23/8/25

INTERNAL ASSESSMENT TEST - 02

(1)

i) Steam Reforming

It is process of producing hydrogen, carbon monoxide using hydrocarbons like methane (CH_4).
It is endothermic process.

Chemical equations:

Primary reaction:

$$CH_4 + H_2O \rightarrow CO + 3H_2$$

Methane on reaction with H_2O produces carbon monoxide & hydrogen

Water-Gas shift reaction:

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

Carbon monoxide with H_2O yields Carbondioxide & H_2

Overall reaction:

$$CH_4 + 2H_2O \rightarrow CO_2 + 4H_2$$

Finally, methane on reaction with H_2O gives Carbondioxide & Hydrogen.

ii) Partial Oxidation:

It is process of producing hydrogen in the absence of limited amount of Oxygen.

It is exothermic process.
It produces, syngas

Overall reaction:

$$CH_4 + \frac{1}{2}O_2 \rightarrow CO + 2H_2O$$

Methane on reaction with Partial O_2 gives Carbon monoxide

General reaction:

$$C_nH_m + \frac{n}{2}O_2 \rightarrow nCO + \frac{m}{2}H_2$$

iii) Biomass Gasification & Pyrolysis.

It is a process of breaking down biomass into useful gaseous or liquid fuels.

Biomass Gasification:

It is Gasification process, where biomass is produced at temp. 300° - 400°C in the presence of gasifying agents like air, water, steam.

Steps:

Partial Oxidation: $C + \frac{1}{2}O_2 \rightarrow CO$

Steam Gasification: $C + H_2O \rightarrow CO + H_2$

Water-Gas Shift reaction:

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

Methanization:

$$C + 2H_2 \rightarrow CH_4$$

Pyrolysis

It is thermal decomposition process of Organic materials in the absence of Oxygen (or) limited amount of O_2.

It produces,

- Char (a solid carbon)
- bio-oil
- Pyrolyate gas.

Reaction:

$$(C_6H_{10}O_5)_n \xrightarrow{\text{heat}} \text{Gases} + \text{bio oil} + \text{char}$$

Bio-oil contains Organic compounds like H, C, O etc.

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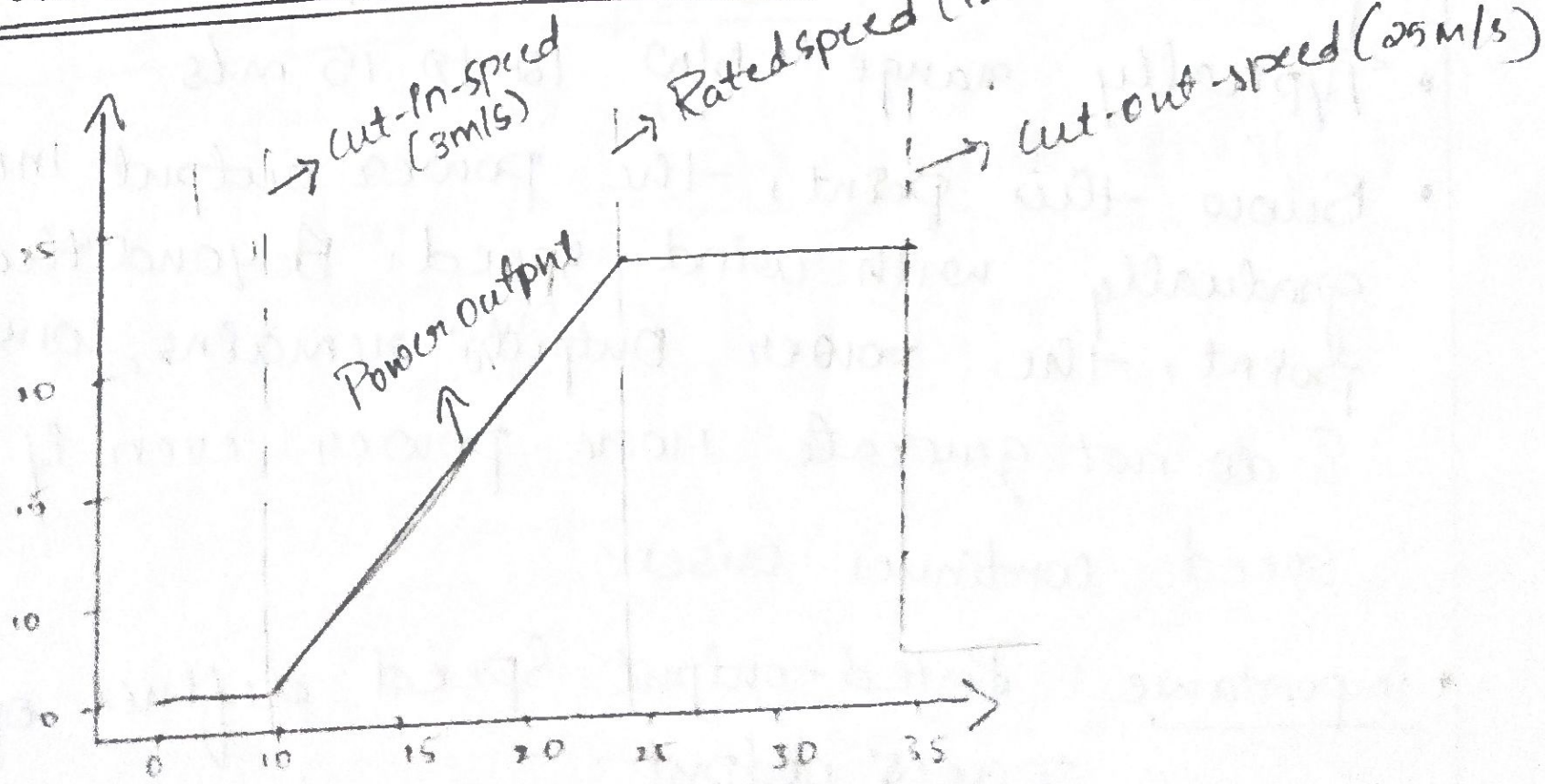
(2) ## Power Vs Wind speed Curve.



9) Cut-In-Speed.

- It defines the minimum wind speed at which turbine begins to generate power.
- Typically range blw 3 to 4 m/s.
- Below this point, it ~~xxxx~~ is difficult to ~~xxx~~ generate kinetic Energy to overcome Mechanical fluid. As a result, ~~xxxxxx~~ power output remains constant or rotates too slowly to generate Electricity
- Importance: It marks the point of ↓ generation start of of power output.

9A) Rated-output Speed.

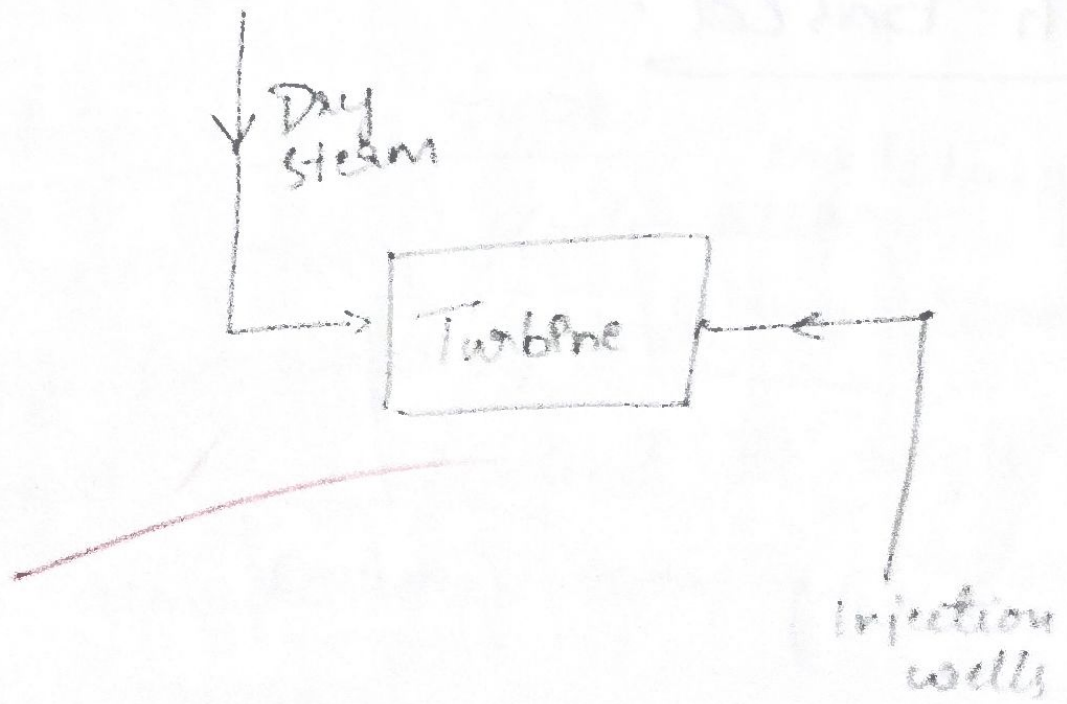
- It is the wind speed at which turbine generates maximum power output.
- Typically range blw 12 to 15 m/s.
- Below this point, the power output increases gradually with wind speed. Beyond this point, the power output remains constant & do not generate more power even if wind speed continues rises.
- Importance: Rated-output speed defines optimal powers output.

PPP) Cut-out Speed

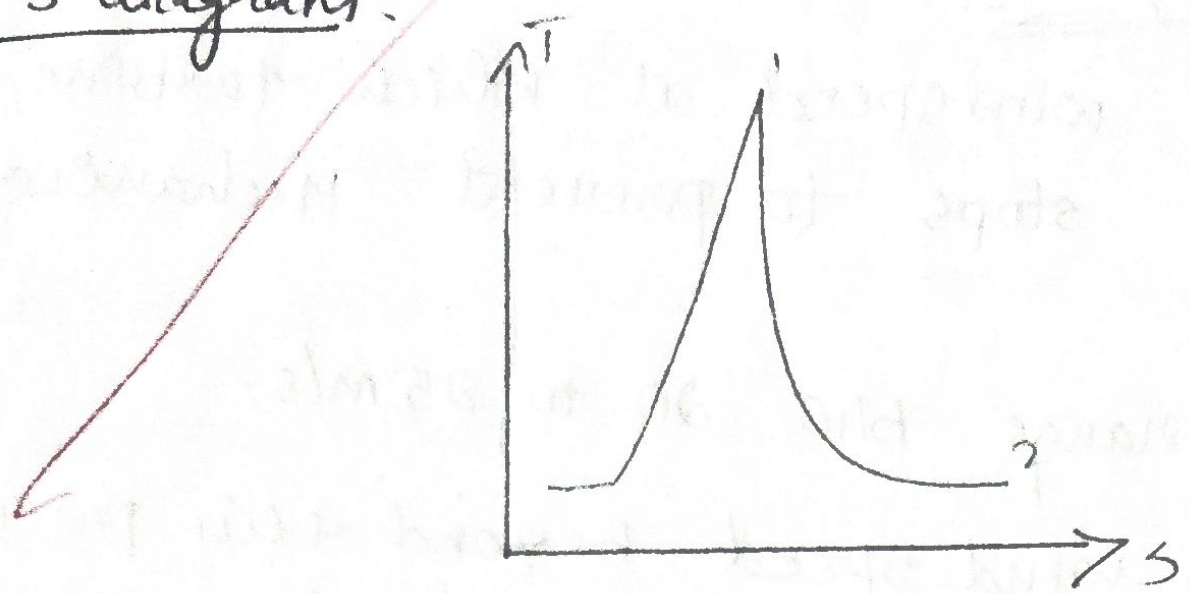
- It is the windspeed at which turbine automatically stops to prevent mechanical damage.
- Typically range b/w 20 to 25 m/s.
- ~~Very~~ High wind speed beyond this point creates mechanical stress & vibration. To ensure safety, ~~turbine~~ of blades, gearbox & generator turbine automatically braked., stopping further power generation.
- Importance: Prevents structural damage, Improves longer operational life.

(9)

(3) Dry Steam based power plant.

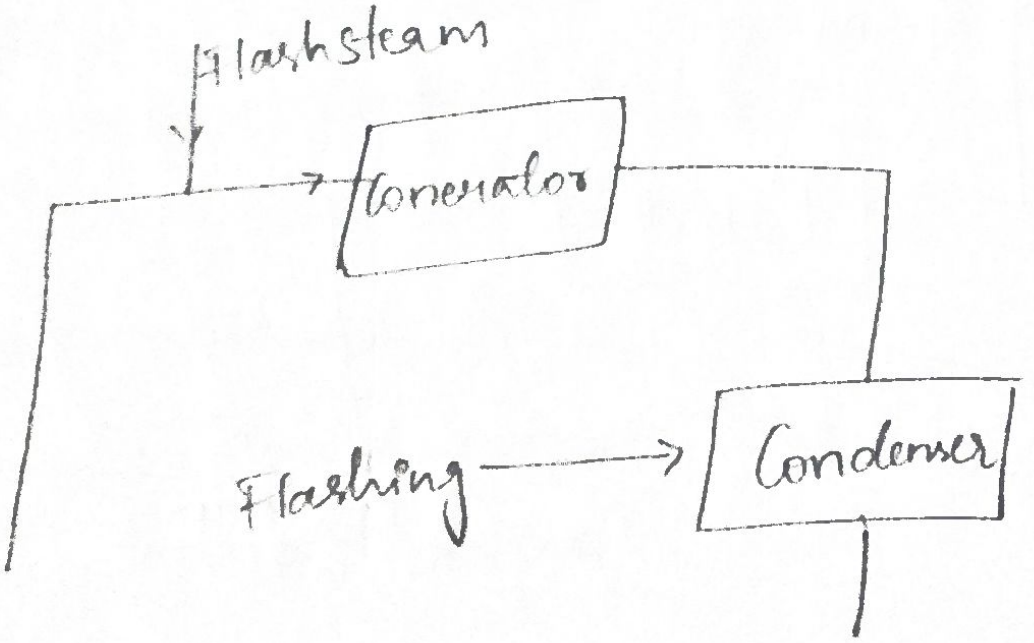


T-S diagram.

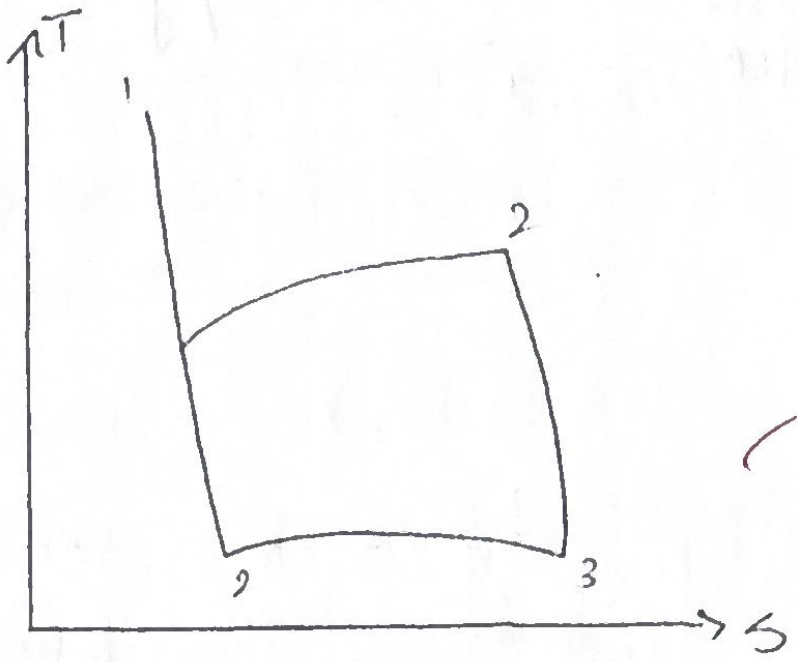


- Dry saturated steam are directly from geothermal well.
- Uses dry steam into turbines.
- Steam directly goes to turbines & generate Electricity.
- Then it is condensed & reinjected.
- It is isentropic process.
- It is simple & efficient.
- Typically range: 10-12%.

Single Flash based:



T-S diagram

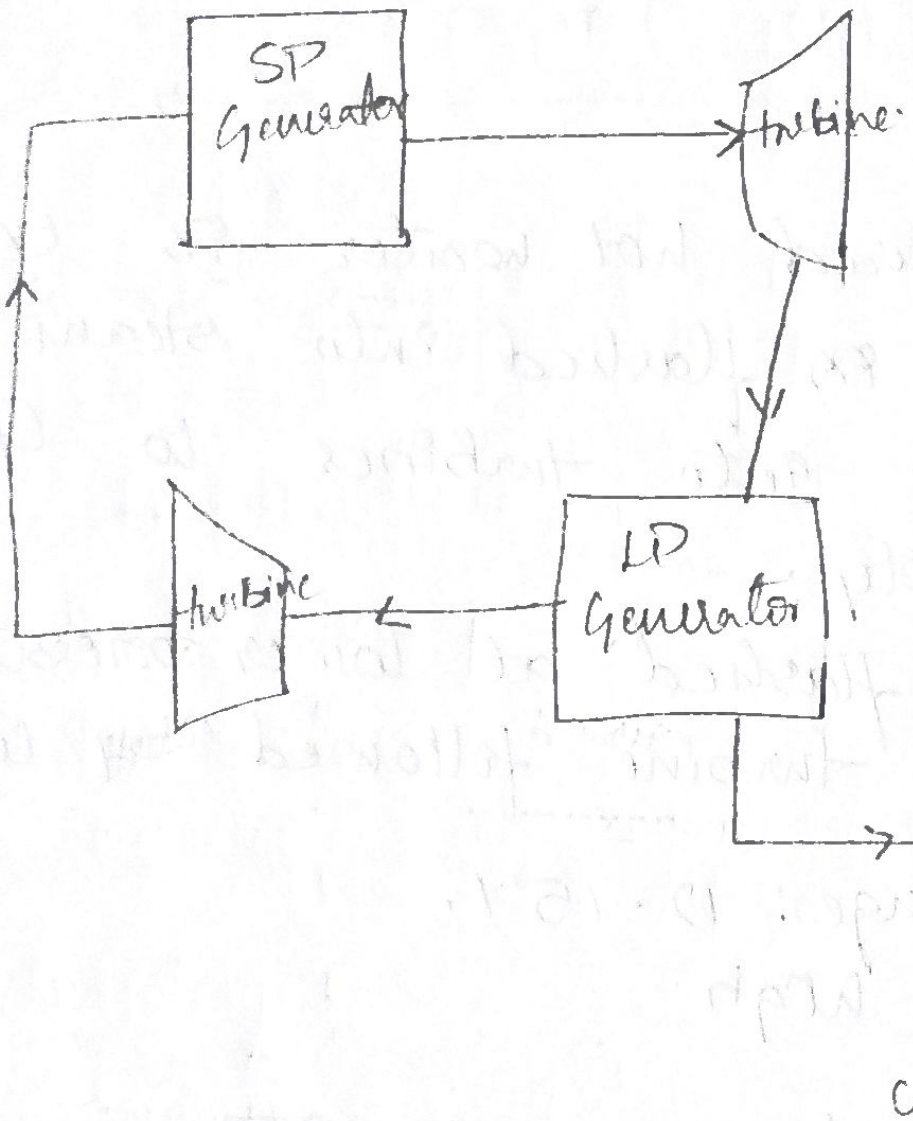


- Highly pressured hot water is extracted.
- Flash steam is flashed into steam.
- Flash steams into turbines to Generate Electricity.
- First it is flashed at lower pressure, then expansion of turbine followed by condensation.
- Typically range: 12-15%.
- Initial cost is high.

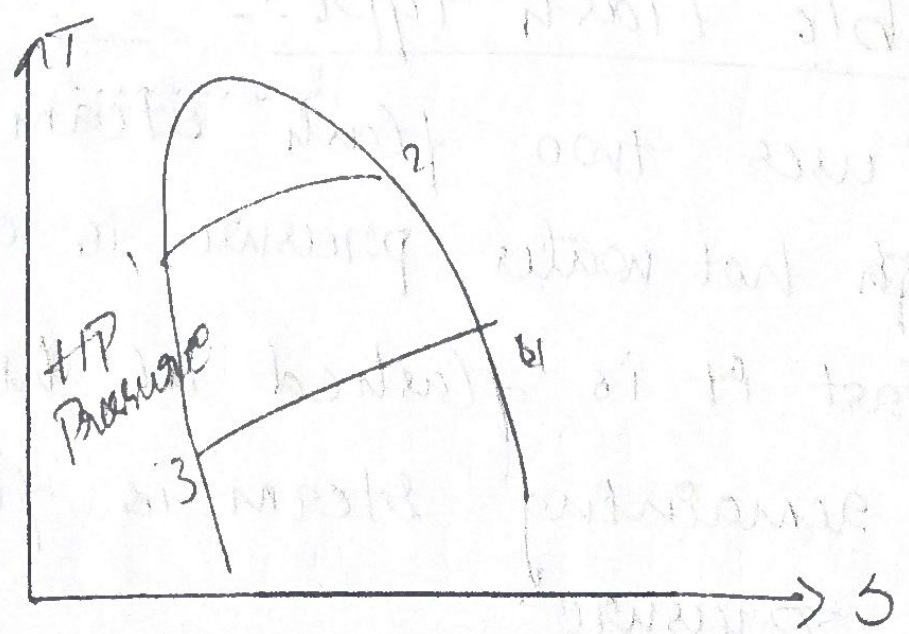
Double Flash type.

- It uses two flash steam.
- Hot water pressure is done twice.
- First it is flashed at high pressure, then the remaining steam is flashed at lower pressure.

- Generates more Energy at a time & at single source.



T-S diagram



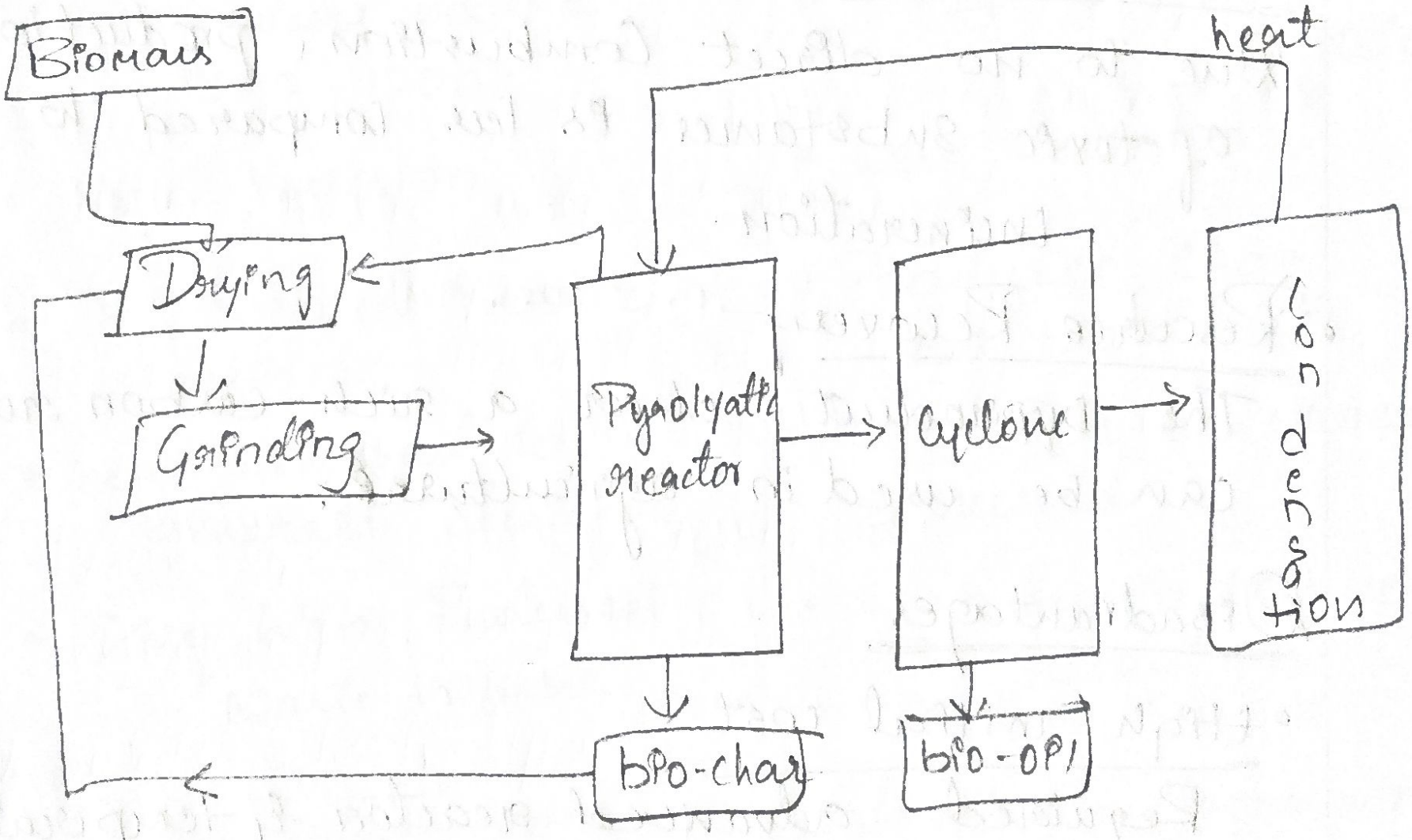
(4)

PYROLYSIS.

It is thermal decomposition of Organic material like biomass, in the absence of Oxygen (or) limited amount of Oxygen.

~~Description~~:

- The temperature typically range 300°-700°C.
- $(C_6H_{10}O_5)_n \xrightarrow{heat}$ Gases + bio-oil + Char.



It produces,

bio-oil (pyrolysis oil) → liquid fuel

Pyrolysis Gas (Syngas) → H_2, CO_2

Char → a solid carbon rich residue.

Advantages

- **Energy Efficient →**
  It produces char & bio-oil which is used as fuel.
- **Reduced Waste Volume.**
  It reduces waste generate to landfills.
- **Lower Emission**
  Due to no direct Combustion, production of toxic substances is less compared to incineration.
- **Resource Recovery**
  The byproduct char a rich-carbon residue can be used in agricultural.

Disadvantages

- **High initial cost.**
  Required advanced reactor & temperature System.
- **Complex gas cleanup.**
  'char' contains 'tar' component which is particularly creates need for filtering.

- Feedstock Sensitivity
  Not all waste materials are equally suitable.

Incineration process	Pyrolysis
• Requires Oxygen	• No Oxygen.
• Temperature range 800°-1200°C	• Temp. range : 300° to 700°C
• High Emission	• Less Emission.
• It produces heat & ash.	• Produces Char, bio oil, Gas
• heat is used to generate Electricity	• Oil & Gas are stored & reused.
• Very High Reduced waste volume	• High waste volume reduction.
• May cause Air pollution if not controlled.	• It is Environment friendly.

(1)

(5) Classification of Biogas Plant:

The biogas plant is broadly classified based on design & operational principles.

* Based on design:

- **Fixed dome type**
  - uses fixed structure, unmovable dome.
  - gas pressure varies with pressure.
- **Floating drum type.**
  - It is movable, floating metal drum.
  - pressure remains constant, volume varies.
- **Bag (or) Ballon Type.**
  - It is made up plastic or rubber.
  - Simple & efficient.
- **Vertical & Horizontal Type.**
  - Varies according to direction of digestor layout.

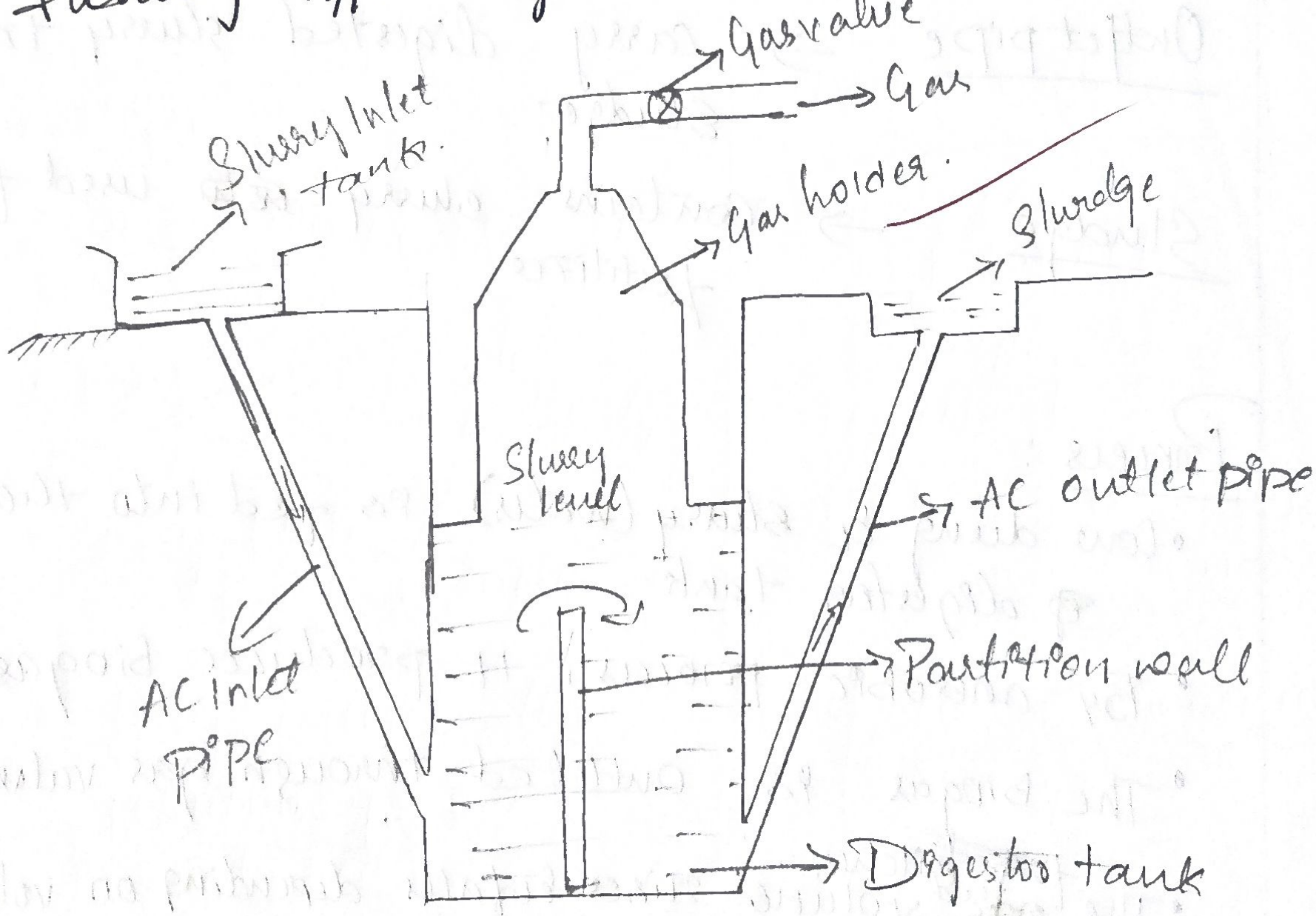
* Based on Input Feed.

- **Batch type**
  - loaded once & sealed for digestion cycle.
  - Suitable for intermittent.

- Continues type
  - Slurry is feeded regularly, generates Gas Continuously.

KVIC type Biogas Plant.

Khadi and Village Industrial Commission model is used to generate biogas using floating type biogas plant.



Slurry Inlet tank → collects Cowdung & water (slurry)

Inlet pipe → Carries slurry into digestor tank.

Digestor tank → It is horizontal structure digestor tank where anerobic process takes place.

Gas holder → steel drum contains gas & slurry.

Outlet pipe → carry digested slurry to sludge.

Sludge → Contains slurry used for fertilizer.

Process:

- Cow dung & slurry (water) is fed into the digestor tank.
- By anerobic process, it produces biogas.
- The biogas is outleted through gas valve.
- The gas pitcher.
- The volume rises & falls depending on volume
- The digested slurry is used as fertilizers for plants.

Advantages.

- Environment friendly
- Simple to implement & maintain.

Limitation

- High Initial cost.
- Steel drum which can cause corrosion or rusting.