

GASIFICATION

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INTRODUCTION

- Gasification is the process in which the supply of oxygen is controlled and biomass are converted into fuel gas or chemical product called producer gas.
- It is a high temperature process(750-850°C).
- Raw materials are converted into an intermediate chemical product, which constitutes mainly of carbon monoxide and hydrogen.
- The calorific value of producer gas is 950-1200 kcal/m³
- It has the thermochemical conversion efficiency of about 70 to 90 %.

- **Products of gasification :**

- * Hydrocarbon gases (also called syngas).

- * Hydrocarbon liquids (oils).

- * Char (carbon black and ash).

- **Syngas** is primarily carbon monoxide and hydrogen (more than 85 percent by volume) and smaller quantities of carbon dioxide and methane

COMPONENTS OF PRODUCER GAS

CARBON MONOXIDE	(18-24%)
HYDROGEN	(18-20%)
CARBON DIOXIDE	(9-12%),
NITROGEN	(45-55%),
METHANE	(1-5%)
WATER VAPOUR	(4%)

- In gasification, the solid fuel is subjected to a series of thermochemical processes like **drying, pyrolysis, oxidation and reduction**. The resultant product is **producer gas**.

Importance Of Gasification

- It offers high flexibility in terms of various biomass materials as feedstock.
- Efficiency of 70%-90% can be achieved.
- The area requirement for gasification equipment is lowest per unit output of energy in the form of heat /or electricity.
- The gasification outputs are suitable as a fuel for all types of internal combustion engines.
- It has small to large scale applications.

Raw Materials for Gasification



saw dust cubes

Wood Chips

GASIFICATION AGENT

- In order to convert solid biomass into inflammable gas, a substance to promote the chemical reaction is necessary.
- This substance is called the gasification agent, and mainly **air (N₂, O₂), oxygen (O₂), H₂O, or CO₂** are applied as an appropriate mixture.
- Air (only O₂ reacts) and heat by oxidation, and increased O₂ decreases the effective amount of inflammable gas.

GASIFIER

Gasifiers are used to convert the solid fuel materials into producer gas.

It is basically a **chemical reactor** where various complex physical and chemical processes takes place.

Biomass gets **dried, heated, pyrolysed, partially oxidized and reduced**, as it flows through it.

The basic components of a gasifier **are reactor, air supply system, feeding system, gas outlet system, grate, ash removal system** etc.

PROCESS OF GASIFICATION

1.DRYING :

Biomass fuels consist of moisture ranging from 5 to 35%. They are dried at a temperature above 100°C, water is removed and converted into steam.

Biomass + Heat \rightarrow Loss of water

2.PYROLYSIS (biomass + heat \rightarrow carbon + gas)

Large molecules such cellulose, hemi-cellulose and lignin break down into medium size molecules.

It release of three kinds of products : solid, liquid and gases.

The ratio of products is influenced by the chemical composition of biomass fuels and the operating conditions.

The heating value of gas produced during the pyrolysis process is low (3.5 - 8.9 MJ/m³)

3.Oxidation zone

- Air is introduced at this zone.
- Reaction with oxygen are highly exothermic and result in a sharp rise of the temperature(700-2000°C).
- Actual combustion of tar and charcoal takes place producing carbon dioxide and water vapour.
- **$C + O_2 = CO_2 + 406$ [MJ/kmol]**
- Hydrogen in fuel reacts with oxygen in the air blast, producing steam .

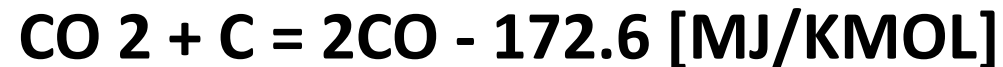


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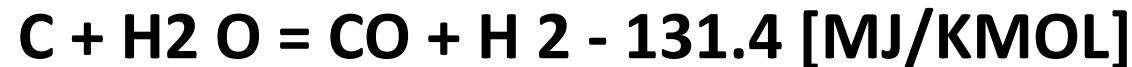
4.Reduction zone

- The reaction products of the oxidation zone (charcoal and hot gases) move downward into the reduction zone. carbon dioxide is reduced to form CO, methane and hydrogen.

BOUDOUARD REACTION



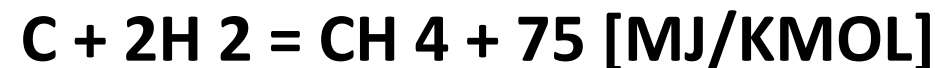
WATER-GAS REACTION



WATER SHIFT REACTION



METHANE PRODUCTION REACTION

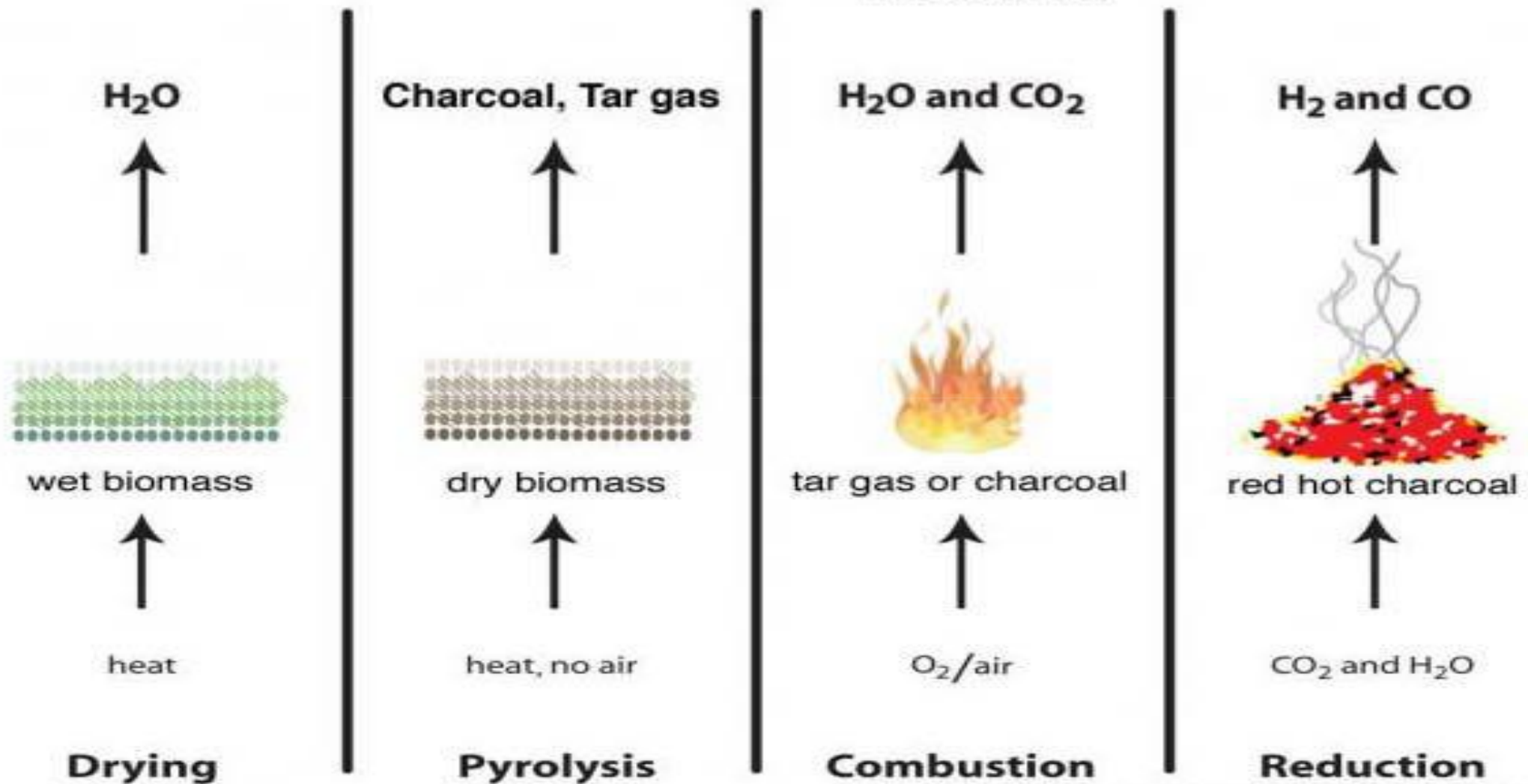


PROPERTIES OF PRODUCER GAS

- The heating value of producer gas vary from 4.5 to 6 MJ/m³ .
- Carbon monoxide is produced from the reduction of carbon dioxide and it's quantity varies from 15 to 30 % by volume basis .
- Hydrogen is also a product of reduction process in the gasifier. Hydrogen posses the octane number of 60-66% and it increases the ignition ability of producer gas.

4 Processes in Gasification

not necessarily in order



* Biomass is a combination of C, H, and O (C H_{1.4}O_{0.6})

Gasification Stage	Reaction formula	Reaction heat
Stage 1:	$C + 1/2O_2 \rightleftharpoons CO$	Exothermal
Oxidation and Other exothermic Reaction	$CO + 1/2O_2 \rightleftharpoons CO_2$ $C + O_2 \rightleftharpoons CO_2$ $C_6H_{10}O_5 \rightleftharpoons xCO_2 + yH_2O$ $H_2 + 1/2O_2 \rightleftharpoons H_2O$ $CO + H_2O \rightleftharpoons CO_2 + H_2$ $CO + 3H_2 \rightleftharpoons CH_4 + H_2O$	
Stage II : Pyrolysis	$C_6H_{10}O_5 \rightleftharpoons C_xH_z + CO$ $C_6H_{10}O_5 \rightleftharpoons C_nH_mO_y$	Endothermic
Stage III : Gasification (Reduction)	$C + H_2O \rightleftharpoons CO + H_2$ $C + CO_2 \rightleftharpoons 2CO$ $CO_2 + H_2 \rightleftharpoons CO + H_2O$ $C + 2H_2 \rightleftharpoons CH_4$	Endothermic Exothermal

TYPES OF GASIFIER

- It is classified according to:-
 1. The **direction** of the gas flow (updraft, downdraft, cross draft)
 2. Output or **capacity** of the gasifiers (small size, medium size, large size, very large size, gasifiers for direct thermal energy applications)
 3. **Type of bed** (fixed bed, fluidized bed)

UPDRAFT GASIFIER

- It is a type of **fixed bed** gasifier.
- Air enters below the combustion zone and the producer gas leaves near the top of the gasifier.
- It is easy to build and operate.
- The gas produced has practically **no ash** but **contains tar** and water vapour because of passing of gas through the unburnt fuel.
- The tar and volatiles produced during this process will be carried in the gas stream.
- Ashes are removed from the bottom of the gasifier .

The major **advantages** are

- Its simplicity
- Low temperature of gas exit.

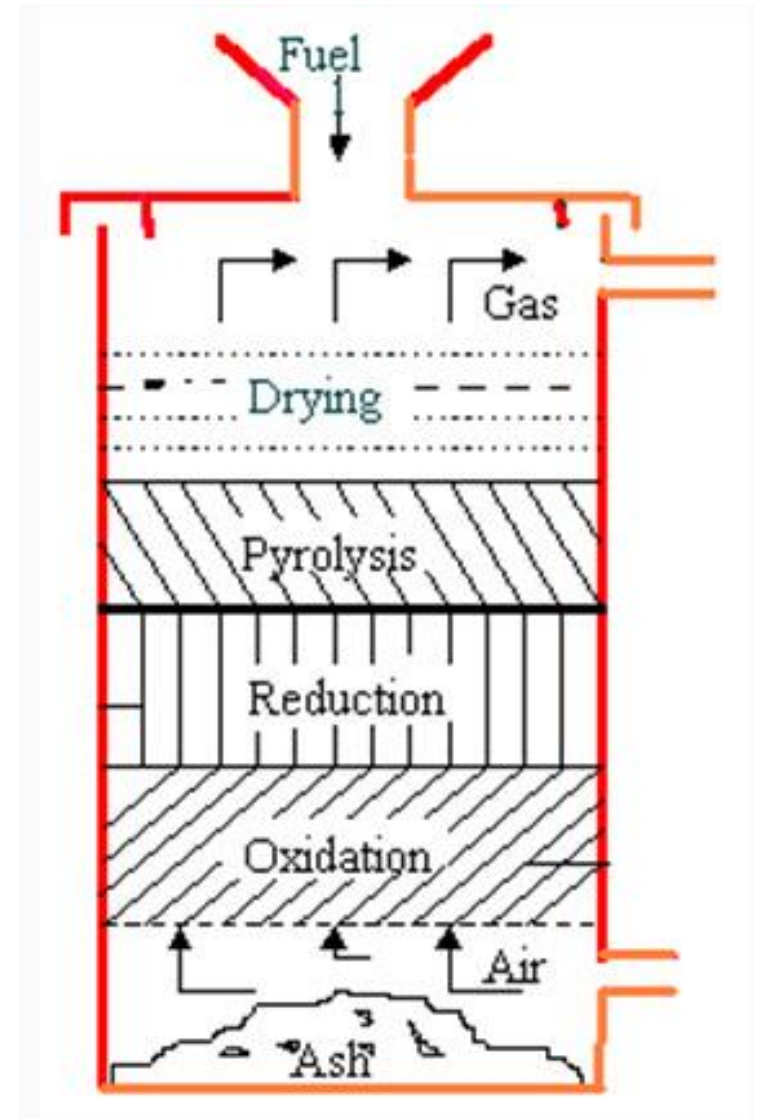


Fig.1. Updraft Gasifier

DOWNDRAFT GASIFIER

- It is a type of **fixed** bed gasifier.
- In this type of gasifier the fuel is introduced at the top of the gasifier and air is introduced at or above the oxidation zone of the gasifier.
- The producer gas is removed at the bottom of the apparatus , so that the fuel and gas move in the same direction.
- For engine applications downdraft gasifier is the **most suitable** as it produces gas having **less tar content** which is very suitable for the **engine applications**.

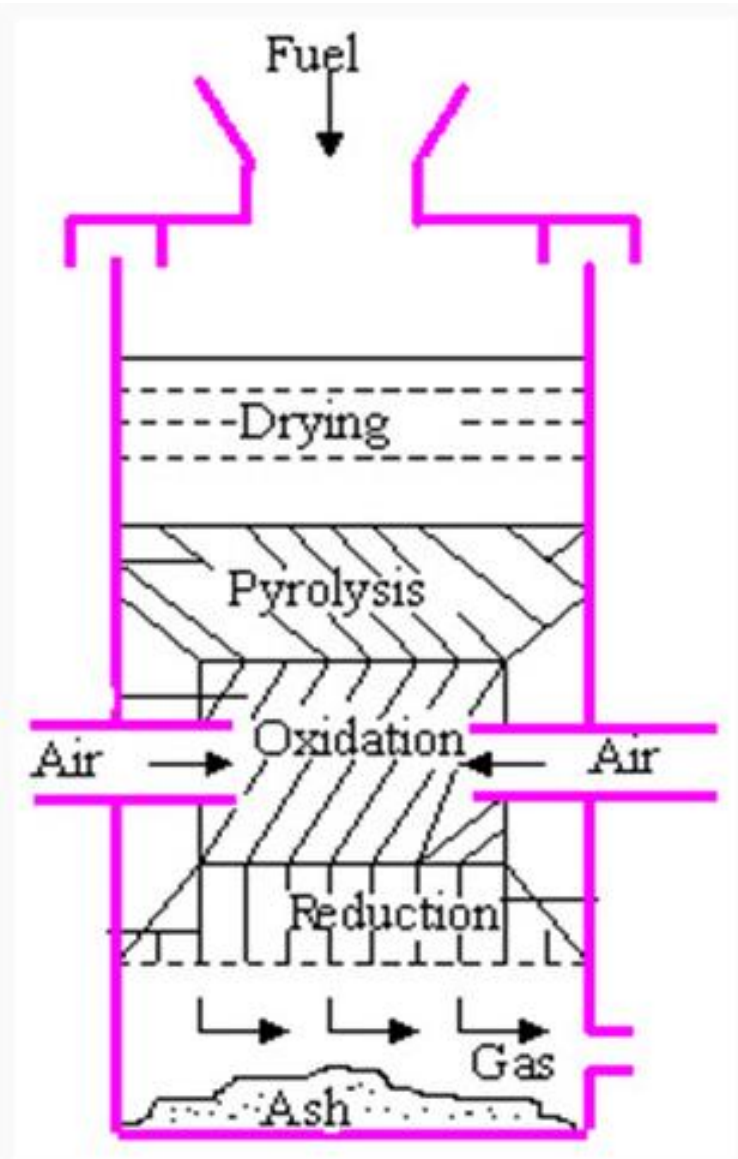


Fig.2 Downdraft Gasifier

CROSSDRAFT GASIFIER

- The gas produced passes upwards in the annular space around the gasifier which is filled with charcoal.
- The *charcoal acts as insulator and dust filter*.

ADVANTAGES

- Short design height
- Very fast response time to load
- Flexible gas production

DISADVANTAGES

- Minimum char converting capacity
- High exist gas temperature
- High gas velocity

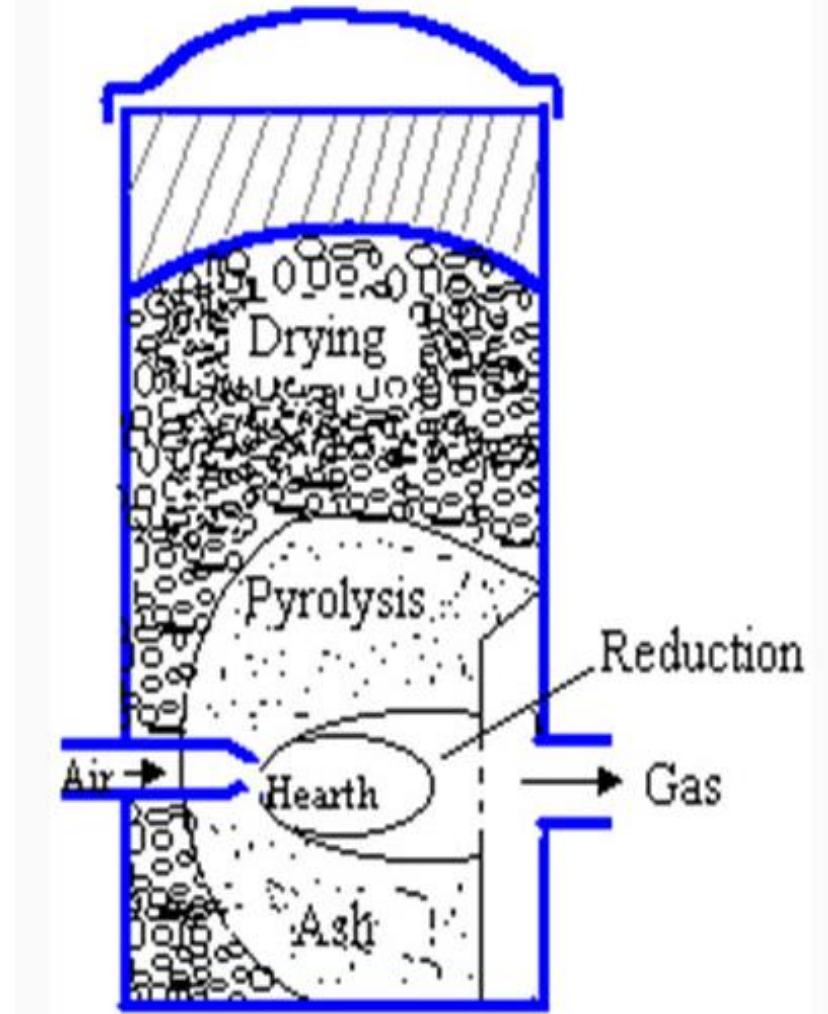
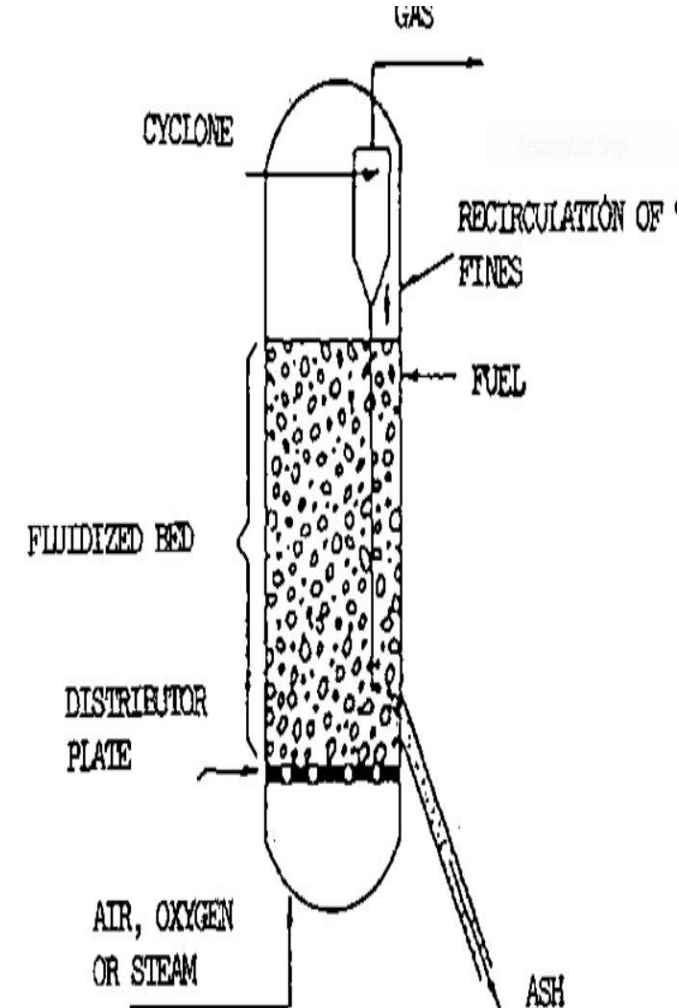


Fig.3. Crossdraft gasifier

Fluidized bed Gasifier

- It is the most versatile gasifier and any biomass can be gasified.
- The combustor is a hot bed of inert particles which are held in suspension (fluidized) by an upward current of air.
- It has high heat release rates, effective heat transfer resulting from rapid mixing and turbulence within the fluidized bed.
- The operating temperatures of the bed ranges from 750-950°C.
- The fluidized bed generally contains inert materials like sand or reactive materials like limestone to help in heat transfer and provide catalytic and gas clearing action.



Advantages of fluidized bed gasifier:-

1. Fuel flexibility
2. Good heat storage capacity
3. Quick start up
4. High combustion efficiency
5. High output rate
6. Consistent rate of combustion
7. Usage of fuel with high moisture content
8. Rapid response to fuel input changes
9. Operation is simple

ASSIGNMENTS (SUBMISSION DATE:29.10.19)

1. Write the advantages and disadvantages of:
 - a. Updraft gasifier
 - b. Downdraft gasifier
 - c. Cross draft gasifier
 - d. Fluidized bed gasifier
2. Write the difference between constant volume biogas plant and constant pressure biogas plant.
3. Write the difference between producer gas and biogas
4. Draw diagram of KVIC biogas plant and Deenabandhu biogas plant.
5. Calculate the minimum solar energy power requirement for your house.