, precautions must be taken to ensure that corrosive combustion products donot damage the boiler, flue gases must also be conditioned to remove noxious products before release.

2. <u>Liquids</u> : Alcohols and vegetable oils are now replacing petrol and diesel as transport fuels in several Countries.

→ <u>Alcohol</u> : Alcohols have high octane rating, but a lower Calorific value than petrol. However, alcohols can improve engine performance, they burn with higher efficiency and at lower temp. and are free from lead and sulphur. This reduces noxious emissions.

Pipes, Pumps and fuel tanks must be Protected ∵ alcohols (methanol, ethanol), particularly methanol Contains traces of water and corrosive organic impurities.

→ <u>Vegetable oils</u> : From crushed seeds and nuts (sunflower seed, Peanuts, Palm, soya and corn) can be burnt in unmodified diesel engines. They can be blended with diesel fuel or used directly.

3. <u>Gases</u> : The production of biogas from dung and agricultural wastes is now extensive in some developing Countries. Biogas is a mixture of methane, CO_2 and traces of hydrogen sulphide. It is impossible to store large volumes of biogas at low pressure. ∴ most economically it is used as it is produced. eg. in space, water heating and cooking needs on farms. Biogas can be compressed and stored by removing CO_2 by chemical treatment.

Factors affecting Biodigestion or Generation of Gas :

1. Temperature : Methane bacteria work best at a temp. b/w 35°c - 38°c. The fall in gas production starts at 20°c and stops at a temp. of 10°c.

2. pH or hydrogen ion concentration : The digester is usually buffered in the pH range 6.5 to 7.5. In this pH range, micro-organisms will be very active and biodigestion will be very efficient. ph 4-6 → Acidic , pH 9-10 → Alkaline.

3. Seeding : Although bacteria required for acid fermentation and methane fermentation are present in cow dung, their no. are not large. It would be advantageous to inc. no. of methane formers by artificial seeding with a digested sludge that is rich in methane formers.

4. Mixing or stirring or agitation of the content of the digester : Since bacteria in the digester have very limited reach to their food, it is necessary that the slurry is properly mixed and bacteria get their food supply to improve fermentation.

5. Toxicity : The digested slurry, if allowed to remain in the digester beyond a certain time, becomes toxic to the micro organisms and might cause fall in the fermentation rate.

6. Loading rate: It is the amount of raw material fed to the digester per day per unit volume. Most municipal sewage treatment plants operate at a loading rate of 0.5 to 1.6 kg of volatile solids per m^3 per day. If digester is loaded with too much raw material at a time, acids will accumulate and fermentation will stop.

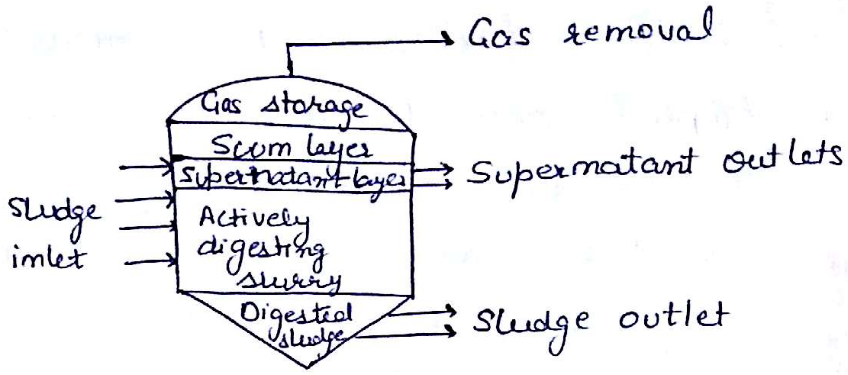
7. Pressure: Some work conducted at National Environmental Engineering Research Institute (NEERI) Nagpur and other places indicated that the pressure on the surface of slurry also affects the fermentation. It has been reported to be better at lower pressures.

Classification of Biogas Plants:

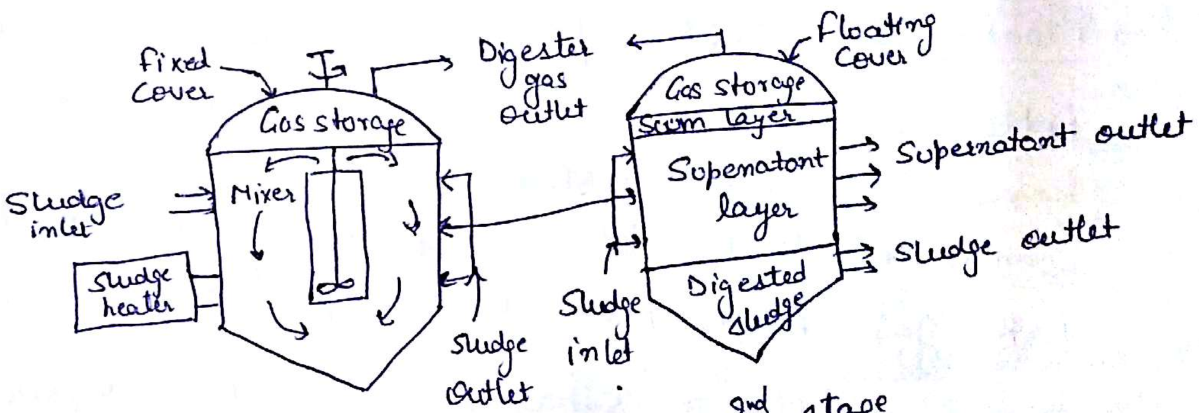
1. Continuous and batch types:

(a) Continuous plant: There is a single digester in which raw material are charged regularly and the process goes on without interruption except for repair, cleaning etc.

→ Single stage Process: The entire process of conversion of complex organic compounds into biogas is completed in a single chamber. This chamber is regularly fed with the raw materials while the spent residue keeps moving out. Serious problems are encountered with agricultural residues when fermented in this process.



→ **Double stage process:** The acidogenic stage and methanogenic stage are physically separated into 2 chambers. Acid production is carried out in 1st chamber and only the diluted acids are fed into 2nd chamber where bio-methanation takes place and biogas can be collected. This offers higher potential of success in fermenting fibrous plant waste materials.



1st stage
Completely mixed

2nd stage
Stratified

Main features of continuous plant:

- → Produce gas continuously
- → Requires small digestion chambers
- → Needs lesser period for digestion
- → Less problems than batch type.
- → Easier in operation

(b) Batch Plant : The feeding is b/w intervals, the plant is emptied once the process of digestion is complete. In this type, a battery of digesters are charged along with lime, urea, etc. and allowed to produce gas for 40-50 days.

Main features of batch plant:

→ Gas production is intermittent depending upon the clearing of the digester.

→ Need several digesters fed alternately for ~~cont~~ continuous gas production.

→ Good for long fibrous material

2. Dome and drum types :

→ Floating gas holder plant : The floating gas holder digester which is used in India is known as KVIC (Khadi Village Industries Commission) Plant. It is of masonry construction with gas holder made of M.S. plates.

The gas holder is separated from the digester. Rusting of gas holder as well as cost of gas holder are main drawbacks of this system.

Advantages:

i) Less scum troubles ∵ solids are constantly submerged. Also, welded braces help in breaking scum by rotation.

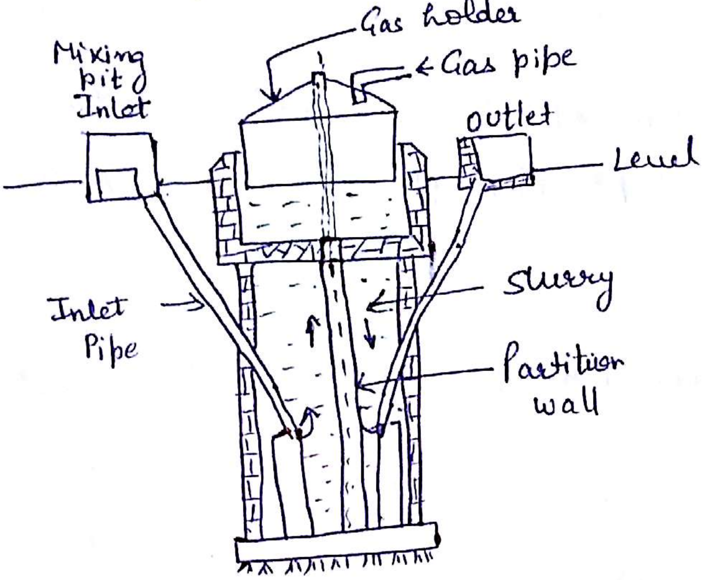
ii) No problem of gas leakage

iii) Const. gas pressure

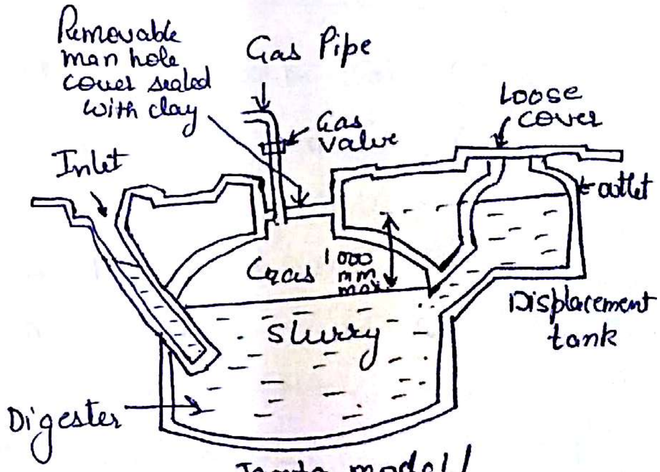
iv) Higher gas production per cu. m of digester volume.

Disadvantages :

i) Higher cost, dependent on steel and cement.
ii) Heat is lost through metal gas holder, hence it troubles in colder regions and periods.
iii) Requires Painting once or twice a year, depending on the humidity of location.
iv) Flexible Pipe joining gas holder to main gas pipe requires maintenance as it is damaged by U.V. rays in the Sun.



KVIC digester



Janta model / Fixed dome digester China

→ Fixed dome type : It is also called chinese plant. In this, gas holder and digester are combined. It is best suited for batch process especially when daily feeding is adopted in small quantities. It is usually built below ground level and is suitable for cooler regions.

Both of these digesters may be vertical or horizontal, cylindrical, rectangular, sperical etc., May be constructed above or underneath the ground.

Advantages:

i) Low cost as compared to floating drum type, as it uses only cement and no steel.

ii) No corrosion trouble.

iii) Heat insulation is better as construction is beneath the ground. Temp. will be const.

iv) No maintenance.

v) cattle and human excreta and long fibrous stalks can be fed.

Disadvantages:

i) Gas Production Per cum of digester volume is less.

ii) Scum formation is a problem as no stirring arrangements.

iii) Variable gas Pressure

iv) Needs skilled masons who are scarce in rural areas.