Biyani's Think Tank

A concept based exclusive material

Energy Resources and Utilization

[B.Sc. Biotechnology Part-I]

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Preface

I am glad to present this book, especially designed to serve the needs of the students. The book has been written keeping in mind the general weakness in understanding the fundamental concepts of the topics. The book is self-explanatory and adopts the "Teach Yourself" style. It is based on question-answer pattern. The language of book is quite easy and understandable based on scientific approach.

Any further improvement in the contents of the book by making corrections, omission and inclusion is keen to be achieved based on suggestions from the readers for which the author shall be obliged.

I acknowledge special thanks to Mr. Rajeev Biyani, *Chairman* & Dr. Sanjay Biyani, *Director* (*Acad.*) Biyani Group of Colleges, who are the backbones and main concept provider and also have been constant source of motivation throughout this Endeavour. They played an active role in coordinating the various stages of this Endeavour and spearheaded the publishing work.

I look forward to receiving valuable suggestions from professors of various educational institutions, other faculty members and students for improvement of the quality of the book. The reader may feel free to send in their comments and suggestions to the under mentioned address.

Note: A feedback form is enclosed along with think tank. Kindly fill the feedback form and submit it at the time of submitting to books of library, else NOC from Library will not be given.

Rajneesh Kumar Mishra

Syllabus
B.Sc. (BT) Part-I
301 : ENERGY RESOURCES AND UTILIZATION

Section A

Introduction : Nature : Crude and Bio-Crude; Synthetic Fuels and their Manufacture; Bio-Fuels and their Synthesis; History Properties of Coal; Agriwaste as Bio-Fuels; Briqueting.

Environmental Audit : Carbon Sequestration, Carbon Credits.

Section B

Gas from Coal : Gasification Technologies; Steam / Oxygen and Steam /Air Gasification; Hydro-Gasification and Catalytic Gasification; Underground Gasification.

Bio-Fuels : Biomass Production, Bio-Fuel Resource Production and Improvement of Bio-Fuels, Solid, Liquid Bio-Fuels, Hydrocarbons from Plants, Bio-Diesel, Bio-Ethanol, Non-Edible Oils as Bio-Fuel Resources, Euro I, II, III Standards of the Fuels.

Section C

Bio-Fuels.

Conversion : Ethanol Production Technologies; Bio-Chemical Conversion; Thermal Conversion; Catalysts : Environmental Aspects – Environmental Effects and their Measure; Air Pollution Control; Water Management; Solid Waste Disposal.

Section D

Economic and Perspective : Large Scale Production and Conversion Technology for the Bio-Fuel Resources; Bio-Refineries; Economic Considerations; Resource, Process and Product Consideration; Industrial Furnaces used in Chemical Process Industry. Fuels for the Future; Hybrid Fuels and Economy.

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Content

SECTION-A

Introduction & Environmental Audit

Q.1 Give the Historical Properties of Coal.

Ans.: Coal is a fossil fuel extracted from the ground by underground mining or open-pit mining. It is a readily combustible black or brownish-black sedimentary rock.

Early History : The word "coal" came from the Anglo-Saxon ccl, which meant charcoal, but archaeological evidence demonstrates a history of use for much longer. Out crop coal was used in Britain since the Bronze Age where it was detected as forming part of the composition of funeral pyres.

Carbon is formed more than 50% by weight and more than 70% by volume of coal.

Origin of Coal : Dicrhodium fern fossils is drillcore Surat Basin, Queensland from silt parting in coal beds forrelised plant material implies this coal formed around plants.

Types of Coal :

i) **Lignite :** It is also referred to as brown coal, is the lowest rank of coal.

ii) **Sub-bituminous Coal :** Whose properties range from those of lignite to those of bituminous coal & are used primarily as fuel for steam electric power generation.

iii) **Bituminous coal :** It is a dense coal, usually black sometimes dark brown, often with well defined bonds of bright and drill material used for electric generation.

iv) **Anthracite :** The highest rank, used primarily for residential and commercial space heating.

Q.2 What is Nature Crude & Biocrude?

Ans.: Biocrude : Biocrude oil is produced by the thermal decomposition of solid biomass under heat and pressure in the absence of oxygen. It is also called "Pyrolysis oil". It is under investigation as substitute for petroleum. It is produced out of dried biomass in a reactor at temperature of about 500^0C and cooled immediately within 1-2 seconds. The produced heat is transferred to dry the biomass.

The biomass is split into solid liquid and gaseous components under the influence of heat only (anhydrous pyrolysis). The produced charcoal may be used for heating the process or as activated carbon in absorption processes. The gas consisting of hydrogen (H_2), carbon monoxide (CO), carbon dioxide (CO_2) and methane (CH_4), may be burned but the condensable gases have to be kept gaseous until the combustion. The heating value is 15-202 MJ/m3, which is much lower than natural gas.

Natural Crude : Oil produced by the thermal decomposition of solid fossilized organisms under heat and pressure and in the absence of oxygen is called natural crude. It is nonrenewable. Example – petroleum, diesel.

Q.3 What is Synthetic Fuel?

Ans.: Synthetic fuel or Synfuel is a liquid fuel. Obtained from natural gas or biomass. It can sometimes refer to fuels derived from other solids such as oil shale, tar sand, waste plastics or from the fermentation of biomatter.

Process of producing synthetic fuels are three types -

i) CTL (Coal to Liquids)

ii) GTL (Gas to Liquids)

iii) BTL (Biomass to Liquids)

Depending on the initial feed stocks the best known process of synthesis is the – (a) Fisher Tropasch Synthesis

Others are -

(b) Bergius Process

(c) The Karrick Process

Fisher Tropasch Process (FTP) : In FTP synthetic fuels are made from ethanol, methanol etc.

Original Process : $(2n + 1)\ H_2 + 2C_n \rightarrow CnH_{2n+2} + H_2$

H2 & CO can be derived from : $CH_4 + \frac{1}{2}O_2 \rightarrow 2H_2 + CO$

**** It is most commonly used process.***

Bergius Process : In this process lignin is added with heavy oil & catalysed by nickel or tungsten which further gives mixed oil, light oil or gasoline.

Karrick Process : In this process materials are brushed in the absence of air at 270^0C – 680^0C temperature and we get gasoline as a main product.

Material

↓

Burnt in the absence of air at 680^0C

↓

Gasoline is produced

We also use destructive distillation process by which we get coal and from it we produce synthetic fuel.

Q.4 What is Biofuel?

Ans.: Biofuel is a fuel that is derived from biomass. It is a renewable energy source, unlike other natural resources such as petroleum, coal & nuclear fuels.

Biofuel is any fuel with 80% minimum content by volume of materials derived from living organisms harvested within the ten years preceding its manufacture.

Examples : Liquid biofuels – bio-ethanol, bio-diesel

Gaseous bio-fuels – biogas

Solid bio-fuels – processed wood etc.

Q.5 What is Briquetting?

Ans.: **Briquetting in General :** Briquetting is a process where some type of material is compressed under high pressure.

Example : if the raw material is wood the lignin content of the wood is liberated under high pressure thus binding the material into a briquette.

Q.6 What is Carbon Credits & Carbon Sink?

Ans.: **Carbon Credit :** Carbon credits are measured in units of certified emission reductions (CERs). Each CER is equivalent to one tonne of carbon dioxide reduction. India has emerged as a world leader in reduction of greenhouse gases by adopting clean development mechanisms (CDMs) in the past two years.

Carbon Dioxide Sink or Carbon Sequestration : Carbon sequestration is the term describing processes that remove carbon from the atmosphere.

There are two **methods for removal of carbon dioxide -**

(i) **Natural Sinks :**

(a) Forests

(b) Oceans

(c) Soils

(ii) **Artificial Sequestration :**

(a) Carbon capture

(b) Oceans

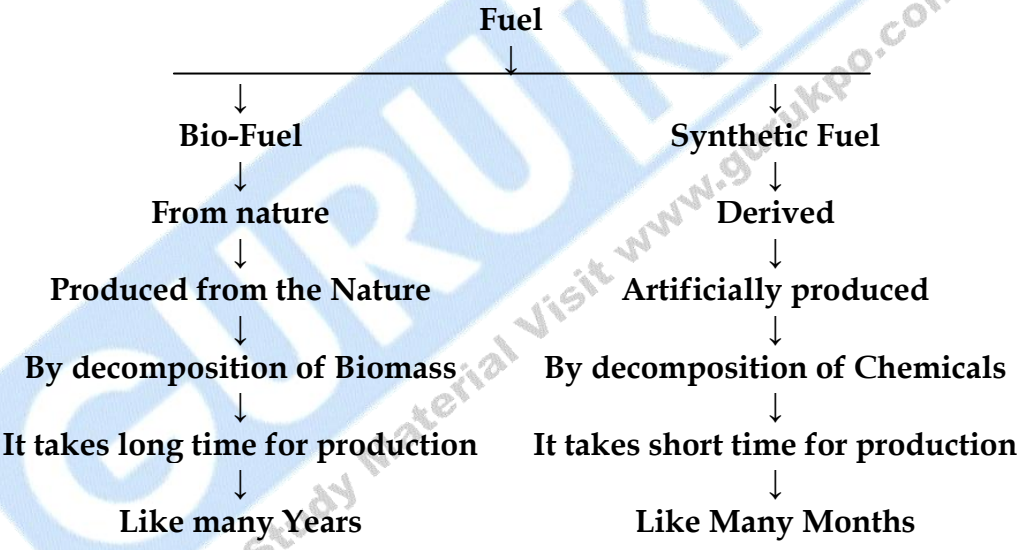
(c) Geological sequestration

(d) Mineral Sequestration

Q.7 What is the difference Between Biofuel & Synthetic Fuel?

Ans.: Biofuel is a biological component which are used as fuel where as synthetic fuel has no biological synthetic cells made up providing energy as fuel.

Comparison :



Comparison between Bio-fuel & Synthetic Fuel :

S.No.	Biofuel	Synthetic Fuel
(i)	Obtained from biological sources like crops e.g., wheat, maize, corn etc.	Obtained from the non-biological sources like fossil fuels e.g., coal & coke etc.
(ii)	The product of the biofuel is the $CO_2 + H_2O$.	The product of the synthetic fuel is the synthetic gas which is $CO+H_2$.
(iii)	Occurs in the solid, liquid and gas forms.	Occurs only in the liquid form
(iv)	It is environment friendly gas.	It is not an eco-friendly process. The reaction is $C+H_2O \rightarrow CO + H_2$
(v)	Biological processes are involved.	Chemical processes are involved.
(vi)	Does not involve very high temp.	Involves very high temperature.
(vii)	Involves micro organisms like Yeast, Amoeba etc.	Does not require the use of the micro organisms.
(viii)	Less toxic for the environment.	More toxic for environment.

□ □ □

SECTION-B

Gas from Coal & Bio-Fuels

Q.1 What is Gasification?

Ans.: Gasification is a thermo-chemical conversion process in which fossil fuel & biomass are converted into gaseous fuels.

Gasification is a process in which high density substrate is converted into low density product & low energy containing substrate is converted in high energy containing product.

Q.2 What is Biomass?

Ans.: Biomass are recently living organisms or their metabolic byproducts such as manure from cows/cattles.

Biomass is a renewable energy source, unlike other natural resources such as petroleum, coal & nuclear fuels.

Biomass is used as fuel often consists of underutilized type like chaff & animal waste.

Q.3 What is Renewable Energy Resources?

Ans.: Natural resources are part of our atmosphere hydrosphere & lithosphere. Natural resources are inexhaustible, available for man for million of years e.g., water, forest, life forms

Renewable Resources are conventional type or traditional e.g., water, forest, food crops, plant species, wild life, aquatic life. These can be called

replaceable resources also because they can be replaced from time to time due to their life cycle

– Forest resources, food resources, aquatic wild life & live stock resources are prominent renewable source of energy to sustain life on the earth.

- Some resources do not have life but can be recycled (water resources) & are renewable -

1) water 2) live stocks 3) forest

Q.4 What are the Principles of Gasification?

Ans.: Gasification reaction comprises three principle stages. These stages are as follows -

(i) Cleavage

(ii) Oxidation

(iii) Reduction

Cleavage : In this step substrate (fossil fuel on biomass) is cleaved into smaller molecules. Cleaved can be described by following Reaction -

$(C_6H_{10}O_5)_n$ + Heat → C_xH_y + CO …… (1)

Starch/Cellulose (Lower Hydrocarbons)

$(C_6H_{10}O_5)_n$ + Heat → $C_nH_mO_y$ …… (2)

(Lower carbohydrates)

Oxidation : This is exothermic reaction substrate & product of reaction (1) & (2) are oxidised by gasification agent into lower molecules weight product & heat.

$C_xH_y + O_2 \rightarrow CO_2 + H_2O$ + Heat …… (3)

$C_nH_mO_y + O_2 \rightarrow CH_4 + H_2O + CO + CO_2$ …… (4)

$C + O_2 \rightarrow CO_2$ + Heat …… (5)

$H_2 + O_2 \rightarrow H_2O$ + Heat …… (6)

Reduction: Ash (Charcoal) produced during combustion reaction with other gases to form fuel gas. This reaction is endothermic in nature coltar is mainly gasified during this step.

$CO_2 + C + Heat \rightarrow 2CO$ …… (7)

$H_2O + C + Heat \rightarrow CO + H_2$ …… (8)

Q.5 Explain the Gasification Technology?

Ans.: There are five **techniques for gasification** -

(i) Processing of Biomass/Coal
- Size reduction
- Drying

(ii) Preparation of substrate

(iii) Gasification

(iv) Gas purification sulfur removal

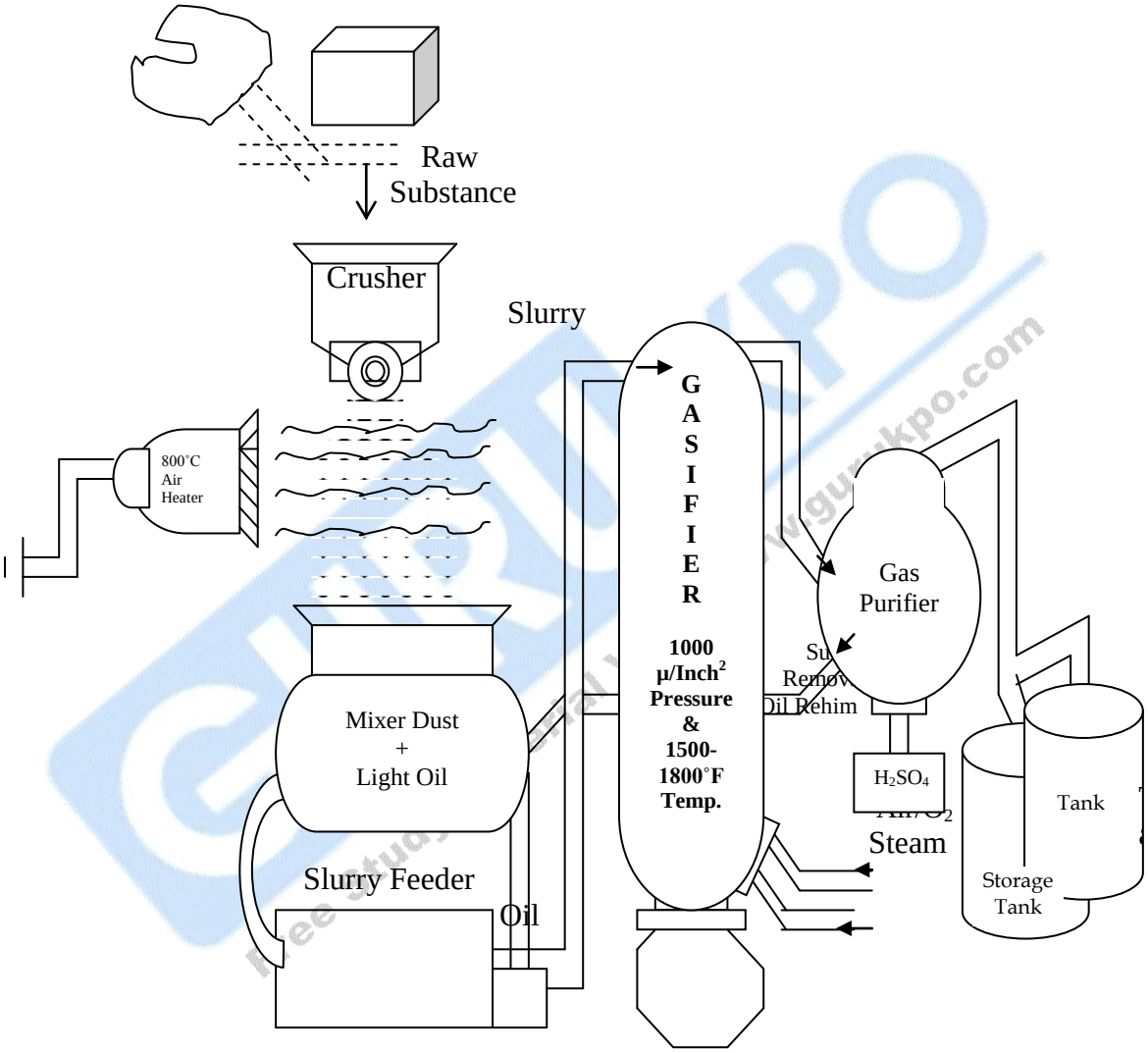
(v) Storage & Usage

(i) **Processing of Biomass / Coal :** Biomass used for gasification is generally rich in starch & carbohydrate. Such biomass & coal should be processed before reaction. Firstly size of substrate is reduced to dust from or 1 cm or less cubes. Then they are dried to remove the moisture by using a hot air drier. Normally temperature of substrate rise up to 700^0 to 800^0 F. Due to this high temperature pyrolysis & cleavage occurs.

(ii) **Preparation of Substrate :** Substrate for gasification can be present either in solid or in slurry phase. Slurry is formed by mixing dust/cubed into light & consisting of slurry is maintained according to type of gasifier.

(iii) **Gasification :** Gasification occurs in a closed chamber of gasifier. Cleaved substrate is oxidized by oxidants or gasification agent. Sequence of reaction occurs these & gaseous fuel is formed.

It is necessary to control the oxidant supply, so nitrogenous compound should not oxidize in NOx. This is done to check the particulate emission of pollutants by fuel.



Schematic Diagram for Gasification

(iv) **Gas Purification :** Obtained gas is purified for various aspects -

Solid particles are separated. Sulfur containing product are reduced to form H_2SO_4, to improve the nature of fuel. It also check pollution emission. Produced H_2SO_4 can be used further.

$$SO_2 + H_2O \xrightarrow{LiAlH_4} H_2SO_4 + O_2$$
$$SO_3 + H_2O \longrightarrow H_2SO_4 + O_2$$

(v) **Storage & Usage :** Purified gas is stored in containers with adequate temperature and pressure gaseous fuel can be used either in boilers heaters & as engine fuel.

Q.6 Explain the Types of Gasification?

Ans.: Gasification reactions can be classified on the basis of different types of oxidation agents -

(i) **Hydro-gasification :** Gasification reaction involving water or steam as gasification agent is called hydro-gasification.

(ii) **Steam/Air Gasification :** Here gasification agent is mix of steam & air.

(iii) **Steam/Oxygen Gasification :** Gasification reaction involving steam & oxygen as gasification agent is called steam/oxygen gasification.

(iv) **Air Gasification :** Gasification involving air as oxidant is called air gasification.

(v) **Oxygen Gasification :** Reaction with oxygen as gasification agent.

Q.7 How plants are used as Biomass Resources for Biodiesel?

Ans.: Plants as Biomass Resources for Biodiesel :

Edible Oils : These oils account for a significant fraction of world-wide edible oil production. There are also used as fuel oils.

(i) Coconut oil, cooking oil, high in saturated fat particularly used in baking and cosmetics.

(ii) Corn oil, a common cooking oil with little odor or taste.

(iii) Cotton seed oil used in manufacturing potato chips and other snack foods very low in trans-fats.

(iv) Canola oil one of the most widely used cooking oils from a cultivar of rapeseed.

(v) Olive oil, used in cooking, cosmetics, soaps and as a fuel for traditional oil lampes.

(vi) Palm oil, the most widely produced tropical oil also used to make biofuel.

(vii) Peanut oil (Ground nut oil) a clear oil used for dressing salads and, due to its high smoke point, especially used for frying.

(viii) Soyabean oil, produced as a by product of processing soyameal.

(ix) Sunflower oil a common cooking oil also used to make bio-diesel.

(x) Mustard oil used in India as a cooking oil and also used as a massage oil.

Non Edible Oils : These oils are extracted from plants that are cultivated solely for producing oil based biofuel. These, plus the major oils described above have received much more attention as fuel oils than other plant oils.

(i) Algae oil, recently developed by MIT Scientist "Isaac Berzin", by product of smoke stack emission reduction system.

(ii) Copaiba, an oleoresin tapped from species of genus "Copaifera", used in Brazil as a major sources of Bio-diesel.

(iii) Honge oil, pioneered as a biofuel by "Udipi Shrinivasa"in Bangalore, India.

(iv) Jatropha oil widely used in India as a fuel oil.

(v) Jojoba oil, from the simmondsia chinensis, a desert shrub.

(vi) Euphorbia oil.

(vii) Karanjia oil.

(viii) Castor oil, with many industrial and medicinal uses.

Q.8 Explain the term Biodiesel with its Production Process?

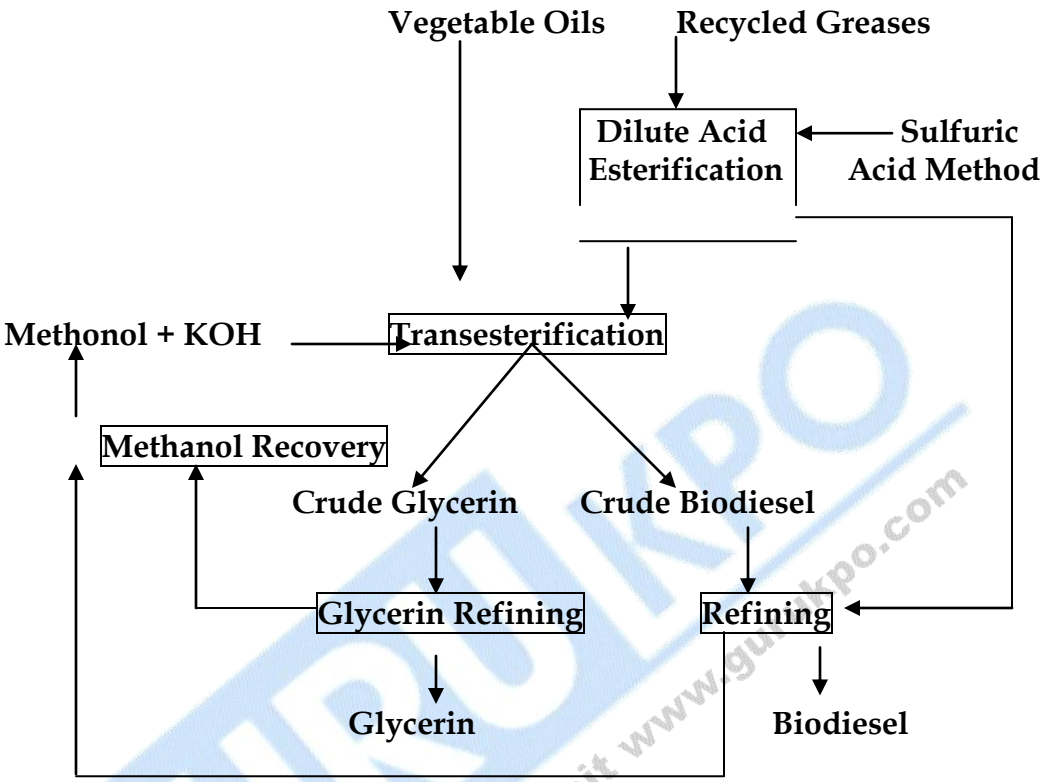
Ans.: Biodiesel is safe, biodegradable, and reduces serious air pollutants such as particulates, carbon monoxide hydrocarbons, airtoxics.

Blends of 20% bio-diesel with 80% petroleum diesel (B20) can generally be used in unmodified diesel engines, Bio-diesel can also be used in its pure form (B100), but it may require certain engine modifications to avoid maintenance & performance problems & may not be suitable for winter time use.

The best emission reductions are seen with B100. In the U.S. Bio-diesels are mainly derived from soyabean oil & in Europe from the sunflower oil. However, as India is deficient in edible oils non edible oils may be material of choice for producing bio-diesel like Jatropha.

The use of Bio-diesel decreases the solid carbon fraction of particulate matter [since the oxygen in bio-diesel enables more complete combustion to CO_2] & reduces the sulfate fraction (Bio-diesel contains less than 15 ppm sulfur). While the soluble or hydrocarbon, fraction stays the same or increases. Therefore, bio-diesel work well with emission control technologies such as diesel oxidation catalysts. Bio-diesel fuel can be made from new or used vegetable oils & animal fats, which are nontoxic, biodegradable, renewable resources. Bio-diesel can be produced by a variety of esterification technologies. The oils & fats are filtered & preprocessed to remove water & contaminants.

Production Process :



(i) Acid Esterification
- Mechanical Extraction using a series of presses
- Mechanical Extraction / Solvent Extraction

(ii) Refining

(iii) Degumming

(iv) Bleaching

(v) Neutralization

Transesterification : The main reaction for converting oil to bio-diesel is called transesterification.

Triglycerides + Free Fatty Acids (<4%) + Alcohol → Alkylesters + Glycerin.

(i) **Acid Esterification :** Oil feed stocks containing more than 4% free fatty acids go through an acid esterification process to increase the yield of bio-diesel these feed stocks are filtered preprocessed to remove water & contaminants & then fed to the acid esterification process. The catalyst sulfuric acid is dissolved in methanol & then mixed with pretreated oil. The mixture is heated.

There are two main process for the extraction of vegetable oil :

(a) **Mechanical Extraction :** This is a process of mechanical separation of the oil from the oil from the oil seed this process produces a crude oil & a cake meal, which contain approximately 10% of the oil content. This seeds are firstly cleaned to remove stones & pieces of metal, which may be present.

(b) **Solvent Extraction :** This is a process where by a solvent is used to remove the oil. Prior to solvent extraction. Most processes use a mechanical extraction process to remove around 20% of the oil content. The remaining cake is then fed into a solvent extractor on a moving bed. The solvent is sprayed over the cake in a counter – current clockwise stream & the oil is removed, as it is soluble in the solvent.

(ii) **Refining** : Once the crude oil has been extracted., it must go through a refining process. The impurities present in the oil need to be removed as they can affect the trans esterification process.

(iii) **Degumming :** This process is used to remove the phospholipids minerals, chlorophylls & colloidal proteins using phosphoric acid.

(iv) **Bleaching :** Bleaching is a process used to remove the colour pigments in the oil. These pigments are absorbed into the bleaching

earth. The bleaching earth also removes trace metals soaps & oxidation products.

(v) **Neutralization :** The addition of an alkali (Caustic Soda) in a centrifuge removes the free fatty acids. This process also removes heavy metals, which would start the oxidation of the oil.

Q.9 What are Euro I, II and III standards?

Ans.: Emission standards are requirements that set specific limits to the amount of pollutants that can be released into the environment. Standards generally regulate the emission of NO_x, particulate matter (PM) or root, carbon mono-oxide (CO) or volatile hydrocarbons. The main components of automobile exhaust, carbon dioxide (CO_2) and water vapor (H_2O), have so far not been regulated by emission standards mandatory CO_2 standards and USA has reflected it in the greenhouse gas score.

European emission standards are sets of requirements defining the acceptable limits for exhaust emissions of new vehicles sold in EU member states. The standards are defined in a series of European union directives staging the progressive introduction of increasingly stringent standards.

EURO I : EURO I was the emission standard for cars introduced in the EU (European Union) in 1992 that limits cars emissions to 8 g/kwh of Nitrogen oxides and 0.36 g/kwh of PM (Particerle Matter). It was replaced by EURO II in 1995.

EURO II : EURO II was the emission standard for cars introduced in the EU in 1995 that limits car emissions to 7g/km of NO_x and 0.15 g/km of PM (Particle Matter) when tested using the NEDC driving cycle.

It was replaced by EURO III in 1999.

EURO III : EURO III is the emission standard for vehicles introduced in the EU in 1999. It limits diesel car emission to 0.5 g/km of NO_x and 0.05 g/km of particulate matter (PM), Petrol cars to 0.15 g/km NO_x and heavy goods vehicles (HGVs) to 5 g/kwh of NO_x and 0.1 g/kwh of PM.

It has been replaced by EURO IV in 2005.

Q.10 What is Bio-ethanol & how it can be obtained?

Ans.: Bio-ethanol :

Ethanol produced by microorganisms eg. Saccharomyces cerevisiae from biomass is called Bio-ethanol.

→ Bio ethanol is the most widely used bio fuel for transport purposes especially in Brazil & U.S.A.

→ At present bio ethanol is not cost competitive as compared to petrol, but is being used for transport due to government subsidies.

Bio-ethanol Production Process : At present there are three important **routes for the production of bio ethanol -**

(i) **From Starch or Sugar Crops :** Including roots, tubers or grains that are rich in starch. Sugar crops including molasses or juice derived from sugarcane palm or sugarbeet from cellulose (wood or waste product rich in cellulose) follow enzymatic hydrolysis.

(ii) **From Cellulose follows Chemical Hydrolysis :** Commercial production of ethanol involves three steps -

(a) Preparation of Substrates

(b) Fermentation

(c) Recovery of Ethanol by Distillation

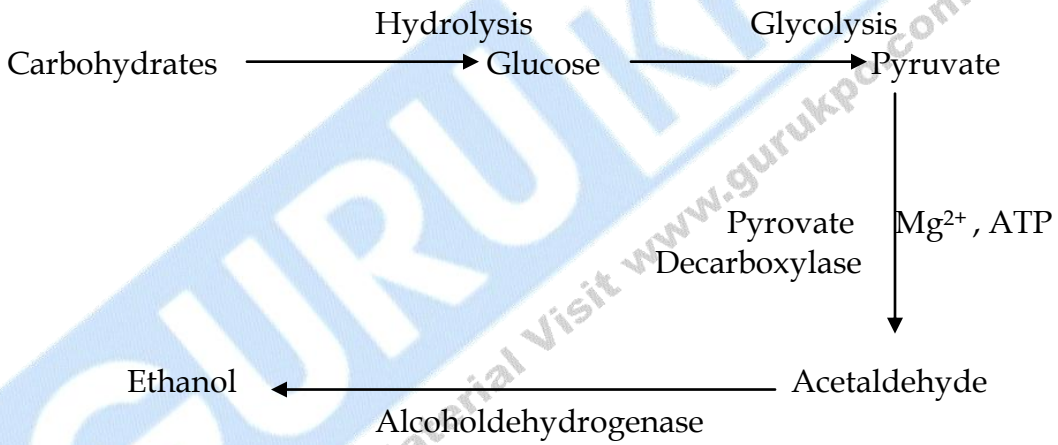
(a) **Preparation of Substrates :** starts with those of parts of plants which are rich in starch such as seed. First of all seeds are ground filtered and dried. The starch is liquefied by boiling under pressure cooled and then hydrolyzed enzymatically.

(b) **Fermentation :** In India ethanol is produced mainly by fermentation of molasses which are produced as by

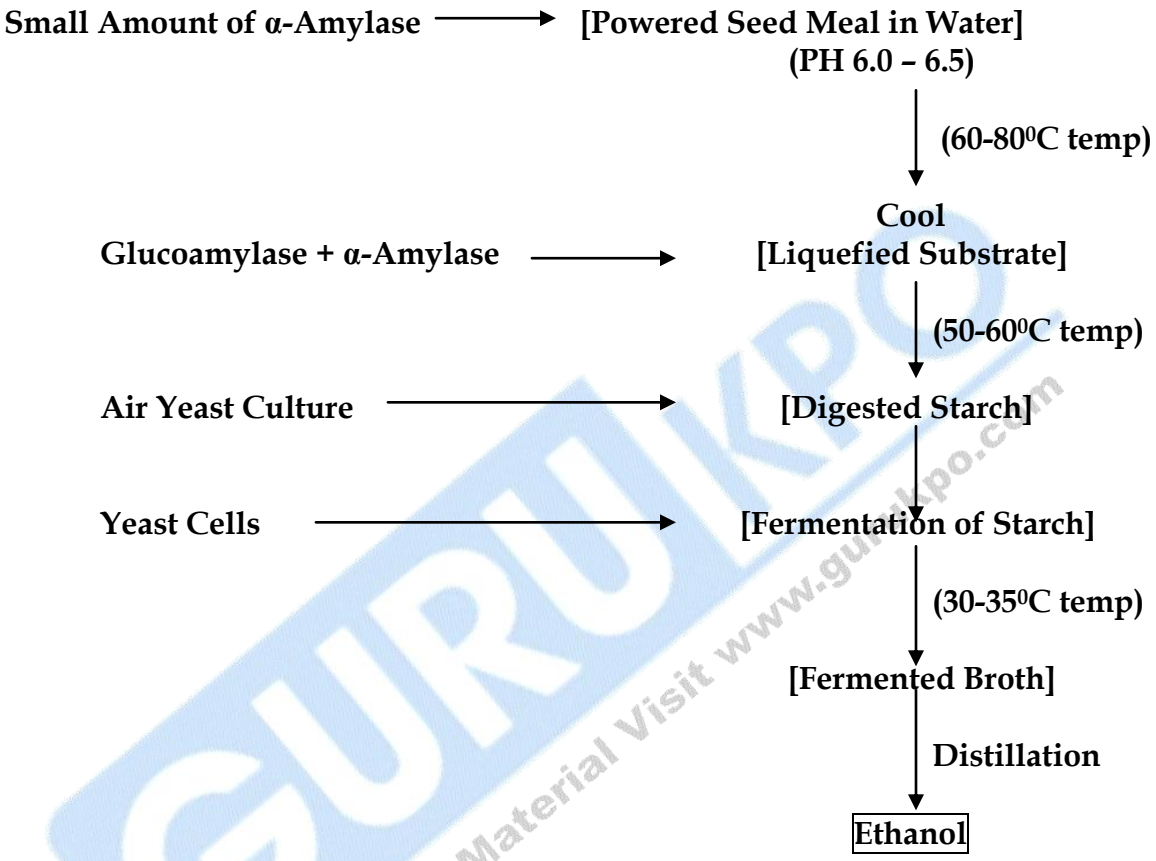
product in sugar factories and are quite rich in fermentable sugars.

In a typical fermenter using molasses as a substrate di-ammonium phosphate (as a source of nitrogen for the yeast) is mixed up with the substrate. The PH is maintained at 5.0 and fermentation is carried out at 30 -35^{0}C temperature. After fermentation, yeast cells are separated by centrifugation or sedimentation and used again.

Fermentation is carried out generally under anaerobic condition -

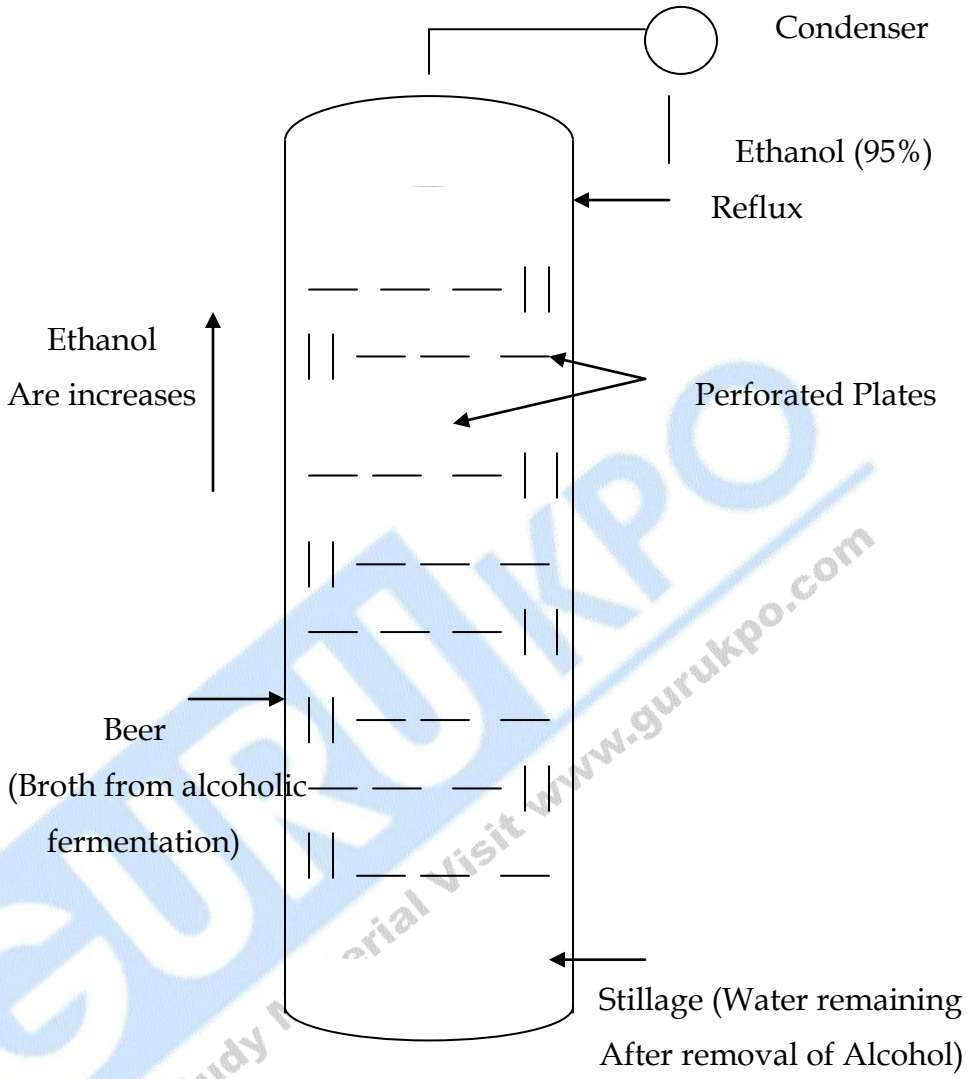


Flow Chart for Ethanol Production :



(c) **Ethanol Recovery by Distillation :** Ethanol from the fermented mixture is recovered by distillation process. The principle of Sequential distillation column which is divided into chambers perforated plates.

The fermentation broth (Ethanol water mixture, is boiled using steam & the vapor rises in the column. Each chamber of the column functions as a distillation unit so that the proportion of alcohols goes on sequentially. A properly designed column would yield 95% ethanol from its topmost chamber.



Sequential Distillation of Ethanol

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SECTION-C

Conversion Fundamentals

Q.1 Define the term Pyrolysis with its various types.

Ans.: Pyrolysis : Pyrolysis means chemical decomposition induced in organic material by heat in the absence of O_2.

- It is not possible to achieve a completely O_2 free atmosphere. Hence actual pyrolytic systems are operated with less quantities of O_2. Because some O_2 will be present in any pyrolytic system, nominal oxidation will occur
- Pyrolysis transforms (convert) hazardous organic materials into gaseous components, small quantities of liquids and solid residues (Coke) containing fixed carbon and ash.
- Pyrolysis of organic material produces combustible gases including CO, H_2, CH_4 and other hydrocarbon. Pyrolysis occurs under pressure & at operating temp above 430^0C.

Type of Pyrolysis :

(i) Anhydrous Pyrolysis

(ii) Hydrous Pyrolysis

(iii) Vacuum Pyrolysis

Anhydrous Pyrolysis : Without water this phenomenon commonly occurs whenever solid organic material is heated strongly in absence of O_2 e.g., When frying, roasting, baking, etc.

Hydrous Pyrolysis : Pyrolysis in the presence of water e.g., steam cracking of oil. The term hydrous pyrolysis is also used for thermolysis in the presence of water.

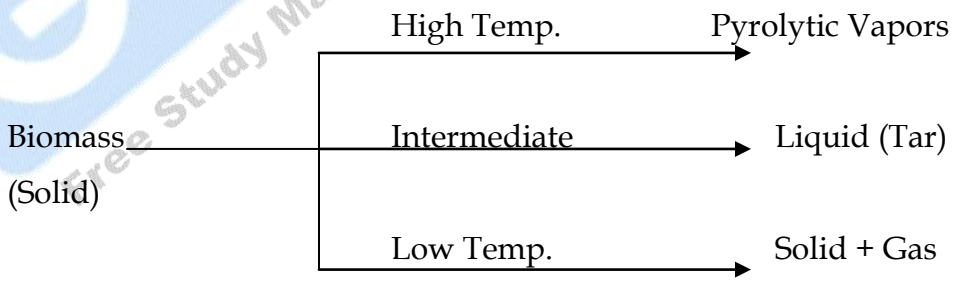
Vacuum Pyrolysis : In this organic material is heated in a vacuum (where air is absent) in order to decrease boiling point & avoid adverse chemical reactions.

Q.2 Explain the Principles behind Pyrolysis.

Ans.: Pyrolysis : Thermal degradation of substrate is called pyrolysis. It occurs at 500 to 800^0C temperature.

Principles behind Pyrolysis :

(i) **Temperature :** Temperature is crucial variant in pyrolysis. Temperature of reactor define the physical state of product. Volume occupied by substrate is proportional to temperature at constant pressure, following. Conversion will take place.



($\because V \propto T$)

(ii) **Pressure :** Pressure on any system can be divided into two parts -

(a) Pressure applied by surrounding.

(b) Pressure produced by conversion of biomass at constant temperature & volume. Pressure obtained depends upon physical state. Pressure is proportional to no. of moles present in volume.

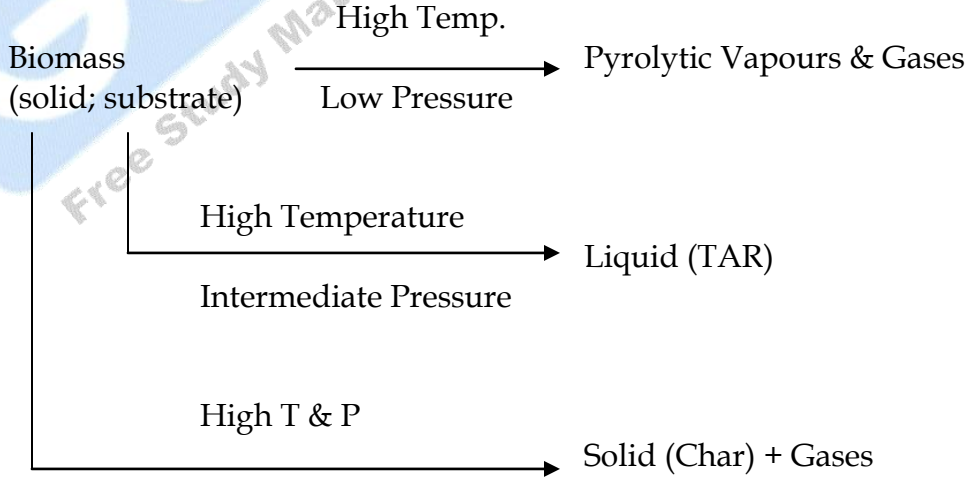
Physical state	**No. of Moles**	**Pressure excepted by on system**
Solids	Maximum	Maximum
Liquids	Intermediate	Intermediate
Gases	Minimum	Minimum

$(\because P \propto n)$

(iii) When temperature and pressure both are variables -

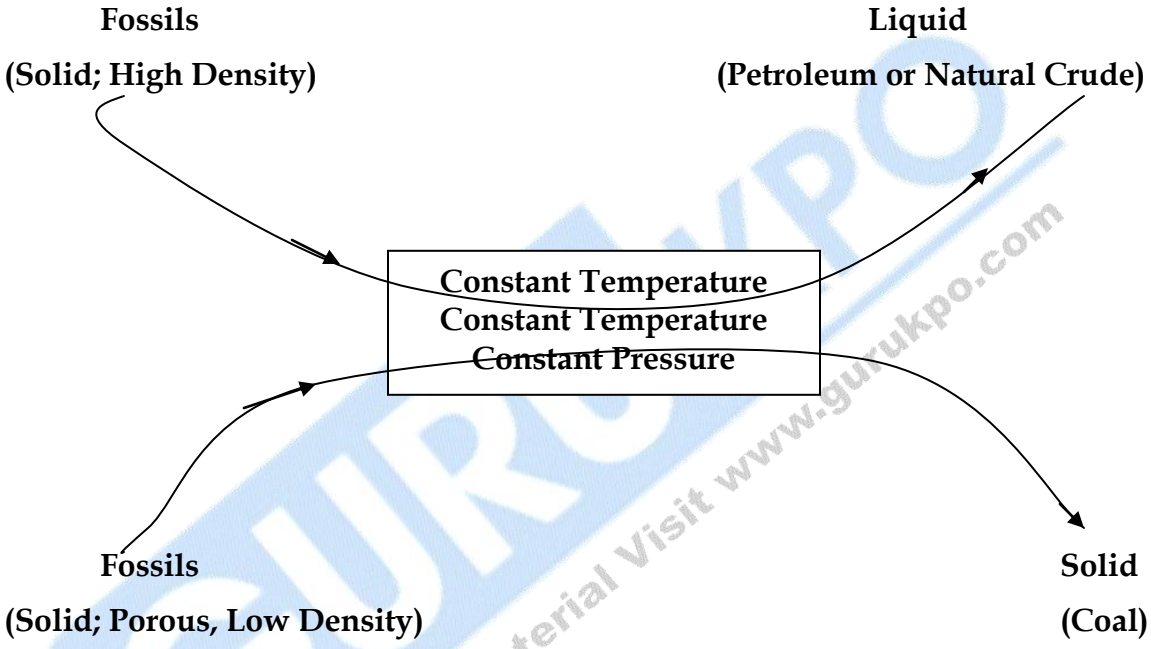
Here combination of temperature defines the physical state of products.

Pressure & Temperature at constant volume to obtain various products are as following.



(iv) **Density :** Density is ratio of mass & volume at constant temperature and pressure. Substrate with different density produces different products.

Example : Production of coal and petroleum from fossil.



Q.3 Describe Solid Waste Disposal.

OR

What are the treatment methods of Solid Waste?

Ans.: **Solid Waste Disposal :** Solid waste disposal basically means the process of proper degradation or recycling of solid-waste.

Source of Solid Waste are :

(i) Domestic Waste – eg. Kitchen Waste

(ii) Industrial Waste

(iii) Hazardous Waste

(iv) Agriculture Waste

(v) Household Waste

Techniques which are used to dispose these wastes are :

i) Sanitary land fill → Area, Trench, Mounding

ii) Incineration

iii) Composting

i) **Sanitary Land Fill :** The waste should be dumped at some particular place where they don't create any problem or any kind of environmental pollution. These are of three types:-

(a) **Trench :** In this solid waste is dumped deep inside the soil. The water here is deep inside. The layer of clay is present which further reduces the waste.

(b) **Area :** Area is landfill which is formed by its own like a valley and waste should be dumped there. The water level is quite good.

(c) **Mounding :** In this landfill the water is at the surface level the waste is dumped at the surface itself.

ii) **Incineration :** It is an expensive process in comparison to sanitary landfill. In this 80-90% solid waste is burnt out. Due to this further when sanitary landfill method is used the wastes cover small amount of land.

iii) **Composting :** This method by the help of solid waste or their recycling make the soil fertile. It is very useful and not expensive as incitation. By making fertile soil. It reduces the content of CO_2 and many sand organisms and make soil useful for irrigation.

Q.4 Write about the Water Gas Shift Reaction.

Ans.: The water gas shift reaction is an inorganic chemical reaction in which water and carbon monoxide react to form carbon dioxide and Hydrogen (water splitting).

$$CO + H_2O \rightarrow CO_2 + H_2$$

The water gas shift reaction is part of steam reforming of hydrocarbons & is involved in the chemistry of catalytic converters. It was discovered by Italian physicist Felice Fontana in 1780.

While this reaction could be used to produce hydrogen, the high temperature required make it cost prohibitive. This reaction is usually done via the byproducts of fossil fuel combustion. The carbon monoxide can also be generated by bogs or other waste regenerative means.

Attempts to lower the reaction temperature of this reaction have been done primarily with a catalyst such as Fe_3O_4 (magnetite) or other transition metals & transition metal oxides.

Q.5 What is Water Gas?

Ans.: Water gas is a method of hydrogen production that combines steam & coke gas in the following chemical reaction:

$$CO + H_2O \rightarrow CO_2 + H_2$$

In 1873, Professor Thaddeus S.C. Lowe developed and patented a process by which large amount of Hydrogen gas could be generated for residential and commercial use in heating and lighting unlike the common coal gas, or coke gas which was used in municipal services. Water gas provides a more efficient heating fuel.

Q.6 Which techniques are used for Water Management?

Ans.: The water management techniques are as follows -

(i) **Eliminate Single Pass Cooling :** It uses a continuous flow of water that is circulated once through the system for cooling purposes, and is then disposed of down the drain.

(ii) **Culture Water Reuse :** Several EPA laboratories require water for aquatic culture research. In some cases, culture water is pumped into laboratory specimen tanks from local bodies of water, such as lakes or boys, but then might be discharged into the sewer after use.

(iii) **Control Reverse Osmosis System Operation :** Up to 10% EPA laboratory water consumption can be related to the multi-step process of generating deionized water through reverse osmosis. Water savings can be achieved by carefully regulating DI generation rates to meet laboratory demand.

(iv) **Landscape Irrigation/ Xeriscaping :** Xeriscaping is a type of landscaping that conserves water by planting native, water efficient plants rather than water intensive ones, utilizes techniques that minimize the need for irrigation.

(v) **Sanitary Fixtures :** Several EPA laboratories received water efficiency upgrades, including new toilets with efficient flow rates of 1.6 gpf, urinals with 1.0 gpf rates, faucets with water aerators, and even waterless urinals in some men's bathrooms.

(vi) **Air Handler Condensate Recovery :** The normal operation of air conditioning equipment in warm, humid climates produce condensate water from the cooling coils, Rather than draining this water into the sewer system, some EPA laboratories are capturing this water for use in cooling towers and other various applications.

(vii) **Cooling Tower Optimization :** Cooling Towers provide a vital source of cooling for laboratories. Cooling tower operations can be optimized by carefully controlling the ratio of the quantity of water evaporated to the quantity of water discharged (blow down).

(viii) **Autoclave Water Control :** Autoclaves use cooling water to temper steam condensate discharge from the autoclave to the laboratory drain. Many older autoclaves discharge a continuous flow of tempering water to the drain, even when it is not needed.

(ix) **Rooftop Rainwater Recovery :** Rooftop recovery systems capture rainwater from the roof and redirect it to a storage tank. This cache of water can then be used for various purposes throughout the facility, such as flushing toilets, supplying cooling towers and irrigating the landscape.

(x) **Meter/Measure/Manage** : The process of metering, measuring and managing laboratory facilities is essential for effective water management. Metering and measuring help in analyzing a facility's water usage, and proper management of mechanical equipment results in greater water efficiency. Making sure that the equipment is run correctly and maintained properly is the key to presenting excess water usage through leaps and malfunctioning mechanical equipment.

□ □ □

SECTION-D

Economic & Perspective

Q.1 What is Large Scale Production?

Ans.: With the global population growing by 90 millions a year, the demand for food & energy is set to intensify. Despite our best efforts agricultural practices are still compromising the natural resource base that we rely upon for food production.

The future of Agricultural policy is complicated by the emerging potential for large scale bio energy production. The dependence of the united states on foreign, non-renewable sources of energy has been a topic of heated debate among U.S. Policy makers and the general public.

One path to energy independence lies in the development of renewable energy technologies and policy. Such as those that promote the expansion of bio fuel production.

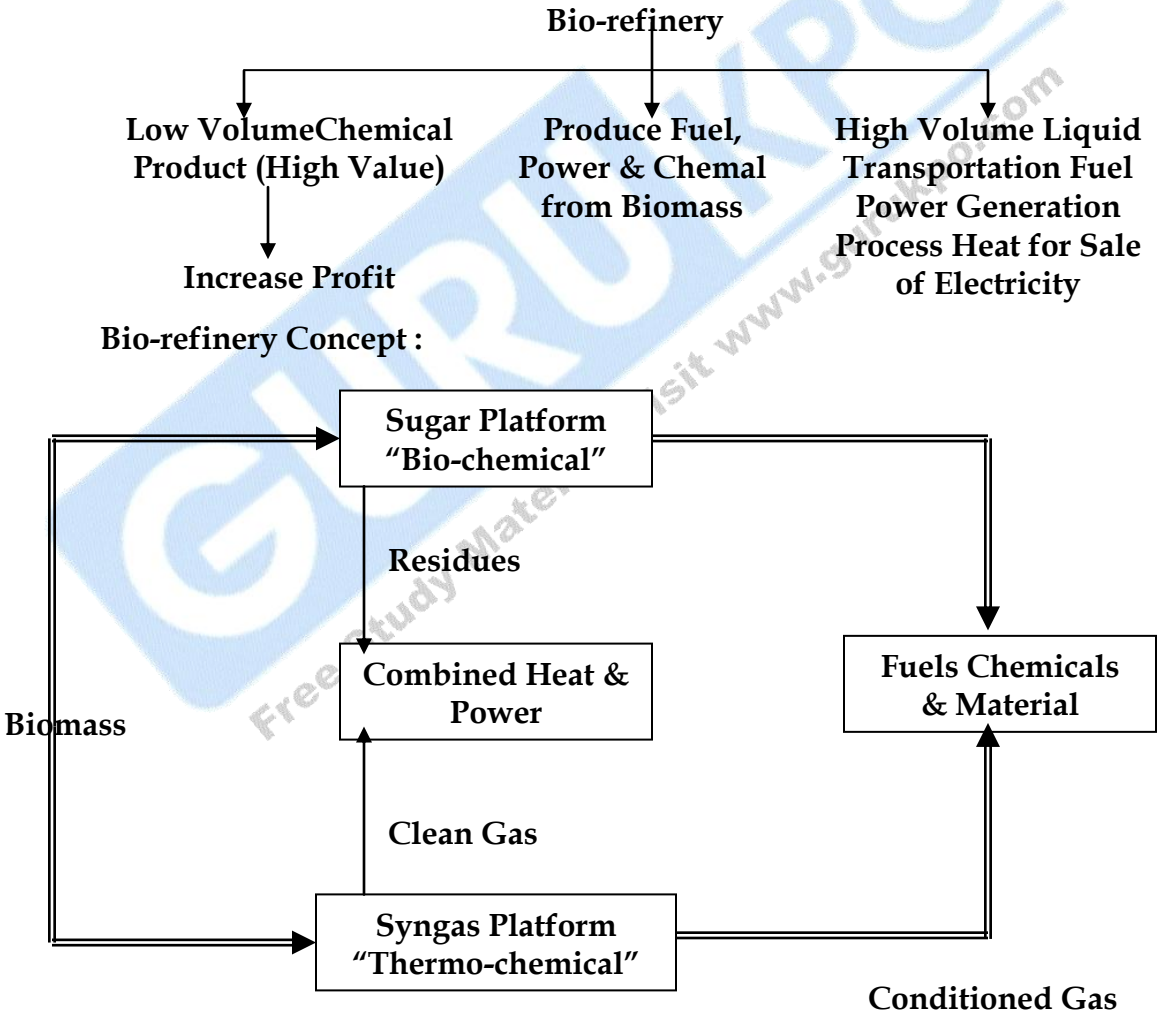
The growing demand for cleaner burning fuels such as ethanol is likely to generate changes in agricultural cropping patterns and land management practices possibly further threatening our natural resource base. How policy is formulated will have a significant impact on how bio fuel production develops. For example, a policy that favours increased production of starch based ethanol from sources such as corn could potentially have a negative impact on water quality.

As compared to other crops corn production has a higher nitrogen fertilization rate and greater nitrogen run off, which would further compound existing water related problems such as the hypoxic zone in the Gulf of Mexico.

By examining the environmental costs and benefits of bio fuel technologies & policy will have on the health of our nation's water quality and atmosphere.

Q.2 Explain Bio-refineries.

Ans.: Bio-refineries : Bio-refinery is a facility that integrates biomass conversion process & equipment to produce fuels, power and chemicals from biomass by producing multiple products, a bio-refinery takes advantage of the various components in biomass & their intermediates.



Following process are included in bio-refinery :

(i) Conversion of biomass in bio-ethanol.

(ii) Conversion of biomass in bio-diesel.

(iii) Conversion of biomass in bio-electricity.

(iv) Conversion of biomass in acids, sugar, medicines drugs alcohols.

(v) Conversion of biomass in clothes, fibres further useful things.

(vi) Production of bio-fertilizer, compact etc during biodegradation of solid waste.

Q.3 Describe Industrial Furnaces with suitable diagram.

Ans.: Furnace is a device used for heating. In American English, the term furnace on its own is generally used to describe household heating system based on a central furnace known either as a boiler or a heater in British English.

The term furnace can also refer to a direct fired heater used in boiler application in chemical industries. For providing heat to chemical reaction for processes like cracking and for metallurgical furnaces.

→ A furnace is an equipment used to provide heat for process or can serve as reactor which provides heats of reaction.

→ Furnace designs vary as to its function, heating duty, type of fuel & method of introducing combustion air.

→ Fuel flows into the burner is burnt with air provided from an air blower.

→ There can be more than one burner in a particular furnace which can be arranged in cells which heat a particular set of tubes.

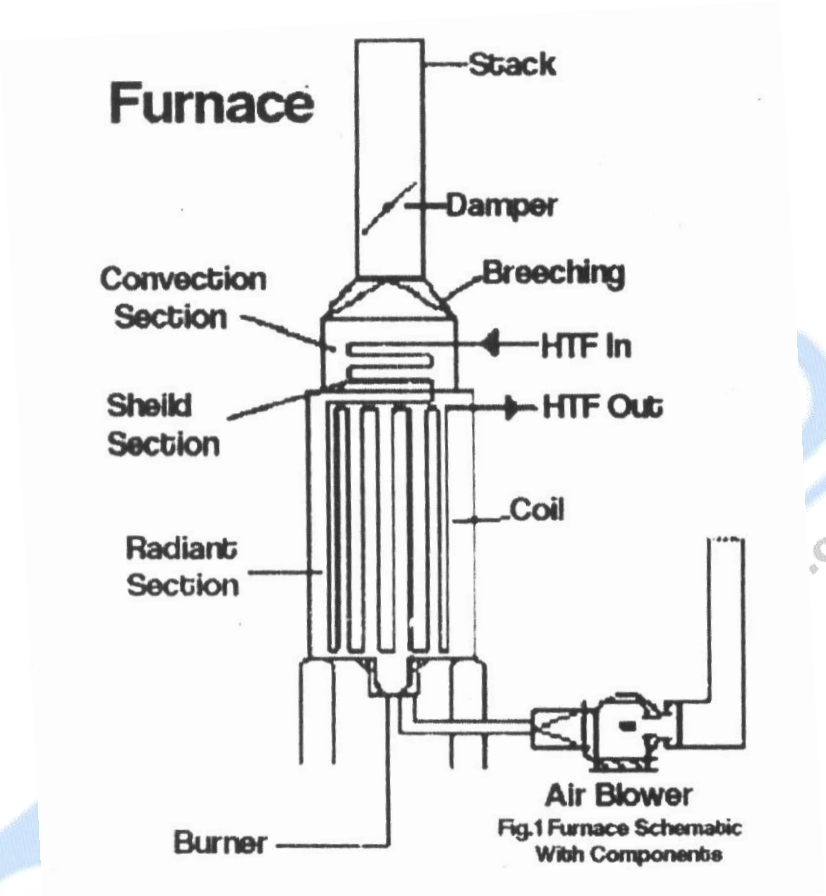
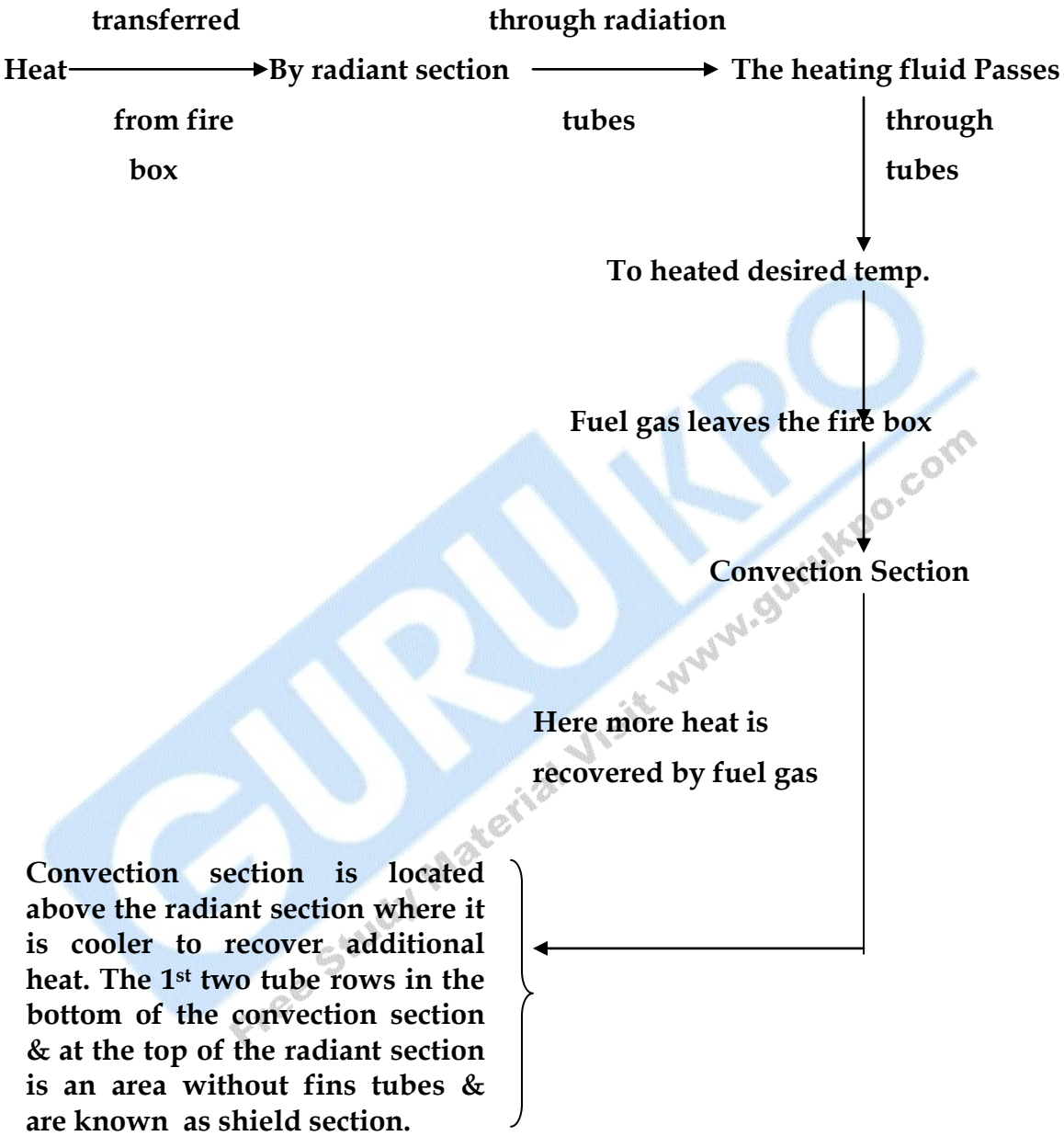


Fig. Furnace Schematic with Components

→ The flames heat up the tubes which in turn heat the fluid inside in the first part of furnace known as radiant section. In the chamber where combustion take place known as fire box. The heat is transferred mainly by radiation to tubes around the fire in the chamber.



The area of the radiant section just before flue gas enters the shield section and into the convection section is called Bridgezone.

Burner : The burner in vertical cylindrical furnaces above is located in the floor & fires up ward the burner tile in made of high temperature refractory and is here the flame is contained in.

Air Blower: It is located below the burner and at the outlet of the air blower are devices with movable flaps that control the shape and patterns of flame.

Air Register are of three types : 1) Primary air registers supply primary air which is the first to be introduced in the burner 2) secondary air registers are added to supplement primary air.

Soot Blower : These are found in convection section here air movement is slower. It is normally done when the efficiency of the convection section is decreased. It is utilized flowing media such as water, air or steam to remove deposits from the tubes.

Stack : The flue gas stack is a cylindrical structure at the top of all the heat transfer chambers The stack damper contained within works like butterfly value & regulates pressure difference between air in take and air exit in the furnace. It also regulates the heat lost by the stack.

Insulation : this is an important part of the furnace because it prevents excessive heat loss. Refractory materials like firebricks and ceramic fibres are used for roof and wall of the furnace.

Q.4 Define Future Fuel.

Ans.: Future Fuels : Now that we are into the 21st century, lots of new technologies are being developed and many scientists feel that it is time to create fuel to supplement or even replace fossil fuels. These Scientists want to eliminate our dependency on fossil fuels for several reasons. The high rate of fossil fuel consumption causes damage to our environment because CO_2 is emitted where fossil fuel combust.

→ Electric Cars

→ Fuel cell cars

→ Hybrid cars

→ Ethanol

→ Methanol

→ Natural gas

→ Hydropower

Electric Cars : Discover the different types of electric cars and the disadvantages and advantages of each

An electric car is a car that runs on electric batteries. The source of power from the electric car usually comes from rechargeable batteries (pure electric cars) fuel cell or combination of gasoline and rechargeable batteries (Hybrid cars).

Difference between gasoline powered cars and electric cars include no transmission, no gas tank, no tail pipe a charger and a voltage gauge to replace the gas gauge.

Advantages :

i) No exhaust is produced so widespread use could reduce air pollution.

ii) They use batteries instead of petrol

iii) They are quite

Disadvantages :

i) Pure electric cars are impractical because they can not go more than 100 miles before needing to be charged.

ii) Charging stations are needed to recharge the batteries and could take about three hours to get a fuel charge.

iii) Charging stations are not popular as gas stations; so long trips in an electric car are not possible.

Fuel Cell Cars : A fuel cell is a device that generates electricity by converting H_2 and O_2 into H_2O

A battery generates electricity by converting the chemicals stored inside into electricity so in fuel cell cars it eliminates the need for batteries

There are different types of fuels used or fuel cells with hydrogen being the most common type. Other fuels used include methane and methanol.

Advantages:

They help in reduction of pollution and they can go longer between refueling.

Disadvantages :

The downside of fuel cell is that they are expensive so they are not as proper as other cars. Hydrogen is also difficult to store and distribute.

Hybrid Cars : A Hybrid electric vehicle is a car that uses an electric motor and a gasoline engine. The engine charge the battery and extends the range and provide extra power.

Hybrid car include a fuel tank a generator, batteries and a transmission.

Fuel tank is the energy storage site for the gasoline engine. It holds a lot more energy than batteries. The generator produces electric power. The batteries are the energy storage devices for the motor.

Advantages :

Hybrid car is the extra motor and battery. The extra motor and battery gives it power when it needs to go up a steep hill or when it is in a hurry. The car can turn off the engine if the car does not need it.

Car also uses low resistance tires and light weight materials to increase mileage.

Q.5 What do you understand by Hybrid Fuels?

Ans.: Hybrid fuels are mixes of petroleum fuel or coal with bio-fuels.

They are economically and environmentally safe due to presence of bio fuel, pollution emission is less and thus it proves healthier for our environment as price of bio fuel are lesser for same.

Average cost of blends (mixtures)/hybrid fuel become less than normal.

Hybrid fuels are more sustainable as we can use higher proportion of biofuels in scarcity of petro-fuels and vice versa incase of shortage or delay in manufacturing biofuels.

Examples of Hybrid fuels :

i) **Bxx :** A representation for the bio-diesel to petroleum content in a diesel mixture eg; B_{20} a mixture of 20% bio-diesel & 80% petroleum diesel based on volume .

ii) **Exx :** A representation for Bio ethanol to petroleum content in an alcohol mixture.

iii) **E10 :** A mixture of 10% ethanol and 90% unleaded gasoline also called gasohol. (gasohol mixture of gasoline & ethanol is derived from fermented agriculture products containing 10% ethanol by volume. Gasohol Emission content less carbon monoxide than those from gasolin is more commonly known as E_{10}. Super unleaded plus ethanol unleaded plus.

iv) **E85 :** A mixture of 85% ethanol and 15% unleaded gasolines.

v) **Mxx** : A representation for bio-methanol to gasoline content in a alcohol mixture.

Example **M85** : A blend of 85% methanol and 15 % unleaded regular gasoline used as a motor fuel.

M100: Neat methanol (100%) used as a motor fuel in dedicated methanol vehicles.

vi) **Co-firing**: Burning of coal and coke along with biomass (fire fuels, wood etc.)

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B.Sc. /M.Sc. (Part I) Examination, 2011

(Faculty of Science)

(Common to Three and Five Year Integrated Course)

BIOTECHNOLOGY

Paper BT- 301

Energy Resources and Utilization

Year-2011

Time.: 3 Hours ***Max. Marks : 50***

Attempt Five questions in all, selecting ONE questions from each Section. Questions No.1 is compulsory. Each question carries equal 10 marks.

1. Answer the following questions in short: -

   (i) What is Briquetting?

   (ii) Explain bio-energy.

   (iii) Write the chemical name of biofuel.

   (iv) What is hydro gasification?

   (v) Mention a major sources o energy in India.

   (vi) Define petro plants.

   (vii) What is biodiesel?

   (viii) Explain gasohol.

   (ix) Name few fossil fuels.

   (x) Define Rubbish.

   (xi) What is hog fuel?

   (xii) Explain bioconversion.

   (xiii) Mention about enzymatic digestion.

   (xiv) What is the full form of DNES?

(xv) Define BOD.

(xvi) Mention in brief about energy plantation.

(xvii) Name any two bacteria which can be used for alcohol production.

(xviii) Expand the abbreviation PAN.

(xix) Name any two non-renewable natural resources.

(xx) What is bio gas?

Section-A

2. What are biofuels? How can these be synthesized?

3. Write short notes on:

(1) Carbon credits

(2) Properties of coal.

Section-B

4. Give the characteristics of petro plants. How can they be used for energy requirement?

5. Write short notes on:

(i) Underground gasification

(ii) Improvement of Biofuels.

Section-C

6. What constitutes the solid waste? Discuss in details the current practices of the solid waste management.

7. Write short notes on:
   (i) Pyrolysis
   (ii) Liquefaction

Section-D

8. Discuss about large scale production and conversion technology for the biofuel resources.
9. Write short notes on:
   (i) Industrial furnaces
   (ii) Economic considerations of Biorefineries.

B.Sc. /M.Sc. (Part I) Examination, 2008

(Faculty of Science)

(Common to Three and Five Year Integrated Course)

BIOTECHNOLOGY

Paper BT- 301

Energy Resources and Utilization

Year-2008

Time.: 3 Hours ***Max. Marks : 50***

Attempt Five questions in all, selecting ONE questions from each Section. Questions No.1 is compulsory. Each question carries equal 10 marks.

1. Write the following question in short -

   (i) Write two names of hydrogen producing (biohydrogen) plants.

   (ii) Biodiesel is produced from which plant?

   (iii) What substrates are used to produce bioethanol?

   (iv) For maximum methane production what is the most suitable C : N ratio of substances?

   (v) Name microorganism which is used to produce biobutanol?

   (vi) What is fossil fuel?

   (vii) Give an example of hybrid fuel.

   (viii) Write name of plant which can be used in production of biogas.

   (ix) What do you call a fuel when it is derived from the biomass?

   (x) Euro norms had been implemented for the first time in which country and for what purpose?

(xi) Which technology is used for briquetting?

(xii) What is coal tar?

(xiii) Define synthetic fuel.

(xiv) What is gasohol?

(xv) Define coal.

(xvi) Write the products of pyrolysis.

(xvii) What is charcoal?

(xviii) Name the raw materials used in pyrolysis.

(xix) Give the full form of B.O.D.

(xx) What are fuel cells?

Section – A

2 What is carbon sequestration? Describe novel techniques for long term sequestration of carbon in various ecosystems.

3 Define agriculture waste. Write techniques to convert them into biofuels.

Section – B

4 Describe the production of gas from coal using various gasification technologies.

5 Write notes on –

(i) Hydrocarbons from plants

(ii) Bioethanol production

Section - C

6 Enumerate the various methods commonly employed for the disposal of solid wastes. Discuss the importance of recycling in solid waste management.

7 Discuss air pollution control measures. Give an account of the remedial steps taken by the Indian Government.

Section - D

8 Explain the following in detail –

(i) Hybrid fuels

(ii) Biorefineries

9 Describe conversion technology for production of biofuel on large scale. Discuss its economic perspective in comparison to traditional.

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