Module 5: BIOMASS& GREEN ENERGY

Biomass is biological material derived from living, or recently living organisms. It most often refers to plants or plant-derived materials which are specifically called biomass. As a renewable energy source, biomass can either be used directly via combustion to produce heat, or indirectly after converting it to various forms of biofuel. Conversion of biomass to biofuel can be achieved by different methods which are broadly classified into: thermal, chemical, and biochemicalmethods.

5.1 Benefits of Using Biomass

1) Biomass used as a fuel reduces need for fossil fuels for the production of heat, steam, and electricity for residential, industrial and agriculturaluse.

2) Biomass is always available and can be produced as a renewableresource.

3) Biomass fuel from agriculture wastes maybe a secondary product that adds value to agricultural crop.

4) Growing Biomass crops produce oxygen and use up carbondioxide.

5) The use of waste materials reduce landfill disposal and makes more space for everythingelse.

6) Carbon Dioxide which is released when Biomass fuel is burned, is taken in byplants.

7) Less money spent on foreignoil.

5.2 Biofuels

A biofuel is a fuel that uses energy from a carbon fixation. These fuels are producedfromlivingorganisms. Examples of this carbonfixation are plants and microalgae. These fuels are made from a biomass conversion.

This biomass conversion‘s can being solid, liquid, or gas form. This new biomass can be used for bio fuels. Bio fuels have increased in popularity because of the raisingoil prices and need for energysecurity.

Bio ethanol is an alcohol made by fermentation, mostly from carbohydrates produced in sugar or starch crops such as corn or sugarcane. Cellulosic, derived from non-food sources, such as trees and grasses, is also being developed as a feedstock for ethanol production. Ethanol can be used as a fuel for vehicles in its pure form, but it is usually used as a gasolineadditive to increase octane and improve vehicle emissions.

Biodiesel is made from vegetable oils and animal fats. Biodiesel can be used as a fuel for vehicles in its pure form, but it is usually used as adiesel additive to reduce levels of particulates, carbonmonoxide, and hydrocarbons from diesel-powered vehicles. Biodiesel is produced from oils or fats using transesterification

5.3 Biopower

Biopower, or biomass power, is the use of biomass to generate electricity. Biopower system technologies include direct-firing, cofiring, gasification, pyrolysis, and anaerobic digestion.

Most biopower plants use direct-fired systems. They burn bioenergy feedstocks directly to produce steam. This steam drives a turbine, which turns a generator that converts the power into electricity. In some biomass industries, the spent steam from the power plant is also used for manufacturing processes or to heat buildings. Such combined heat and power systems greatly increase overall energy efficiency. Paper mills, the largest current producers of biomass power, generate electricity or process heat as part of the process for recovering pulpingchemicals.

Co-firing refers to mixing biomass with fossil fuels in conventional power plants. Coal-fired power plants can use co-firing systems to significantly reduce emissions, especially sulfur dioxide emissions. Gasification systems use high temperatures and an oxygen-starved environment to convert biomass into synthesis gas, a mixture of hydrogen and carbon monoxide. The synthesis gas, or "syngas," can then be chemically converted into other fuels or products, burned in a conventional boiler, or used instead of natural gas in a gas turbine. Gas turbines are very much like jet engines,

only they turn electric generators instead of propelling a jet. High-efficiency to begin with, they can be made to operate in a "combined cycle," in which their exhaust gases are used to boil water for steam, a second round of power generation, and even higher efficiency.

Using a similar thermochemical process but different conditions (totally excluding rather than limiting oxygen, in a simplified sense) will pyrolyze biomass to a liquid rather than gasify it. As with syngas, pyrolysis oil can be burned to generate electricity or used as a chemical source for making fuels, plastics, adhesives, or otherbioproducts.

Bio products

The processes are similar. The petrochemical industry breaks oil and natural gas down to base chemicals and then builds desired products from them. Biochemical conversion technology breaks biomass down to component sugars, and thermochemical conversiontechnology breaks biomass down to carbon monoxide and hydrogen. Fermentation, chemical catalysis, and other processes can then be used to create new products.
Bioproducts that can be made from sugars include antifreeze, plastics, glues, artificial sweeteners, and gel for toothpaste. Bioproducts that can be made from carbon monoxide and hydrogen of syngas include plastics and acids, which can be used to make photographic films, textiles, and synthetic fabrics. Bioproducts that can be made from phenol, one possible extraction from pyrolysis oil, include wood adhesives, molded plastic, and foaminsulation.

5.4 Photosynthesis

Photosynthesis is the process by which plants, some bacteria, and some protistans use the energy from sunlight to produce sugar, which cellular respiration converts into ATP, the "fuel" used by all living things. The conversion of unusable sunlight energy into usable chemical energy, is associated with the actions of the green pigment chlorophyll. Most of the time, the photosynthetic process uses water and releases the oxygen that we absolutely must have to stay alive. Oh yes, we need the food as well!

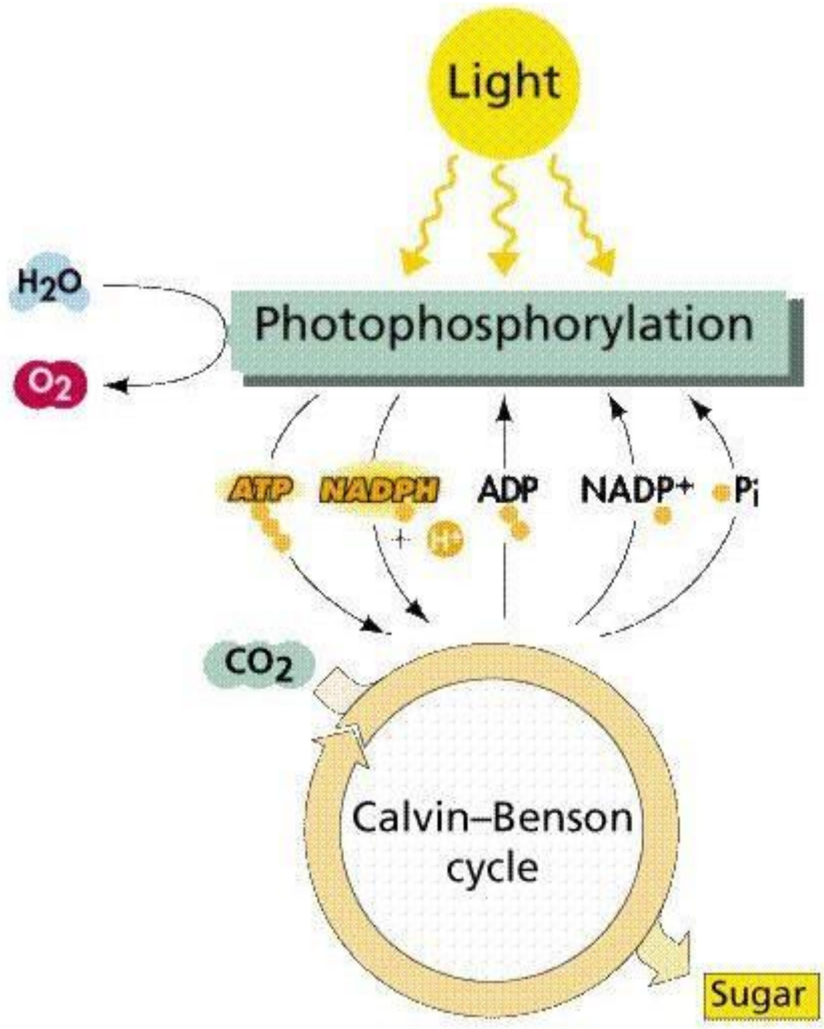
We can write the overall reaction of this process as:

$$6H_2O + 6CO_2 \text{---------} > C_6H_{12}O_6 + 6O_2$$

six molecules of water plus six molecules of carbon dioxide produce one molecule of sugar plus six molecules of oxygen

Photosynthetic Oxygen production

Photosynthesis is a two stage process. The first process is the Light Dependent Process (LightReactions), requires the direct energy of light to make energy carrier molecules that are used in the second process. The Light Independent Process (or Dark Reactions) occurs when the products of the Light Reaction are used to form C-C covalent bonds of carbohydrates. The Dark Reactions can usually occur in the dark, if the energy carriers from the light process are present. Recent evidence suggests that a major enzyme of the Dark Reaction is indirectly stimulated by light, thus the term Dark Reaction is somewhat of a misnomer. The Light Reactions occur in the grana and the Dark Reactions take place in the stromaof the chloroplasts.



Light Reactions

In the Light Dependent Processes (Light Reactions) light strikes chlorophyll a in such a way as to excite electrons to a higher energy state. In a series of reactions the energy is converted (along an electron transport process) into ATP and NADPH. Water is split in the process, releasing oxygen as a by-product of the reaction. The ATP and NADPH are used to make C-C bonds in the Light Independent Process (Dark Reactions).

Energy Plantation:

The need to grow Energy Plantations to meet fuel wood needs without affecting agricultural lands is a pressing priority. Energy plantations on waste lands is one of the most economic and versatile ways of harnessing solar energy through the photosynthetic process. In addition to making fuel wood availability, it can also improve the fertility of degraded lands. Gujarat has over 67 lakh hectares of wastelands (almost 10% of the 63 million hectares of waste land in the country) which

could be productively used to grow energy plantations.GEDA had taken up energy plantation programme in 1985-86 and continued till 1998-99 linking to energy supply, food & fodder, soil regeneration, ecological development, and employment generation through efficient utilisation of wasted, unproductive and neglected lands in AbdasaTaluka of Kutch District.

Decomposition process

The process of decomposition — the breakdown of raw organic materials to a finished compost — is a gradual complex process, one in which both chemical and biological processes must occur in order for organic matter to change intocompost.

there are two processes that yield compost:

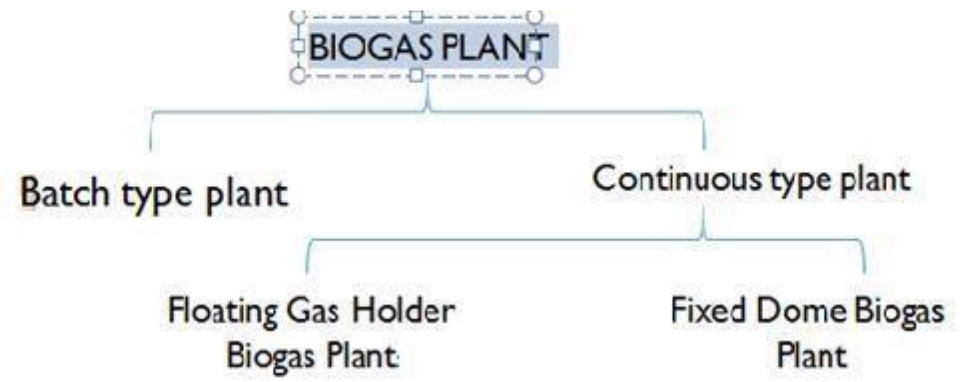
ANAEROBIC (without oxygen)

decomposition.AEROBIC (with oxygen) decomposition

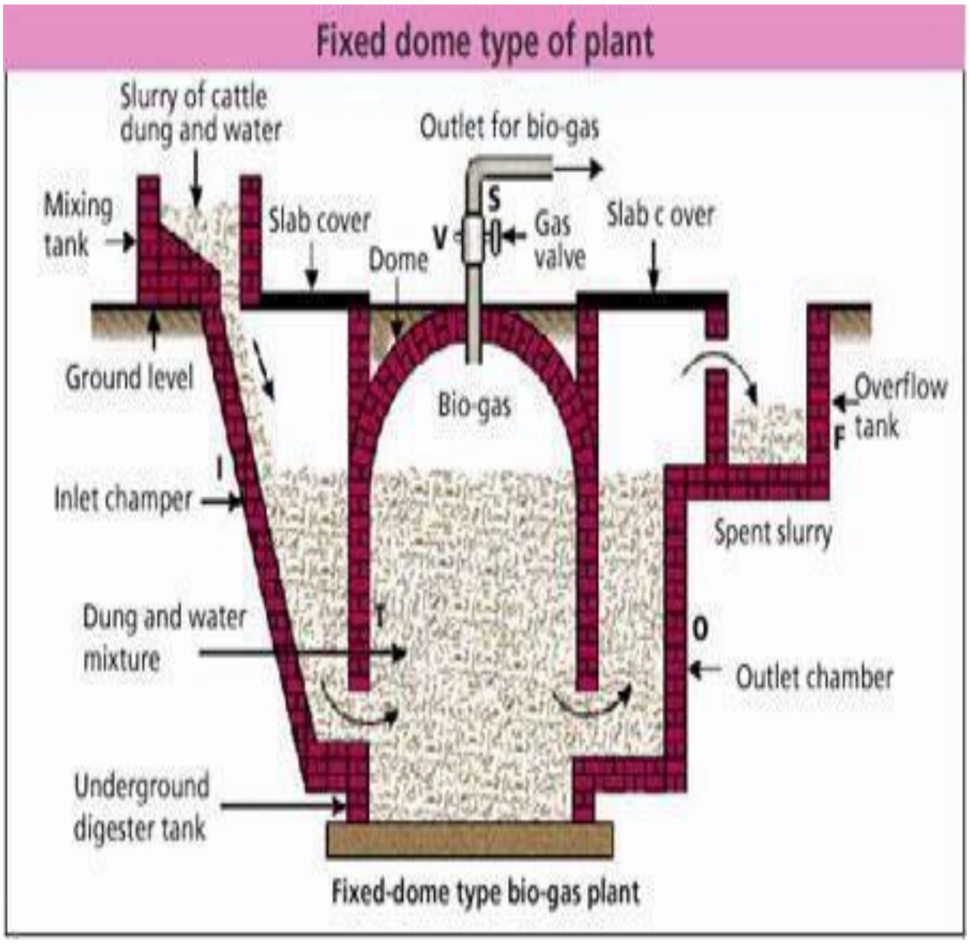
and stabilization.

In these processes, bacteria, fungi, molds, protozoa, actinomycetes, and other saprophytic organisms feed upon decaying organic materials initially, while in the later stages of decomposition mites, millipedes, centipedes, springtails, beetles and earthworms further breakdown and enrich the composting materials. The organisms will vary in the pile due to temperature conditions, but the goal in composting is to create the most favorable environment possible for the desired organisms. Differences between aerobic and anaerobic composting are discussed below.

5.5 CLASSIFICATION OF BIO GAS PLANTS



Fixed dome type of biogas plant



Raw materials required

Forms of biomass listed below may be used along with water.

- Animal dung
- Poultrywastes
- Plant wastes (Husk, grass, weedsetc.)
- Humanexcreta
- Industrial wastes(Saw dust, wastes from food processingindustries)
- Domestic wastes (Vegetable peels, waste foodmaterials)

Principle

Biogas is produced as a result of anaerobic decomposition of biomass in the presence of water.

Construction

The biogas plant is a brick and cement structure having the following five sections:

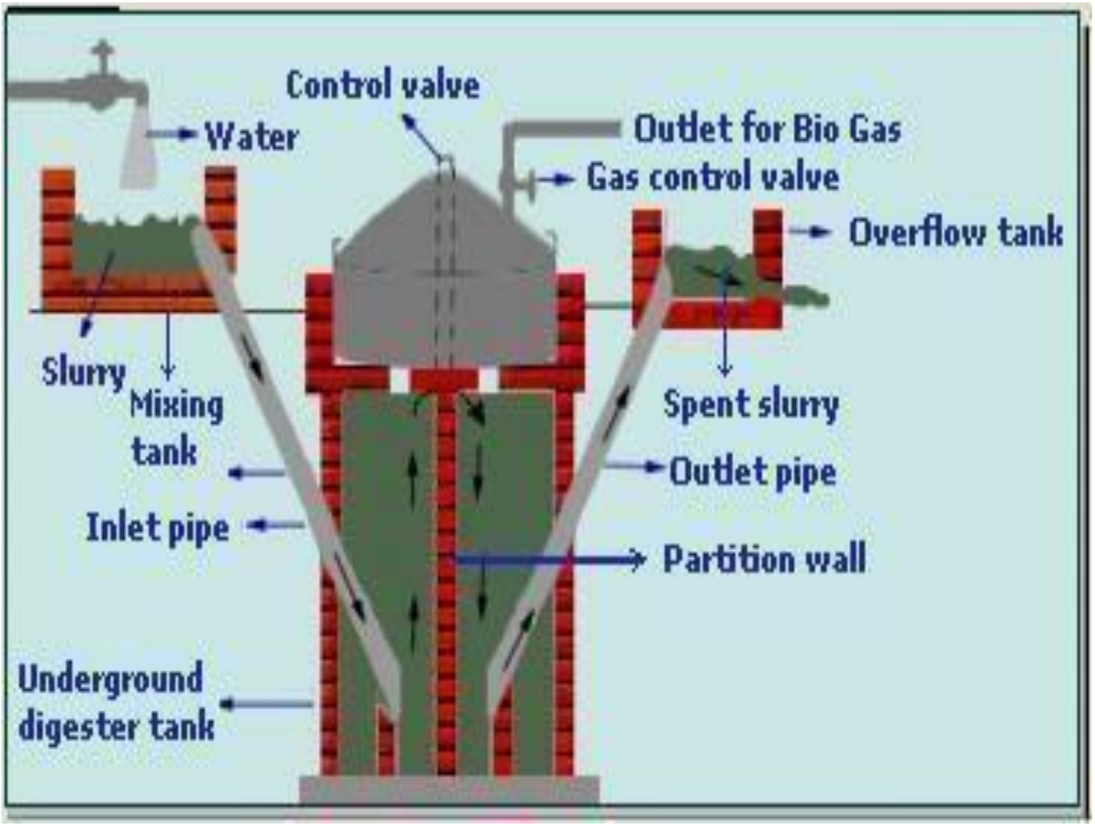
- Mixing tank present above the groundlevel.
- Inlet chamber: The mixing tank opens underground into a sloping inletchamber.
- Digester: The inlet chamber opens from below into the digester which is a huge tank with a dome like ceiling. The ceiling of the digester has an outlet with a valve for the supply ofbiogas.

- Outlet chamber: The digester opens from below into an outletchamber.
- Overflow tank: The outlet chamber opens from the top into a small over flowtank

Working

- The various forms of biomass are mixed with an equal quantity of water in the mixing tank. This forms theslurry.
- The slurry is fed into the digester through the inletchamber.
- When the digester is partially filled with the slurry, the introduction of slurry is stopped and the plant is left unused for about twomonths.
- During these two months, anaerobic bacteria present in the slurry decomposes or ferments the biomass in the presence of water.
- As a result of anaerobic decomposition, biogas is formed, which starts collecting in the dome of thedigester.
- As more and more biogas starts collecting, the pressure exerted by the biogas forces the spent slurry into the outletchamber.
- From the outlet chamber, the spent slurry overflows into the overflowtank.
- The spent slurry is manually removed from the overflow tank and used as manure forplants.
- The gas valve connected to a system of pipelines is opened when a supply of biogas isrequired.

Floating gas holder type of biogas plant



The raw materials used and the principle involved are common to both the types of biogas plants.

Construction

- The floating gas holder type of biogas plant has the following chambers/sections:
- Mixing Tank - present above the groundlevel.
- Digester tank - Deep underground well-like structure. It is divided into two chambers by a partition wall inbetween.
- It has two long cementpipes:

  i) Inlet pipe opening into the inlet chamber for introduction ofslurry.

  ii) Outlet pipe opening into the overflow tank for removal of spentslurry.

- Gas holder - an inverted steel drum resting above the digester. The drum can move up and down i.e., float over the digester. The gas holder has an outlet at the top which could be connected to gas stoves.
- Over flow tank - Present above the groundlevel.

Working

- Slurry (mixture of equal quantities of biomass and water) is prepared in the mixingtank.
- The prepared slurry is fed into the inlet chamber of the digester through the inletpipe.
- The plant is left unused for about two months and introduction of more slurry isstopped.
- During this period, anaerobic fermentation of biomass takes place in the presence of water and produces biogas in thedigester.
- Biogas being lighter rises up and starts collecting in the gas holder. The gas holder now starts movingup.
- The gas holder cannot rise up beyond a certain level. As more and more gas starts collecting, more pressure begins to be exerted on theslurry.
- The spent slurry is now forced into the outlet chamberfrom the top of the inletchamber.
- When the outlet chamber gets filled with the spent slurry, the excess is forced out through the outlet pipe into the overflow tank. This is later used as manure forplants.
- The gas valve of the gas outlet is opened to get a supply ofbiogas.
- Once the production of biogas begins, a continuous supply of gas can be ensured by regular removal of spent slurry and introduction of freshslurry.

Thermochemical conversion on biomass

There is increasing recognition that low-cost, high capacity processes for the conversion of biomass into fuels and chemicals are essential for expanding the utilization of carbon neutral processes, reducing dependency on fossil fuel resources, and increasing rural income. While much attention has focused on the use of biomass to produce ethanol via fermentation, high capacity processes are also required for the production of hydrocarbon fuels and chemicals from lignocellulosicbiomass.

5.6 Types of Gasifiers

Up draught or counter current gasifier

The oldest and simplest type of gasifier is the counter current or updraughtgasifier shown schematically in Fig

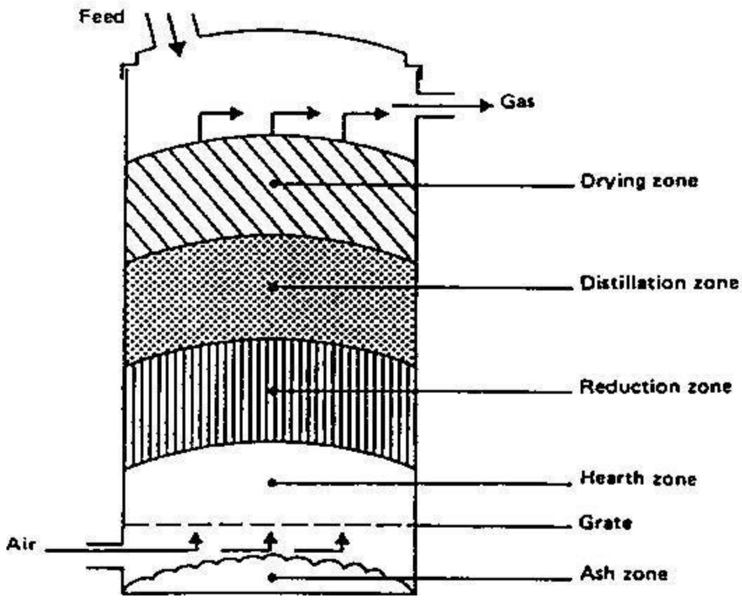


Fig:Updraught or counter current gasifier

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 thegasifier.

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.

Downdraught or co-current gasifiers

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 inFig.

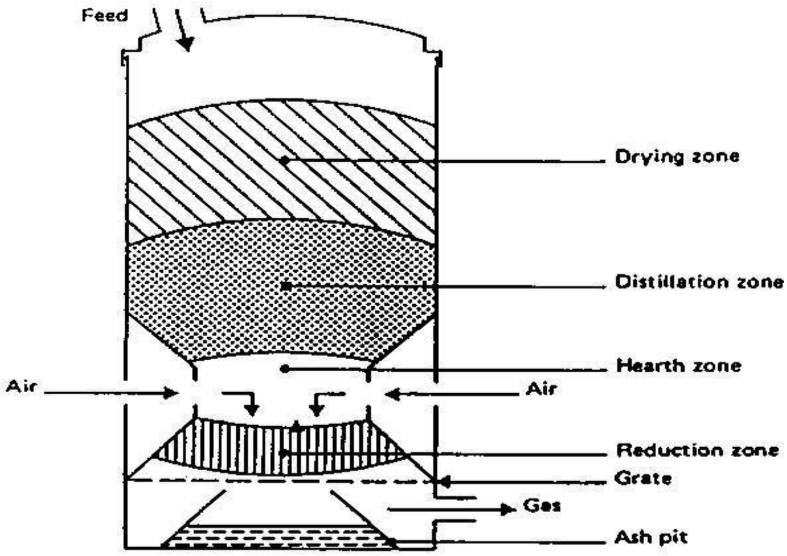


Fig: Downdraught or co-current gasifier

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 isachieved.

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 updraughtgasifiers.

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 updraughtgasifiers.

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).

Cross-draught gasifier

Cross-draught gasifiers, schematically illustrated in Figure 2.9 are an adaptation for the use of charcoal. Charcoal gasification results in very high temperatures (1500 °C and higher) in the oxidation zone which can lead to material problems. In cross draught gasifiers insulation against these high temperatures is provided by the fuel (charcoal) itself.

Advantages of the system lie in the very small scale at which it can be operated. Installations below 10 kW (shaft power) can under certain conditions be economically feasible. The reason is the very simple gas-cleaning train (only a cyclone and a hot filter) which can be employed when using this type of gasifier in conjunction with small engines.

A disadvantage of cross-draught gasifiers is their minimal tar-converting capabilities and the consequent need for high quality (low volatile content) charcoal.

It is because of the uncertainty of charcoal quality that a number of charcoal gasifiers employ the downdraught principle, in order to maintain at least a minimal tar-cracking capability.

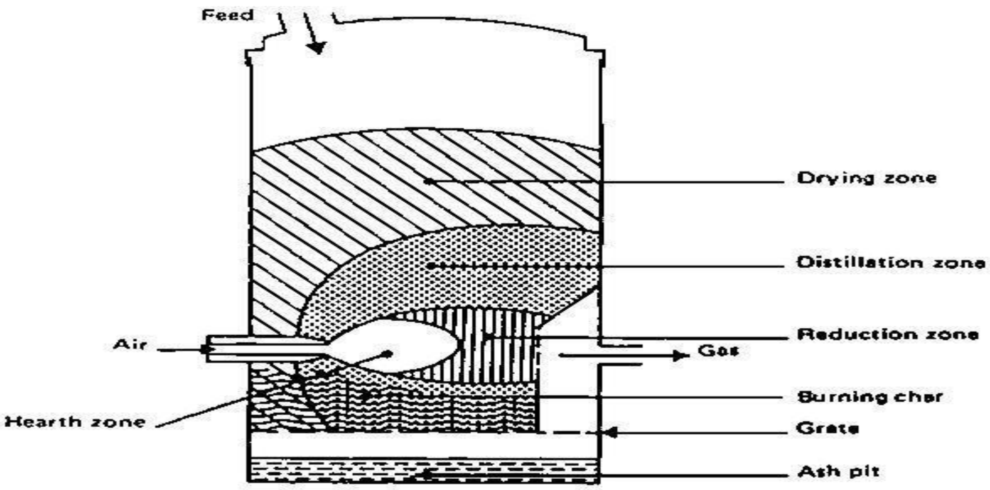


Fig:Cross draught gasifier

Fluidized bed gasifier

The operation of both up and downdraught gasifiers is influenced by the morphological, physical and chemical properties of the fuel. Problems commonly encountered are: lack of bunkerflow, slagging and extreme pressure drop over the gasifier

A design approach aiming at the removal of the above difficulties is the fluidized bed gasifier illustrated schematically in Fig

Air is blown through a bed of solid particles at a sufficient velocity to keep these in a state of suspension. The bed is originally externally heated and the feedstock is introduced as soon as a sufficiently high temperature is reached. The fuel particles are introduced at the bottom of the reactor, very quickly mixed with the bed material and almost instantaneously heated up to the bed temperature. As a result of this treatment the fuel is pyrolysed very fast, resulting in a component mix with a relatively large amount of gaseous materials. Further gasification and tar-conversion reactions occur in the gas phase. Most systems are equipped with an internal cyclone in order to minimize char blow-out as much as possible. Ash particles are also carried over the top of the reactor and have to be removed from the gas stream if the gas is used in engine applications.

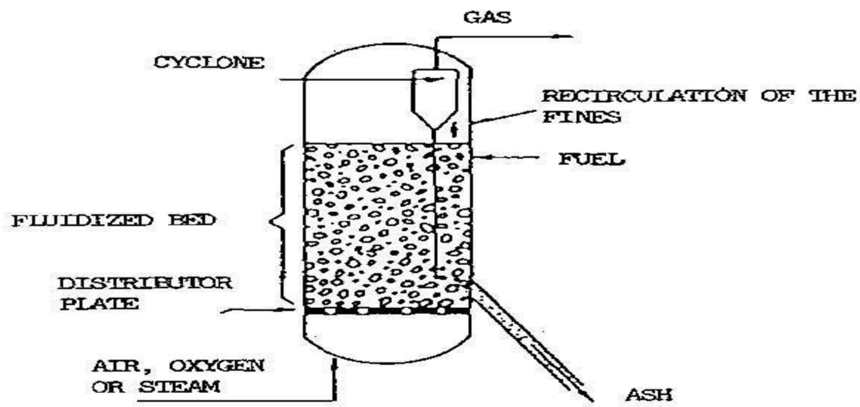


Fig ;Fluidized bed gasifier

The major advantages of fluidized bed gasifiers, as reported by Van der Aarsen (44) and others, stem from their feedstock flexibility resulting from easy control of temperature, which can be kept below the melting or fusion point of the ash (rice husks), and their ability to deal with fluffy and fine grained materials (sawdust etc.) without the need of pre-processing. Problems with feeding, instability of the bed and fly-ash sintering in the gas channels can occur with some biomass fuels.

Other drawbacks of the fluidized bed gasifier lie in the rather high tar content of the product gas (up to 500 mg/m³ gas), the incomplete carbon burn-out, and poor response to load changes.

Particularly because of the control equipment needed to cater for the latter difficulty, very small fluidized bed gasifiers are not foreseen and the application range must be tentatively set at above 500 kW (shaft power).

5.7 Ocean Thermal Energy

Principle of OTEC

Ocean Thermal Energy '(OTE) has its main source in the oceans, which in turn is originated from the sun. Absorption of solar energy at the surface of the ocean creates a relatively warm layer of water (27 to 29°C) that remains above the colder (4 to 7°C), more dense water layer in the lower depths of the ocean. Rotation of the earth causes the cold water coming from the direction of the poles to flow slowly along the ocean b~se towards the tropics. In the tropical region, the cold water density decreases. The water warmed in this manner, flows at the surface in another current toward the polar regions. The cycle is *i* repeated as the water cools and starts a return trip towards the tropics. These broad currents of water carry great amounts of thermal energy. The temperature difference between the , two streams is of the order of 20 to 25°C, which is an attractive and potential source for the generation of electric power. This thermal energy is used for running a turbine (using open or closed cycle) and generate electric energy.

These broad currents of water carry great amounts of thermal energy and represent potential sources *of* electric power. The feasibility of converting ocean thermal energy into electrical energy is dependent upon the existence of two broad currents of water, one warm and the other cold, flowing in close proximity to each other. There are numerous such locations near tropical waters, such as Caribbean sea and the gulf stream

OTE Power Plant Development

In 1882,D'Arsonval suggested that it is possible generate power based on the ocean thermal energy, by utilising the energy in the warm surface water of the ocean and rejecting heat to the colder water of the lower layer.

The first attempt to utilize the GTE was made in 1926 by G. Claude, a French scientist. He construded a 40 kW land-based GTEC power plant near Cuba. In his plant, a part of the warm surface water was converted into steam in a low-pressure flash evaporator operating at a high vacuum. In tfie flash evaporating process, sensible (heat) energy in the water gets converted into latent energy. The steam produced in the evaporator was expanded in a turbine and subsequently condensed by direct contact with the cold sea water piped from the lower layer in the ocean. .

However, Claude's system to utilize the GTE for power generation was not successful, mainly due to reasons like corrosive nature of the sea water (corrosion resistance materials were expensive), the pressure was low as water was evaporated at low temperature, high pumping work required for operations, requirement of very large turbine, and conveying the cold sea-water to the power plant over a long distqnce.

Thus, Claude's experiment demonstrated that the GTE power plant will inherently require large components, have a relatively low -power output, and operate at a high vacuum when the working fluid is water.

Problems Encountered in Harnessing OTEC

1) The sea water is more corrosive, thus the life of the plant is less.
2) The water can be evaporated (in a flash evaporator) at low temperatures only, thus the corresponding pressure is low, thus only smaller outputs are possible.
3) Much pumping work is required to remove the non- condensable gases.
4) The specific volume is more due to low pressure and temperature. This necessitates a large turbine.
5) The plants have to be based at lands, some distance away from the GTE source. This requires long pipelines to convey cold sea water to the power plant. 6) Due to low output and large components the cost of the GTE power plant is high. 7) The plant requires expensive and large size structures for installation and operation.generator to generate electric energy. In this fashion, ocean thermal energy is converted into electric energy in open OTEC system.

5.8 Geo-thermaI Energy

Geothermal energy is the thermal energy stored in under ground deposits as steam, hot water and hot dry rock. The inner core of the earth is highly radioactive, and as a consequence a natural flow of heat occurs from the core to t~e surface of earth, which can be harnessed into useful energy.

Geothermal energy is normally found in two basic forms, namely, in subterranean hot water or hot dry rock. In some locations, the vapour phase of the hot water is predominant, hence the geothermal energy source is described as steam. Where the hot water is entirely in the liquid phase, the term geo-hydrothermal or geo~pressurized, is applied. .

Utilization of Geothermal Energy (GTE)

Among the nonconventional energy sources, today the utilization of GTE is being investigated through a number of research and ~evelopment programs. Like the solar and wind energy, GTE is quantitatively significant, but the extraction of this energy from the ground and subsequent conversion to electrical energy is not cost free and not without certain operating problems. But, geothermal energy generation is not subject to interruptions that are inherent in solar and wind power generation. The Geothermal power plant is capable of continuous operation, provided that the generating capability properly matches the energy supply.

IAt the Geysers, the turbines operate with inlet steam pressures of 450 and 690 kPa. IBoiler

There are many locations in the world where geothermal steam and water (hot) are utlized for heating buildings. Even it can be used for industrial processing.

Geothermal Power Plant Operation - General Discussions

The geothermal power plant operates on a simple, low-pressure steam power cycle.

and fuel handling' equipment are not required. Also, since there is no need to lconserve the condensate, a direct~contact condenser can be used

The geothermal steam discharged from a well contains a quantity of non-condensable gases that can cause operating difficulties, including corrosion in the condensing system. These gases are removed from the steam in the condenser by the vacuum pump, usually a steam jet ejector, and expelled into the atmosphere.

Most of the wells drilled for geothermal power production dischMge a mixture of steam and water. If the hydrostatic pressure is sufficiently high at the bottom of the well, the water will flow, unaided to the surface. Hot water rising in the well and subjected to reduced pressure, partially flashes into vapour. At the well head the water is mechanically removed from the mixture in cyclone separators, and the relatively dry steam is transported to the power station.

The steam and water mixture flowing from the geothermal wells contains dissolved solids that are particularly trouble some. It ranges from 1 to 20 gm per kg of water. In addition to the dissolved solids some wells may give out the mixture containing some acids. In general, the dissolved solids and acids in geothermal water cause scaling anp corrosion. Scale formation can be particularly severe in the outflow pipeline in which the discarded water is carried away from the separator.

Geothermal power production cause air and water pollution in operation. Ear splitting noise caused by escaping steam and the escape of radioactive gases are other objectionable characteristics that have been observed.

Advantages & Disadvantages of GTE

Advantages

1) GTE is available free of cost, in large quantities.
2) There are no interruptions in GTE conversion as in solar and wind energy conversions.

3) It is capable of continuous operation. ,

4) Boiler and Fuel handling equipment are not required.

5) There is no need to conserve the condensate, thus a direct contact condensate can be used.

6) Operation and maintenance costs are less.

Dis.advantages

1) Such plants will always be located far away from the load centres.

2) Erection and installation costs are high.

3) It causes air, water, thermal and noise pollution. Ear-splitting noise caused by the escaping steam causes noise pollution.

4) The hot water geothermal sources have higher mineral contents and their disposal is a probl~m. .'

5) Seismic activities are caused, if water is injected into hot rocks to recover the thermal energy.

SOURCES OF GEOTHERMAL ENERGY

The various sources of geothermal energy are as follows

1) *Hydrothermal systems:* In these, water is heated by contact with hot-rock in the earth's crust. The temperature of the steam raised by this is in the range of 150 to 200°C.

2) *Geopressure system:* These .sources are similar to hydrothermal systems, and are reservoirs of high temperature water under high pressures (50 to 100 MPa).

3) *Hot dry rocks (HDR):* Also termed *petrothermal systems,* are very hot solid rocks available in the earth's crust at medium depths (2 to 5 km). The temperature is of the order of 300°C. .

4) *Magma source:* These are molten rocks with temperature much above 750°C, available in deep earth's crust.

Presently, the hydrothermal systems and hot dry rocks are more feasible for geothermal energy harnessing.

Hydrothermal Systems

In these, water is heated by contact with hot-rock in the earth's crust. These are two types of hydrothermal systems: .

a) *Steam dominated systems*

In this type of geothermal system, water is vaporised into steam at the lower level in the earth's crust. The steam rises to the earths surface in a dry state (about 200°C and more than 2 MPa pressure). This dry steam can be used conveniently and directly to run steam turbines and generate electric power. The schematic of such a system is illustrated

b) Water dominated systems

In this type of geothermal system, hot water slightly above l50°C under high pressure available under the earth's crust is utilised. Since the water is under pressure, it does not boil even above 100°C. When trapped by wells, the water rises to the surface and looses

(5) *Subsidence*

The removal of huge quantities of underground water causes land subsidence (collapse of ground layers, and *iallln .tb2.f}IOJ.JDO~). Subsidence* causes stre~C\f,

pij:>effnes and *~joJhe...w~ e#~ccm 6e* great(y reduced

6y reinjection of *the used* water. **(6) *Seismic Activity***

It is also possible that earth quakes may take place, if continuous underground water exploitation is done. One cause could be the large underground land subsidence. Even the reinjection of used water may cause seismic activity due to high temperature difference.

(7) *Fog due to escaping steam*

The entry of steam from the cooling towers, separators into the environment may lead to the formation of dense fog which many drift to the nearby busy living areas and cause problems. Also the temperature of the environment may increase leading to thermal pollution and cause discomfort in the surrounding areas due to increases in humidity.

(8) *Sand &other solid particles*

The high pressure water from the geothermal system usually carries sand and other solid particles. These cause separation problem, erosion and scaling problems in the equipments. This causes a lot of maintenance problems for the plant and loss of efficiency.

then extracted by circulating water to produce steam and then run turbines

Problems in Geothermal Conversion Systems

To generate the power the heat energy of the magma has to be tapped by drilling holes close to the magma chamber, where the temperature is around 1800°C. The energy There are a number problems associated with the operation of geothermal systems. Some of the major problems are discussed here.

(1) *Solid particles and non-condensable Gases*

The steam/water from hydrothermal reservoirs contain solid particles and non: condensable gases. The solid particles ar~ removed using centrifugal separators at the well exit and by strainers before the turbine entry. This leads to pressure and temperature loss and hence loss of the thermal efficiency of the complete system.

The main non-condensable gases in the geothermal sources are COz (70 to 80%) and small amounts of methane, Hz, Nz, NH3 and HzS. These gases along with the fluid enter equipments and also escape to the atmosphere through condenser, ejectors and cooling towers. These gases in the equipments cause corrosion and scaling problems. The gases, particularly HzS (a poisonous gas), are also harmful to the living beings.

(2) *Discharge of Used Water*

Discharging large quantities of used water from the geothermal systems to rivers and seas will cause water pollution (both thermal and chemical). This may make the water toxic and becomes hazardous to the animals and users. A possible solution to this problem is to reinject the used water into the well so that land subsidence can be minimised and also avoid environmental pollution.

(3) *Noise Pollution*

In geothermal systems noise pollution is also a major problem. Exhaust~, blow down and centrifugal separators work always with high noise, which is hazardous to the working people. The noise can be minimised by using silencers and its effect on working people can be reduced by using noise protective devices.

4) *Atmospheric Pollution*

The harmful gases in the geothermal water after use will escape (from the cooling tower, separator, etc.) and cause atmospheric pollution. Hydrogen sulphide (HzS) is highly toxic and harmful to the living beings.

Air pollution is severe due to the emission of heavy radioactive gases and hydrogen sulphide gas from the wells. Due to its poor steam condition, geothermal plant discharges. more thermal energy into environment (3 times that of a conventional thermal plant) causing thermal pollution. The stearn-water from well brings many corrosive substances which when mixed with atmospheric water, cause water pollution.

5.9Summary

Tidal turbines are a new technology that can be used in many tidal areas. They are basically wind turbines that can be located anywhere there is strong tidal flow. Because water is about 800 times denser than air, tidal turbines will have to be much sturdier than wind turbines. They will be heavier and more expensive to build but will be able to capture more energy.

5.10 Question bank

1. With the sketch Explain the open cycle OTEC system
2. Enlist the different geothermal resources
3. With the help of a sketch explain the “Hot dry Rock” geothermal plant
4. List any six advantages and disadvantages of Geothermal Energy