Serial No.....

Biomass Energy

Biomass refers to all naturally occuring organic matters except the fossil fuels. The trapping of solar energy in organic material as fixed carbon via photosynthesis is the key initial step for biomass formation.

$$n CO_2 + n H_2O \xrightarrow[\text{solar radiation}]{\text{chlorophyll}} \underset{\text{carbohydrate}}{(CH_2O)_n} + n O_2$$

Each gram atom (12 gm) of carbon absorbed 470 KJ of solar energy.

So that Biomass is a secondary form of solar energy.

The major sources of biomass are:-

i) Agricultural residues
ii) Forest residues
iii) Animal waste
iv) Municipal solid waste (MSW)
v) Food processing industrial waste.

Advantage

i) The idea of using biomass as a source of energy makes sense because it has been estimated that total biomass energy stored worldwide per year is about 10 times the total energy used by man each year.
ii) It is renewable in nature
iii) Biomass also contains some plant nutrients like P, K, N etc.
iv) It holds promising future in developing country.

Assessing potential of Biomass Energy in India

* In India ≈ 35% of the annual energy demand is met from biomass & rest 65% from commercial sources.

* In India 73% of Indians live in villages. In rural India biomass provides 90% of the energy need, due to unavailability of the commercial sources of energy.

* Total agricultural residues or bioproducts generation in India - 320 million tonns/year.

* Biomass calorific value range: 3500Kcal/kg
∴ 80% of coal consumption can be replaced by biomass with advancement in tech.

* Total annual cattle dung production in India is 900 metric tonn/year.

* other than these huge amount of municipal solid waste is generated eg: 2500 tonne/day in Kolkata.

Methods for extraction of energy from Biomass

Traditional method

Direct burning of air-dried biomass in open chulha.

biomass burns with very low efficiency
$\eta = 5-10\%$ → most of the volatiles are lost during the combustion process.
Traditional chulha are not well designed.

conversion
1) Thermochemical ^methods
2) Bio-chemical ^conversion methods.

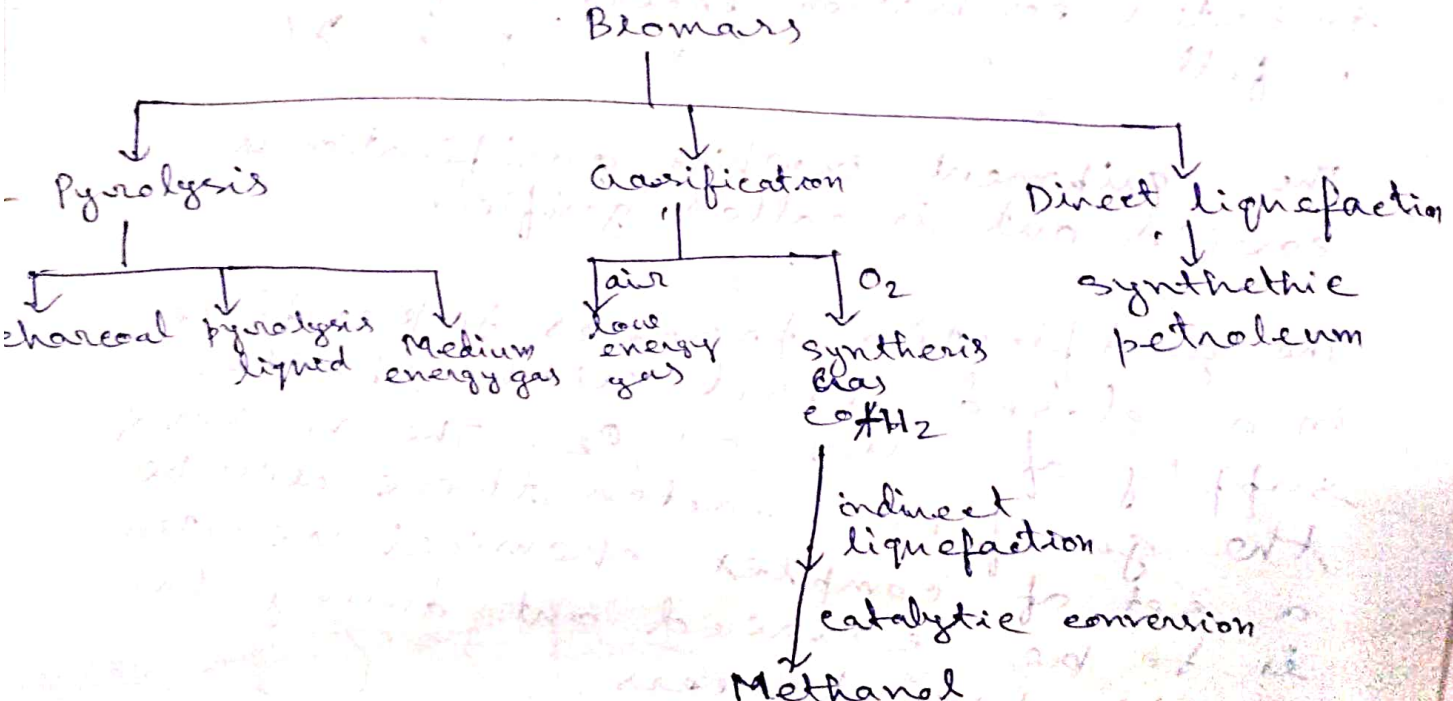
1) Thermochemical conversion of Biomass to energy

Like any other polymer biomass is unstable at high temp. & will break down to form smaller & less complex molecules - both liquid & gaseous. Combustion represents a complete oxidation to carbon dioxide & water.

$$\underset{(C,H,O)}{\text{Biomass}} + O_2 = CO_2 + H_2O$$

By controlling the process using a combination of pressure, temp., catalysts & also by limiting the ^supply of O_2 various useful fuels can be produced.

Major thermochemical processes are.



Preparation of biomass for thermal processing

i) adjustment of particle size by pelletising or chopping
ii) dehydration
iii) removal of incombustible objects
iv) removal of moisture → high moisture content is undesirable moisture content below 20% is desirable. it

before it sent to thermal processing.
→ it affects the reaction rate.

INTRODUCTION

The simplest shape & design of the gasifier itself is the fixed bed reactor, which consist of an upright metal cylinder containing the bed of feedstock having an inlet & outlet for gases, a means of feeding additional solid feedstock from above & a means of ash removal at the base. The biomass is fed in at the top. The solid fuels passes through drying, pyrolysis, combustion & reduction zone. In the drying zone where the temp. is around 150°c moisture from the solid fuel is removed. In the pyrolysis zone where the temp. is 400°c - 500°c thermal break down of fuel takes place in the absence of air, resulting in the formation of methanol, acetic acid & heavy hydrocarbons including tar. The solid material remaining after pyrolysis is mainly fixed carbon in the form of charcoal.

(Kitose)

$$n\,C_6(H_2O)_5 \longrightarrow n\,6C + n\,5H_2O$$

The pyrolysed material passed through combustion zone (900° - 1300°c)

$$C + O_2 \longrightarrow CO_2$$
$$C + H_2O \longrightarrow H_2 + CO$$

In reduction zone (800° - 1100°c)

$$CO_2 + C \longrightarrow 2CO$$
$$CO_2 + H_2 \longrightarrow CO + H_2O$$
$$C + 2H_2 \longrightarrow CH_4$$

The temp. of the gases 250°c

CO : 16 - 25%
H_2 : 13 - 18%
CH_4 : 2 - 5%
Heavy hydrocarbons 0.2 - 0.4%
CO_2 : 5 - 14%, N_2 43 - 54%
water vapour → 20 - 15%

Signature of the Invigilator

HALDIA INSTITUTE OF TECHNOLOGY

.....Test Slot Examination, 200.....

Name.....

Branch.....Semester.....Roll No.....

Subject.....Biomass Energy.....Code No.....

Date of Examination.....

classification of Biogas plants

Biogas plants are mainly classified as:

1) Continuous & batch types (as per the process)
2) The dome & the drum types.
3) Different variations in the drum type.

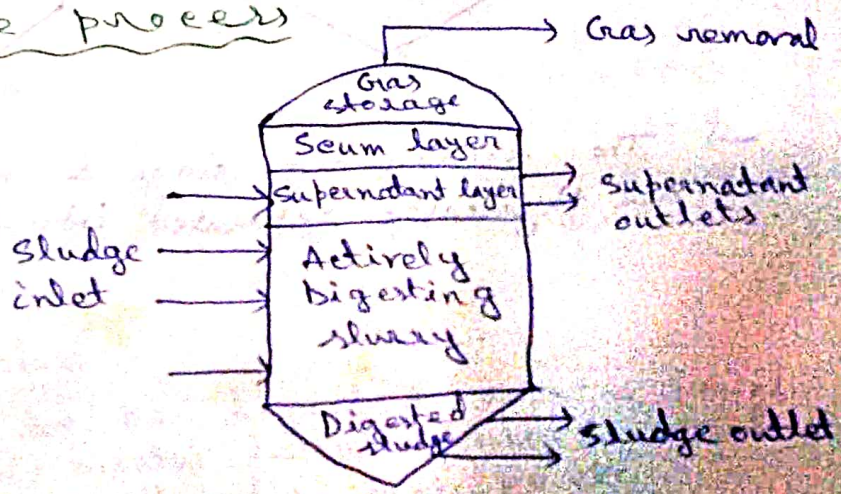
a) continuous plant

→ There is a single digester in which raw material are charged regularly & the process goes on without interuption except for repair & cleaning etc.

→ In this case the raw material is self buffered (like cow dung).

The continuous process may be completed in a single stage or separated into two stages.

1) Single stage process

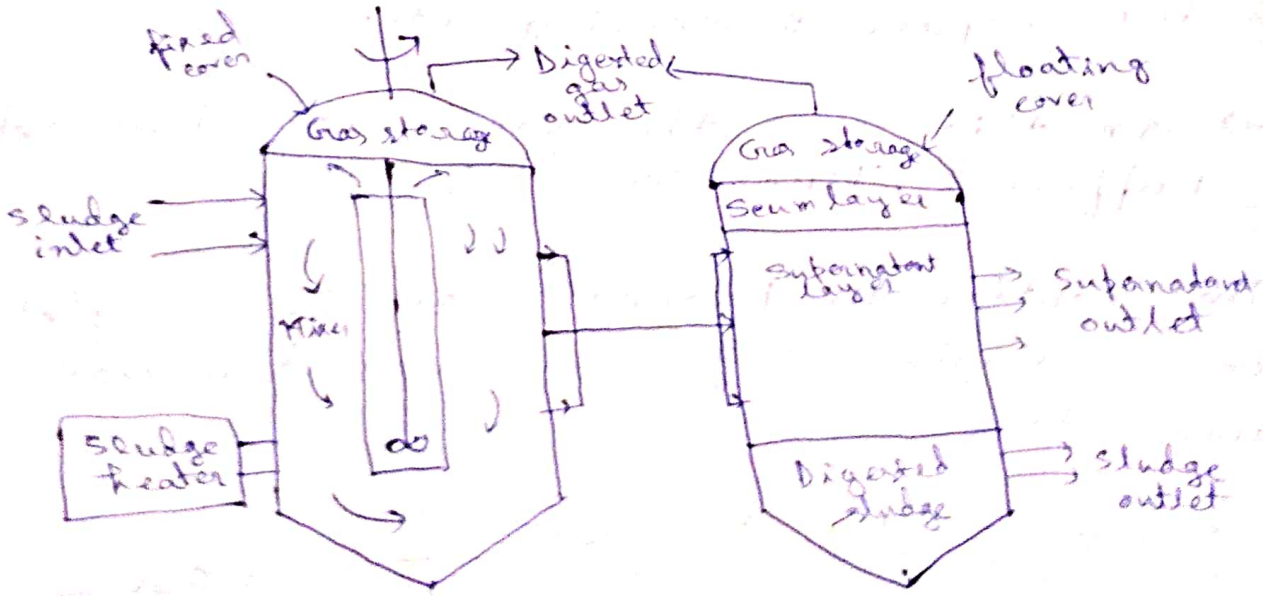


→ The entire process of conversion of complex organic compounds into biogas is completed in a single chamber.

→ This chamber is regularly fed with the raw materials while the spent residue keeps moving out.

→ Serious problems are introduced with agricultural residues when fermented in a single stage continuous process.

ii) Double stage process

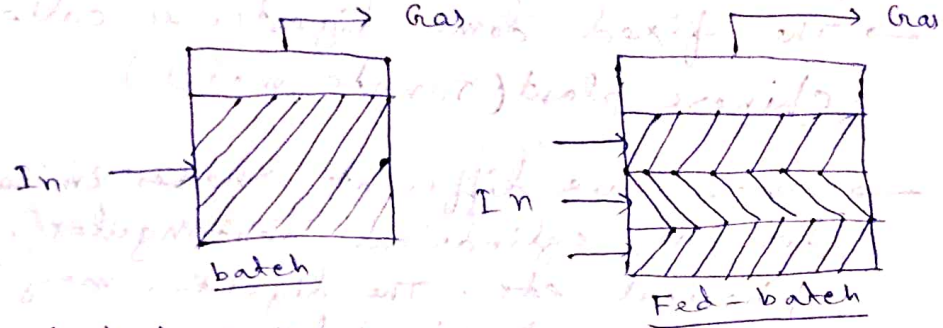


→ The acidogenic stage & methanogenic stage are physically separated into two chambers.

→ Thus the 1st stage of acid production is carried out in a separate chamber & only the diluted acids are fed into the and chamber where bio-methanation takes place & the biogas can be collected from the and chamber.

b) The batch plant

→ The substrate biomass is introduced at one time in the begining of the process.



Fed - batch type

→ In fed - batch type, the substrate biomass is introduced at two or three times, but no residue is removed till the end of the process

The main features of batch type

→ The gas production in it is intermittent, depending upon the clearing of the digester.

→ It needs several digesters or chambers for continuous gas production, these are fed alternately.

→ This plant needs addition of fermented slurry to start the digestion process. There may be a direct change to the acid phase in absence of the fermented slurry, which affects formation of methane.

→ It is expensive.

→ It allowed to be digested over a period of two to six months depending upon the feed material & other parameters like temp, PH etc.

The dome & the drum types

There are numerous models of a biogas plant mainly two main types are usually used:

i) The floating gas holder plant
ii) Fixed dome digester.

→ The floating gas holder digester which is used in India is known as KVIC plant. (The Khadi Village Industries Commission)

→ The fixed dome digester is called the Chinese plant (Janata model)

→ There are different shapes in both the designs, cylindrical rectangular, spherical etc. The digester may be vertical or horizontal.

→ They may be constructed above or underneath the ground.

The floating gas holder

→ The floating gas holder digester is developed in India.

→ The gas holder is separated from the digester.

→ The cost of gas holder are the main drawbacks of this system.

→ KVIC model is a drum type or floating gas holder type, developed in India

Fixed dome digester

→ In this digester, the gas holder & the digester are combined.

→ This is best suited for batch process especially when daily feeding is adopted in small quantities.

→ This digester is usually built below ground level & is suitable for cooler regions.

→ Local materials can be used in this construction.

→ The pr. inside the digester varies as the gas is collected.

→ This is not found to cause any serious problems in small plants.

→ eg: Deenbandhu model developed by Action for food production, New Delhi which is a low cost plant.

→ eg: Janata model is a drumless type similar in construction to the KVIC model except that the steel drum is replaced by a fixed dome roof of masonry construction.

Different variations in the drum type

There are two main variations in the floating drum design.

i) with water seal.
ii) without water seal.

Advantages of water seal

→ water sealing makes the plant completely anaerobic.

→ The corrosion of the gas holder drum is reduced.

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The other variations are of materials used both in construction of the digester & the gas holder.

→ Bricks & stones are the commonly used materials.

Floating drum plant

Advantages

→ It has less scum troubles because solids are constantly submerged.

→ No separate pr. equalizing device needed when fresh waste is added to the tank or digested slurry is withdrawn.

→ Higher gas production

Selection of site for a Biogas plant

1) Distance

→ The distance bet^{n} the plant & the site of gas consumption should be less in order to achieve economy in pumping of gas & minimizing gas leakage. For a plant of capacity 2 m^3, the optimum distance is 10 m.

2) Minimum gradient

For conveying the gas a minimum gradient of 1% must be made available for the line.

3) Open space

The sunlight should fall on the plant as temp. bet^{n} 15°c to 30°c is essential for gas generation at good rate.

4) Availability of water

Plenty of water must be available as the cowdung slurry with a solid concentration of 7% to 9% is used.

5) Distance from well

The seepage of fermented slurry may pollute the well water.

6) Space requirements

Sufficient space must be available for day to day operation & maintenance. As a guideline 10 to 12 m^3 area is needed per m^3 of the gas.

7) Source of cowdung / materials for biogas generation

The distance bet^{n} the material for biogas generation & the gas plant site should be minimum to economise the transportation cost.

Application of the Gasifier

Small size Gasifiers (upto 10 KW)

This category of gasifiers shall find application in rural areas, especially for providing shaft line power to agricultural pumps, processing machinery & agricultural processing machineries like straw choppers etc.

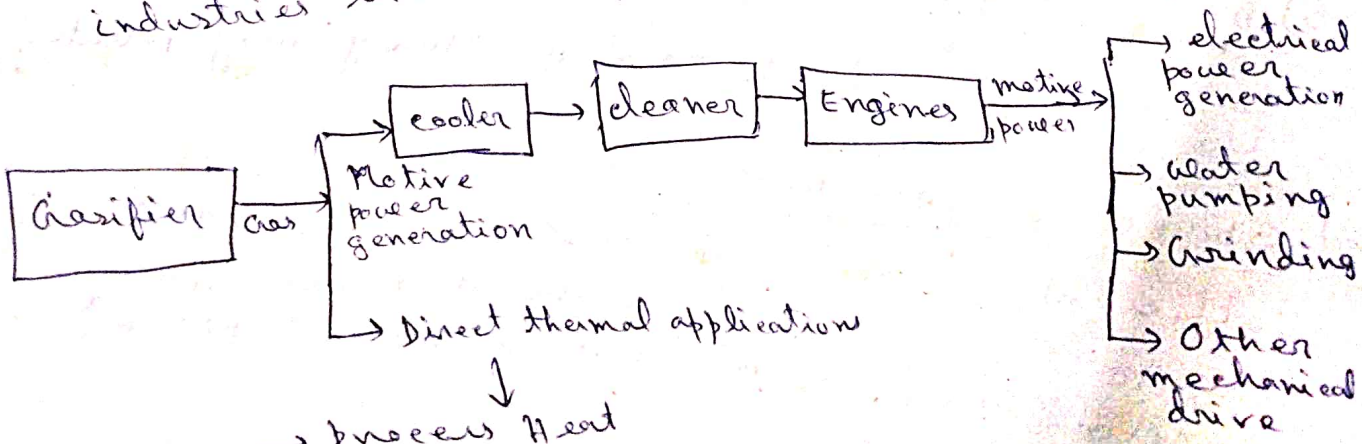
Medium size Gasifiers (10 KW - 50 KW)

This category of gasifiers can easily meet the shaft line power requirements of various rural industries like saw mills, carpentary workshops, mechanical fabrication shops as well as small rice mills.

Large size gasifiers (50 KW & above)

→ This category of gasifiers can find applications in rural as well as urban industries.

→ This gasifiers can meet the shaft power requirements directly or indirectly of various industries like dairy, oil mill, mineral processing.



→ process Heat
→ Run furnace
→ chemicals
→ ceramics & pottery
→

classification of Biogas Plants

1) Continuous & batch types (as per the process)
2) The dome & the drum types
3) Different variations in the drum type

2) The dome & the drum types

a) There are numerous models of a biogas plant mainly two main types are usually used.

i) The floating gas holder plant &
ii) Fixed dome digester → Deen bandhu model.

→ KVIC model (Khadi Village Industries Commission) ~~Janata model~~ steel

KVIC model is a drum type of floating gas holder type. Developed in India.

Deenbandhu model developed by Action for Food production, New Delhi which is low cost plant.

Janata model also called chinese plant is a drumless type similar in construction to the KVIC model except that the steel drum is replaced by a fixed dome roof of masonry construction.

The drum in the KVIC model is the costliest component & its life is comparatively less (about 10 years).

3) Different variations in the drum type

→ There are two main variations in the floating drum design.

⇒ One with water seal &
⇒ without water seal.

→ water sealing makes the plant completely anaerobic & corrosion of the gas holded drum is also reduced.

→ Bricks & stones are the commonly used materials.

→ The other variations are of materials used both in construction of the digester & the gas holder.

Floating Drum plant

Advantages

i) It has less scum troubles becoz solids are contantly submerged.
ii) no problem of gas leakage
iii) constant gas pressure.
iv) Higher gas production per cu m of the digester volume is achieved.

Disadvantages

i) It has higher cost, as cost is dependent on steel & cement
ii) Heat is lost through the metal gas holder, hence it troubles in colder regions & periods.
iii) Gas holder requires painting once or twice a year, depending on the humidity of the location.

Fixed dome type plant.

Advantages

i) It has low cost compare to floating drum type, as it uses only cement & no steel.
ii) It has no corrosion trouble.
iii) No maintenance.

Disadvantages

i) This type of plant needs the services of skilled mason, who are rather scarce in rural areas.
ii) It has variable gas pressure.
iii) Gas production per cum of the digester volume is also less.