

Coal preparation

| Simplest operation \rightarrow separation of fines from lumps
(for small plants)

for large plant \rightarrow multiplicity of operations :-

- 1) Size reduction
- 2) Size separation \rightarrow screens
 - \rightarrow revolving screen
 - \rightarrow vibrating "
 - \rightarrow shaking "

(in)
 large capacity
- 3) cleaning
- 4) drying
- 5) Mixing

Hand picking method \rightarrow to remove dirt and separation of bright and dull coal

\downarrow
Preferred for
domestic use and
coke preparation

\downarrow
Preferred for
furnace and
boilers.

Macro components of coal \rightarrow

Vitrain, clarain, durain and fusain

- | | | | |
|--|--|--|---|
| \downarrow
bright, glossy
part of coal | \downarrow
Semi
bright
part with
banded
structure | \downarrow
dull and
hard band
of coal | \downarrow
Patches of
fibrous material
of coal |
|--|--|--|---|

Q2

Coal cleaning :-

High ash coal need cleaning → to raise the efficiency of utilisation. Indian coals are high in ash content.

For coke prep. in India → 20% ash coal
in abroad → 10% ash max.

Washing of coal.

Advantages of cleaner coal :-

- 1) High efficiency of utilisation
- 2) Economy of transport and storage
- 3) less ash disposal problem
- 4) lesser content of sulfur, phosphorus and chlorine and other harmful elements.

for non-cooking coal, they improve their caking properties due to removal of ash and enrichment of vitrain.

Ease of separation of mineral matter → inherent & extraneous depends on its nature.

Extraneous mm:- Dirt bands and rock particles mixed with the coal during mining or dirt settling on coal during transportation, handing or storage

Inherent mm → Coming from vegetable sources of coal.

(3)

float and sink test:-

- 1) Total float-ash curve
→ Yield of clean coal (float) and its ash content
- 2) Total sink-ash curve → yield of heavy waste (coal + dirt) and its ash content
- 3) Washability characteristics curve → How far it is possible to separate the dirt from the clean coal by washing.

This curve may be of two types → for easily washable coal and difficult to wash coal.

Solvents used → mixtures of organic liquids
benzene (0.88), toluene (0.87),
 CCl_4 (1.6) and bromoform (2.9).

Solvent sp.gr. range → 1.2 to 1.6. by increase increment of 0.05.

Float & sink method is applied to any particle size of coal. → usually 1-2 inch screen size.

Air-dried coal not dry coal should be used
→ separation of clean coal and dirt depends on the difference in sp.gr. and this sp.gr. is in turn dependent on the moisture content of coal.

(4)

Float and sink test

Weighed portion of coal $\xrightarrow[\text{with solvent}]{\text{treated}}$ float on the top
of sp.gr. 1.2 sink at the bottom

filtered float separated air dry moisture and ash
sink separated air dry content determination
 ↓ treated with solvent " " "
 ↓ of sp.gr. 1.25
 float \rightarrow air dry \rightarrow moisture and ash content determination
 sink \rightarrow air dry \rightarrow " "
 ↓ treated with solvent
 ↓ of next higher sp.gr.

In all the cases, float and sinks are separated, weighed, air dried, weighed and their moisture and ash content are determined.

The ~~no~~ weight of floats collected, its moisture and ash content \rightarrow float-ash curve

The weight of sinks collected, moisture and ash content \rightarrow sink-ash curve.

- 1) sp. gr. of solvents used vs. ash contents of floats / sinks \rightarrow washability characteristics curve.
- 2) yield of float / sink vs. ash contents \rightarrow washability characteristics curve.

(3)

If bromoform is used → after filtration → wash with
(b.p. 151°C) methanol before air drying.

Usefulness of coal cleaning process for a particular coal depends on the efficiency with which it separates clean coal ~~and~~ ^{from} dirt.

In ideal case → the separation should be complete and there should not be any wrong migration of particles → i.e., heavier particles to the clean products and lighter products to tailings.

The recovery of the clean coal obtained

$$\% \text{ recovery} = \frac{\% \text{ ash in refuse} - \% \text{ ash in feed}}{\% \text{ ash in refuse} - \% \text{ ash in clean coal}}$$

Coal Carbonisation :-

- Depending on operating temp → 1) Low temp carbonisation (LTC) at around 600°C
- 2) Medium temp C. (MTC) → 800°C → does not have commercial application
- 3) High temp C (HTC) → $1000-1200^{\circ}\text{C}$

LTC → Semicoke, soft coke or char.

HTC → hard coke or coal gas. → smokeless domestic fuel.
Practised in a much bigger scale than LTC because of hard coke production.

(6)

LTC

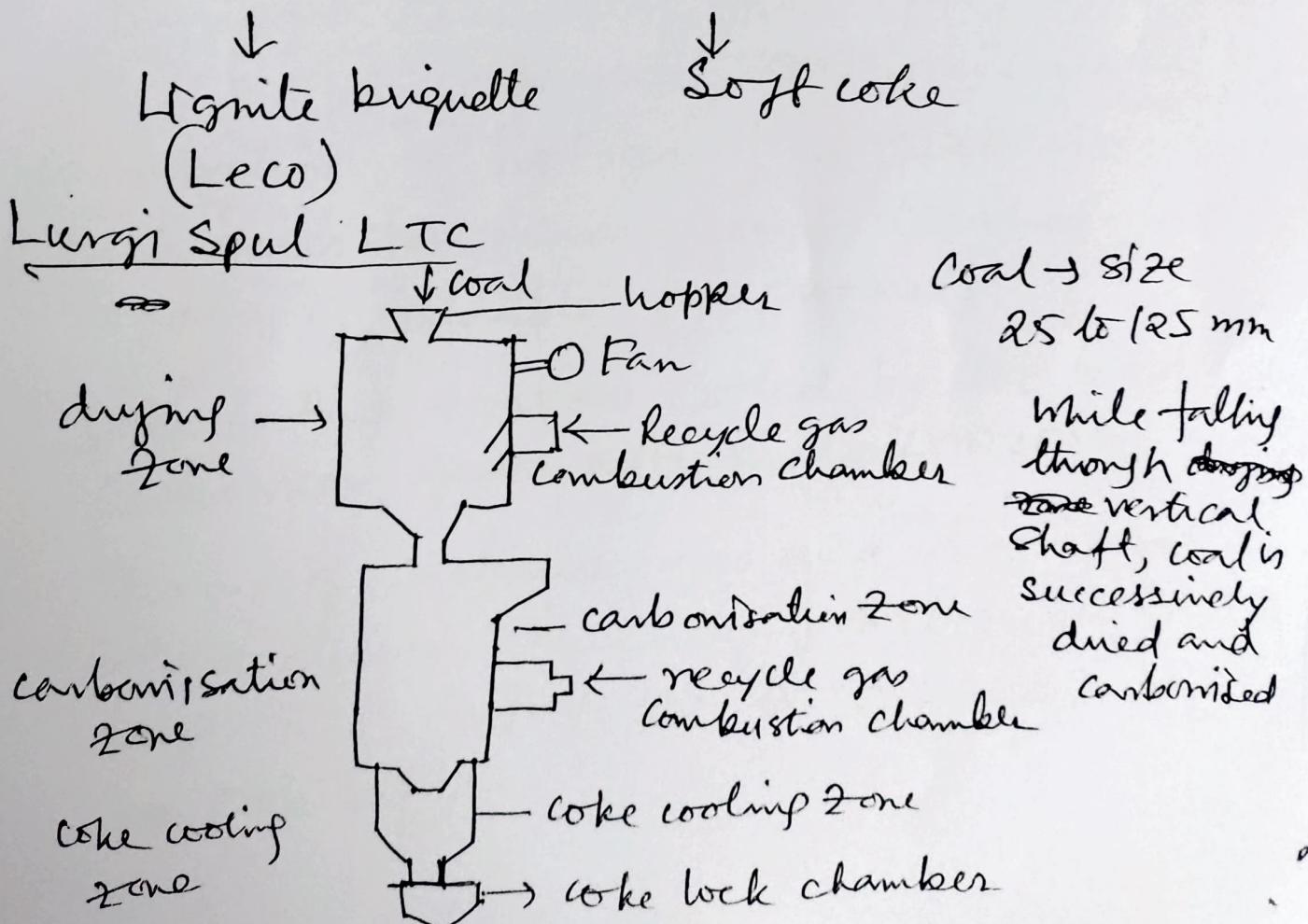
Overcarbonisation of coal is avoided by

- i) Direct heating of the charge by hot gases.
- ii) Movement of charge by vertical fall
- iii) Rotating the carboniser
- iv) Using fluidised bed.

Heat transfer rate is also improved by following these steps.

Two commercial LTC plant in India

- 1) Neyveli (TN) 2) Nasapur (AP)



in LTC plants in India: 1) Neyveli (Tamilnadu)
and Naspm (Andrapradesh)
Neyveli plant → lignite briquette, Loco
Naspm " → Soft coke
Both are based on Lurgi Spul LTC.

Plant consists of a vertical shaft

- 1) Drying zone, 2) Carbonization zone,
3) coke cooling zone.

Coal → fed through hopper → while falling
→ dried and then carbonized.

Drying → combustion gases from drying zone
burner, gas is circulated by ^{a large fan} carboniser burner
Carbonisation → hot gas from carboniser burner
Rich gases from carboniser → treated for
recovery of valuable by-products.

Coke cooling zone → cooled by the cold
carboniser gases after product recovery.

Mixing of carboniser gas and drying gas
is not allowed - ie entry of carboniser gas to
drier and drying gas to carboniser is
~~prohibited~~.

Products of LTC :-

(8)

- 1) Semicoke, 2) low temp tar, 3) liquor,
- 4) crude lowtemp spirit and 5) gas.

Quantity and quality of these products depends on the process and coal used.

Low rank coal is used → Excessive smoke format but the product Semicoke is a clean fuel.

Low temp tar → primary tar → as ~~no~~ almost no secondary cracking due to low temp.

→ complex mixture of higher phenols, substituted aromatic hydrocarbons, various nitrogen and oxygenated compounds of carbon and H etc.

Crude Spirit → crude benzol consisting of paraffins, naphthenes and olefins. Motor fuel may be produced by processing crude spirit

Liquor - Ammoniacal liquor

Gas : CO_2 , hydrocarbon gases, CO , H_2N_2
(50%) (33%)

High temp carbonisation (HTC) :

Practiced mostly in coke ovens and in less extent in gas retorts.

Products → coke and gas

- coke oven → 1) Beehive coke oven
2) byproduct slot type

By products are burned in ① to supply heat for carbonisation, whereas byproducts are recovered in ②

Coke from coke oven → used in metallurgical purpose

Coal gas → principal use as town gas.

Refuse coke → unsuitable for metallurgical use, but is reactive and is a good domestic fuel.

- Gas retorts →
1) Horizontal retort
2) Intermittent vertical retort
3) Continuous vertical retort

Beehive coke oven :-

firebrick chambers, look like beehive
coal is charged from the top hole of the arched roof into the oven, carbonisation starts and evolved gases burn off with air. Heat is supplied by the burning of volatile matter and hence no byproducts are recovered.
Heat transfer is by radiation from hot roof and by conduction from layer to layer

At the end of the carbonisation, coke is removed from the bottom of oven and quenched with water.

Merits and Demerits of beehive coke oven:-

Demerits:

- i) No recovery of by products
- ii) lower coke yield due to partial combustion
- iii) Production of quality coke only from good coking coal
- iv) lack of flexibility of operation.

Merits:

- i) Extremely good quality, strong and blocky coke of required reactivity is obtained if the starting coal is of good coking quality
- ii) low capital and running cost
- iii) coke production is not connected with the availability of a market for the by products

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(11)

coke : Hard, porous, carbonaceous material
 → source of reactive carbon in blast furnace, foundries & gasifiers, briquettes etc.

Three important properties of coke :-

Purity, strength and reactivity

↓ ↓ ↓
moisture, hardness No standard
ash, / brittleness tests, but porosity
sulphur measured by may give an indirect
phosphorous. Shatter and measuring reactivity
 Micum test

Extent of carbonisation → percentage of volatile matter.

Ash & P → concentrated in coke
S → remains unchanged.

Shatter test - for strength and hardness of coke. Coke sample is dropped from a height onto a metal plate and the hardness is reported as the percentage of oversizes on specified sieves.

In micum test :- Coke samples are rotated in a metal drum at a definite rate for a definite period and reported as % oversize and % undersizes of a screen.

M₈₀ or M₈₀ - Brittleness of coke test
determining the particle size distribution
of a 50 kg coke charge in a Micum trommel
rotating at 25 r.p.m over a ~~speed~~ period of
4 mins. The micum index M₈₀ denotes the
% of coke lumps greater in size of 80 mm.

Shatter test → Total 24 ft drop, ~~&~~ 4 drops
6 ft each.

1. From coke oven to coke bench/car
2. From coke car to the loading in wagon
3. From wagon to the hopper of blast furnace
4. From hopper to the charge level of the
blast furnace.

Screens used → 2 inch, $1\frac{1}{2}$ ", 1", $\frac{1}{2}$ "
oversize and undersize cokes are determined
which gives the measure of the brittleness of
coke.

Coal liquefaction:- All the processes which
converts solid fuel into liquid products →
can be used directly as lig fuels or can be
converted into various chemicals.

H-C type lig fuels are obtained:-

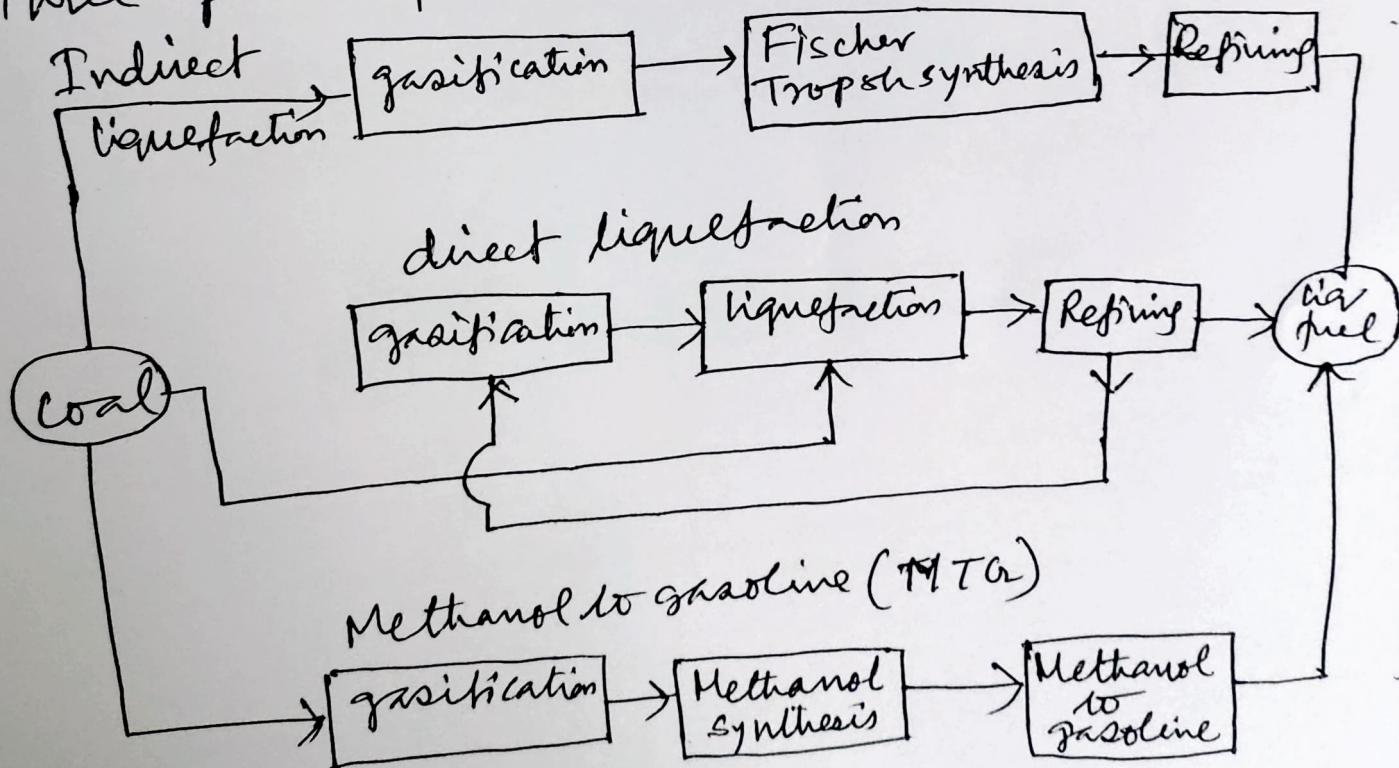
- i) Hydrogenation of coal, ex. Bargin-Pierpont
- ii) Solvent extraction of coal and hydrogenation
of coal extract.

Refining of tar and oil obtained by the carbonisation of various solid fuels and oil shales
 Gasification of solid fuels into synthesis gas and conversion of latter into liquid fuels and chemicals, for ex. Fischer-Tropsch process and methanol synthesis.

Coal to liquid fuel:

- a) Either by removal of carbon → carbonisation
 - b) or addition of hydrogen → liquefaction
- Supplement the natural ^{major objective} source of petroleum.

Three options for coal liquid plants:



coal liquefaction → either directly or indirectly

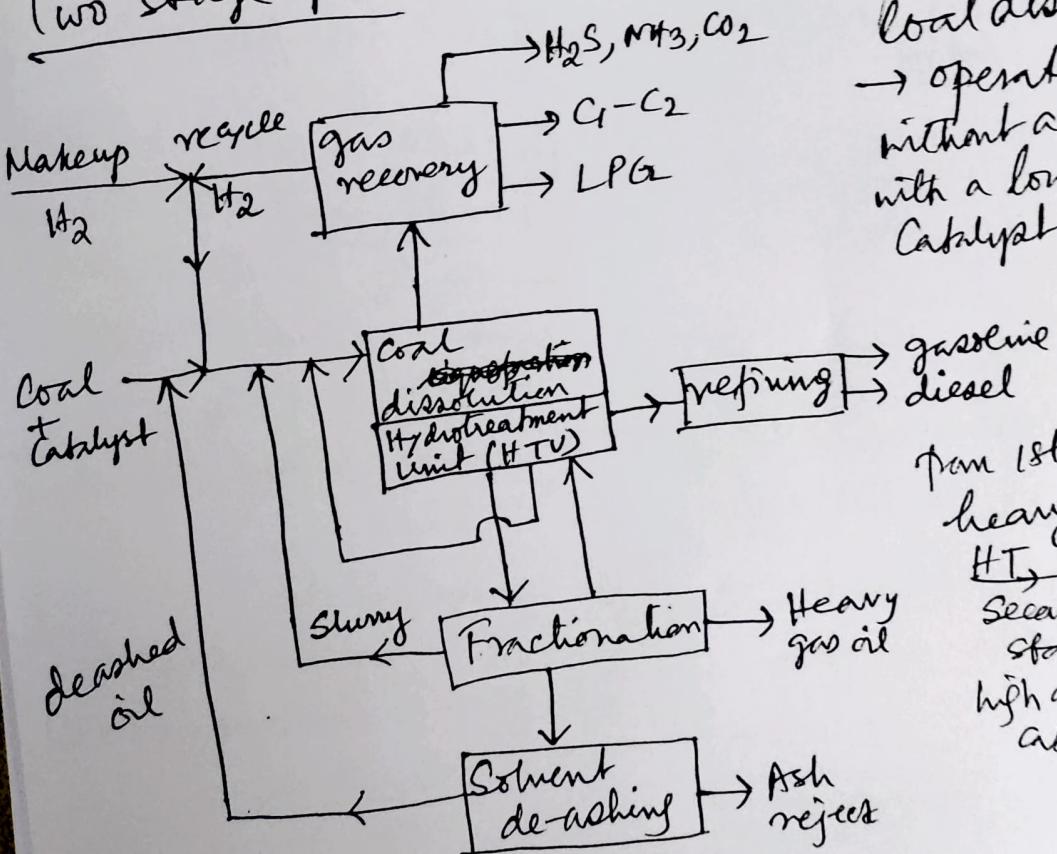
↓
by liquefaction
formation of a
Partially refined
synthetic oil

↓
needs to go through
gasification first

Efficiency of indirect liquefaction is more than the direct one.

Direct liquefaction → 1) Single stage → distillate product through a primary reaction train of reactors in series
2) Two stage produces distillates via two reactors/two trains of reactors in series.

Two stage process



1st stage
Coal dissolution
→ operated either
without a catalyst or
with a low activity
catalyst.

from 1st stage →
heavy coal liquid
HT → distillates
Second stage
high activity
catalyst

Germany, Japan, USA, UK



ANNEXURE - I

**Below details only for projects other than "NOT APPLICABLE"*

PROJECT WISE SUMMARY			
Fin Year	Project	Allocation	Concurrence
TOTAL		0.00	

Project & Cost Centre Wise Summary

Fin Year	Project	Cost Centre	Allocation	Concurrence
TOTAL			0.00	0.00

Indirect liquefaction -

Two steps — post step

1st step → complete breakdown of coal structure by gasification → gasification products $H_2 + CO \rightarrow$ syn gas
S-containing compds are removed.

Syn gas $\xrightarrow{\text{Catalyst}}$ reacted \rightarrow synthetic lig products

↓
Paraffin + olefins + alcohol
(mainly methanol)
 \rightarrow lig composition depends on the catalyst and reaction parameters used..

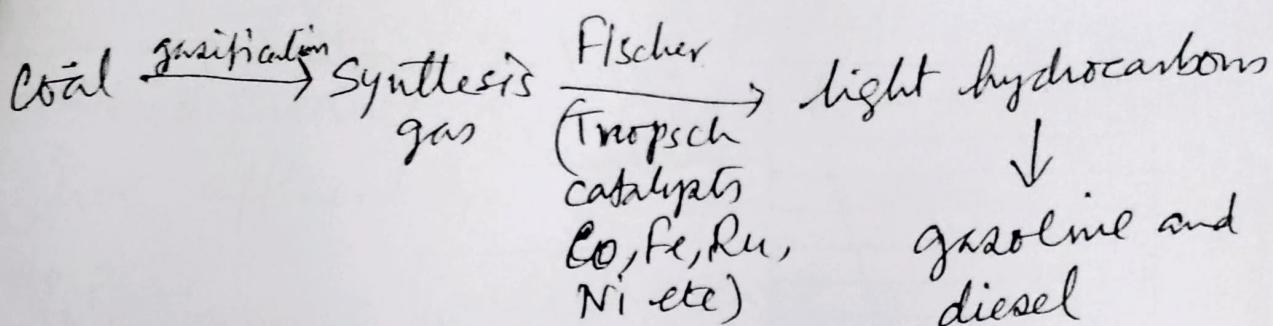
South Africa (Sasol process), USA (Mobil MTG process)
(Shell SMDS process)

Types of processes → 1) Bergius process
2) Fischer-Tropsch process
3) Low temp carbonisation (LTC)

(15)

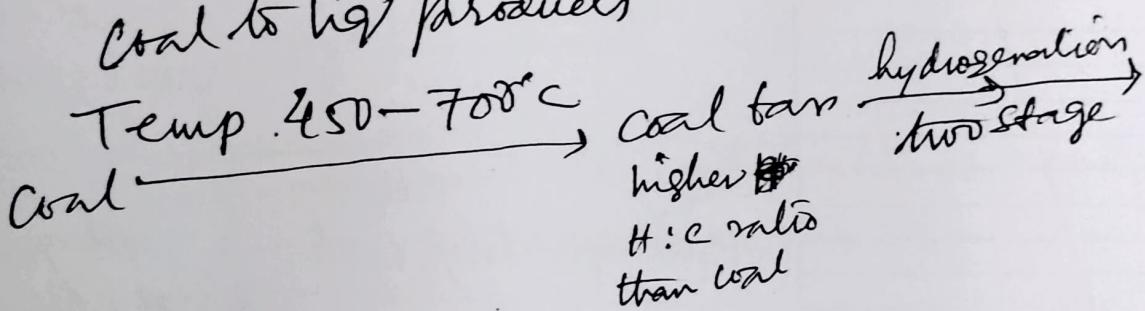
Fischer Tropsch process :-

↓ Indirect route

Syn gas \rightarrow Methanol \rightarrow used as fuel additive

low temperature carbonisation:-

Coal to liq/ products



1st stage hydrogenation \rightarrow 250 atm $\xrightarrow[460-470^\circ\text{C}]{\substack{\text{H}_2 \\ \text{ion &} \\ \text{Molybdenum}}} \text{catalyst}$
 (liq phase)

2nd stage hydrogenation \rightarrow fixed bed reactor $\xrightarrow[400^\circ\text{C}]{\substack{300 \text{ atm H}_2 \\ \text{Molybdenum} \\ \text{and tungsten} \\ \text{catalyst}}}$
 (Vapour phase)

Ultimate product is gasoline range liq product.
 But diesel range liq can also be obtained by changing reaction condition.

Coal $\xrightarrow[\substack{\text{Mild hydrogenation} \\ \text{at 50 ATM}}]{\substack{\text{LTC}}} \text{synthetic crude oil} \xrightarrow{\text{distillation}} \rightarrow \text{Petroleum-like oils.}$

~~Coker~~ Gasoline from methanol (MTG) p.
Mobil process

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graph TD
    Coal[Coal] --> SynthesisGas[Synthesis gas]
    SynthesisGas --> Methanol[Methanol]
    SynthesisGas --> Gasoline[gasoline & byproducts]
    Gasoline --> H2[H2]
    H2 --> Catalysis[Catalyst  
400°C  
20 atm]
    Catalysis --> Zcolite[Zcolite  
catalyst  
400°C, 20 atm  
atm H2]
    Zcolite --> Methanol
  
```

The diagram illustrates the conversion of coal into synthesis gas, which can then be used to produce either methanol or gasoline and other byproducts. The synthesis gas can also be converted into hydrogen (H₂) and then catalyzed at 400°C and 20 atm using Zcolite catalyst to produce methanol.

Coke: ^{coking}
good quality coal → good quality coke
Coal to coke transformation

coke oven → heat is transferred from heated wall to coal charge

↓ 375°-475°C

decomposition to form plastic layers near the wall

\downarrow 475-600°C

Marked evolution of tar, aromatic HC compounds, then resolidification of the plastic mass into semi-coke.

\downarrow 600 - 1100°C

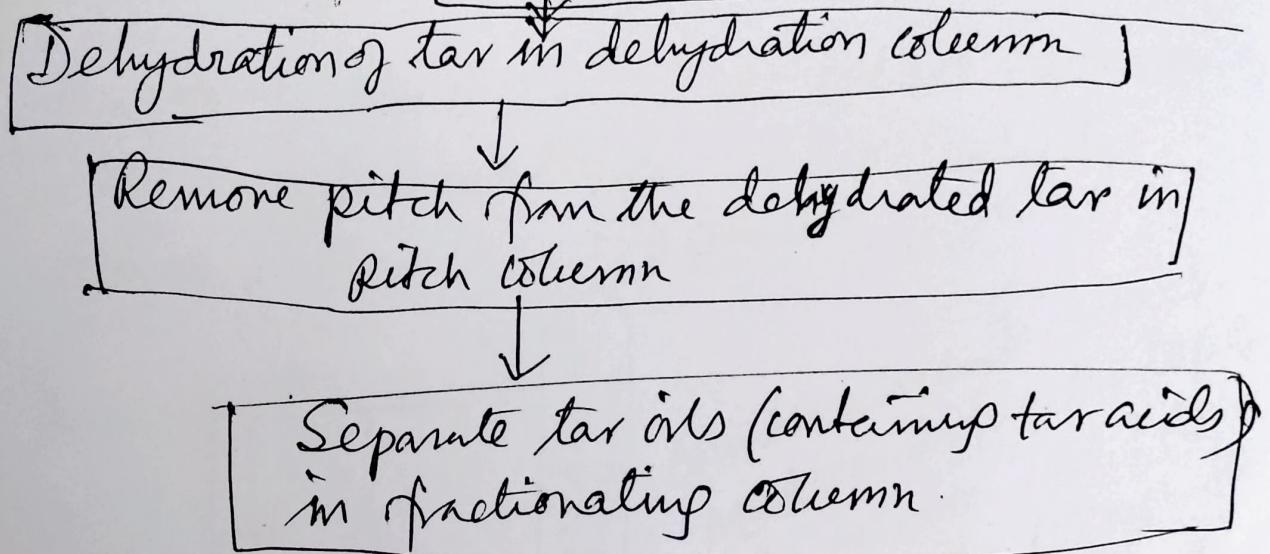
$\downarrow 600 \rightarrow 1100$
Coke stabilisation \rightarrow contraction of coke, structural development and final H_2 evolution

in distillation plant (TDP)

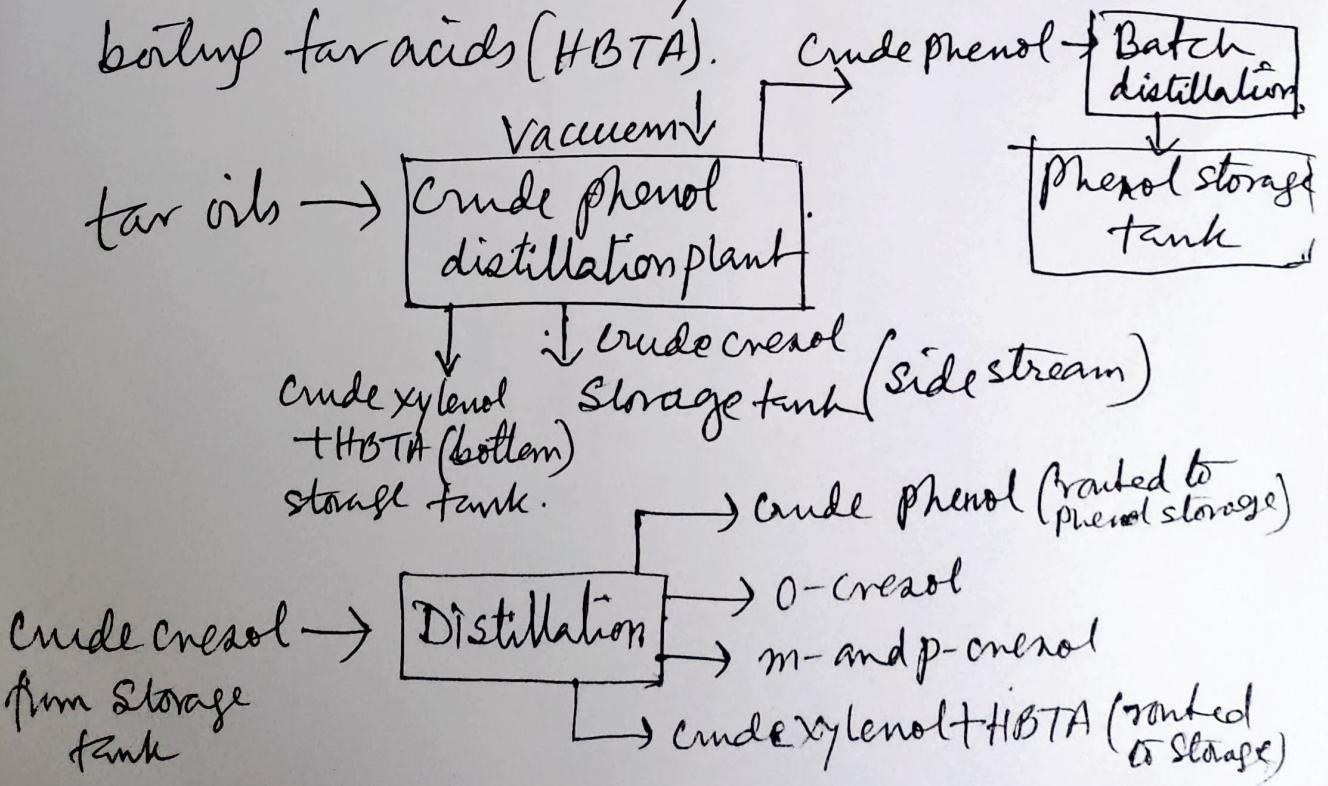
Primary objective :- to produce a number of tar acids products from crude tar & ammoniacal liquor effluent from the coal carbonisation plant.

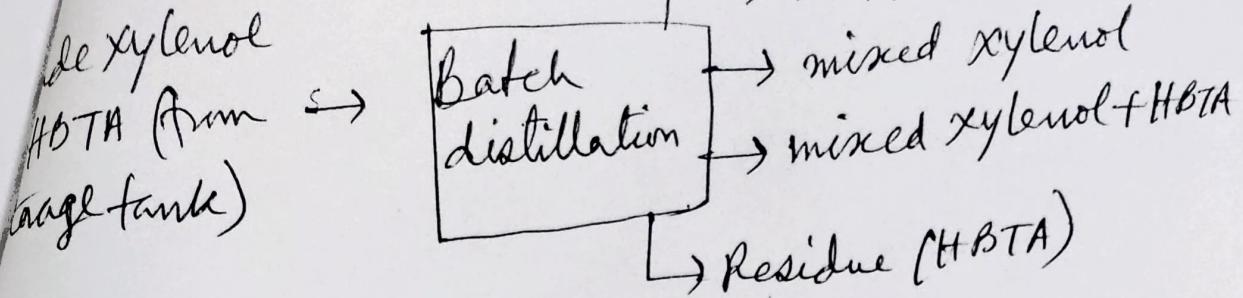
TDP:-

Crude tar storage at elevated temp



tar oil contains tar acids → crude phenol, crude creosols, crude xylenols and ~~tar acids~~ high boiling tar acids (HBTA).





Aqueous liquid liquor extraction Section:-

Purpose of this section: - to extract the faranids in the ammoniacal liquor using isobutyl alcohol (IBA)

