

# **LEARNING MATERIALS**

**SEMESTER-6<sup>TH</sup> SEM.**

**BRANCH-MINING ENGG.**

**SUBJECT-MINERAL DRESSING (TH-4)**

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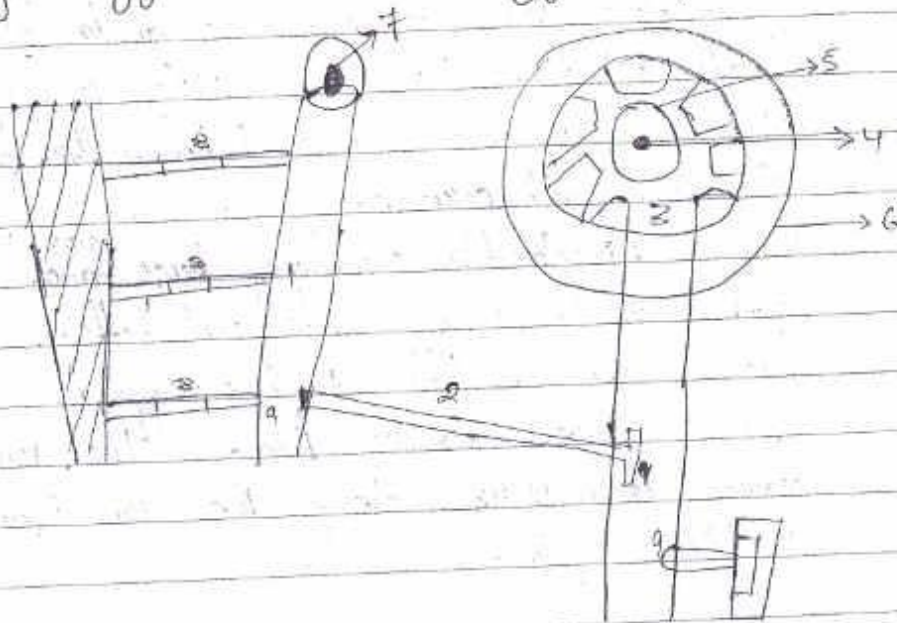
**( CHHENDIPADA , ANGUL )**

# « Mineral Dressing »

1) Describe the working of Blake jaw crusher with neat sketch?

Ans → It is the most popular and widely used primary crusher. It has a moving jaw pivoted at the top. Through the working principles of blakes and Dodge crushers are different. Constructionally both look alike excepting few notable differences between them.

The Blake crusher may be classified as single toggle or double toggle type.



- |               |                      |
|---------------|----------------------|
| 1) Jaw plates | 7) Top hinge (Pivot) |
| 2) Toggle     | 8) Check plate       |
| 3) Pitman     | 9) Bearing           |
| 4) Main shaft |                      |
| 5) Eccentric  |                      |
| 6) Fly wheel  |                      |



## «Constructional Features»

→ As the name suggest a jaw crusher has two jaws set to form a V-shaped - the top through which feed is admitted into the jaws space. One of the jaws is fixed to the main frame of the machine almost vertically while the other is movable. The swinging jaw is driven by an eccentric that reciprocates in a horizontal plane, making an angle of  $50-30$  degrees with the stationary jaw. Then the angle between the two jaw is known as angle of bite or angle of nip. The jaws apply a huge compressive force on the ore caught between them and ultimately the ore get crushed.

Replaceable crushing ~~bits~~ <sup>bars</sup> and ~~bits~~ <sup>bars</sup> fixed into the jaws by bolts and nuts. The crushing jaws are of hot field manganese steels for enhanced service life. The jaw width vary from 2-48 inches. The jaw speed is between 100-400 cycles per minute.

## Working of Blake crusher :

→ Initially a large lump ore cut and broken at the top. The broken parts fall down to the narrow bottom space and are crushed again when the jaws close for the next cycle. This action continues until the feeds come out.

In this machine, an eccentric drives the pitman. The connector to it and down motion



is converted to and fro motion with the help of toggles. One of the toggles is fixed to the main frame and pitman with the other one is fixed to the moving jaw and pitman.

As the swinging jaw pivoted at the top the amplitude movement is less at the bottom.

The maximum distance the moving jaw travels is called throw of the crusher. The throw is between 7-7 cm. The distance between the jaw plates at the feed opening end is known as gap.

The distance between the jaw is the discharge size is known as set (s). An important part of jaw crusher is the fly wheel mounted on the main shaft. The use of fly wheel is important because as crushing takes place a heavy work load on the machine. To reduce the load and balance the machine the fly wheel is filled.

Differentiate between jaw crusher and gyratory crusher.

Jaw Crusher	Gyratory Crusher
i) The load on the machine members is <u>intermittent</u> .	→ The load on the machine members is <u>uniform</u> .
ii) crushing action is <u>intermittent</u> .	→ crushing action is <u>continuous</u> .
iii) It has a <u>lower cost</u> of installation.	→ It has a <u>higher cost</u> of installation.



- iv) It is suitable for lower rate of production → It is suitable for higher rate of production.
- v) The wear on the jaw plates is not uniform. → The wear on crushing head is quite uniform.
- vi) Power consumption is highest for jaw. → For same production rate and capacity.

crusher for a particular the gyratory capacity, production rate and crusher requires less power.

- vii) Irregular power draft      Regular power draft.

3) Describe the operation of ball mill. Operation of ball mill.

Ball mill may be continuous or batch type, in which grinding media and the ore or be ground are rotated around the axis of ball mill. Due to the friction between the liners-ball or liners-ore lump both the ore lumps and ball are carried up along the inner wall of the shell nearing the top from where the media fall down on the ore particles. This is usually happens at the toe zone of the ball mill.

The energy used in the lifting of the grinding media is thus utilized in reducing the size of the ore lumps. The entire grinding



process is carried out by three stages:

- i). Cascading
- ii). Catacting
- iii). centrifuging.

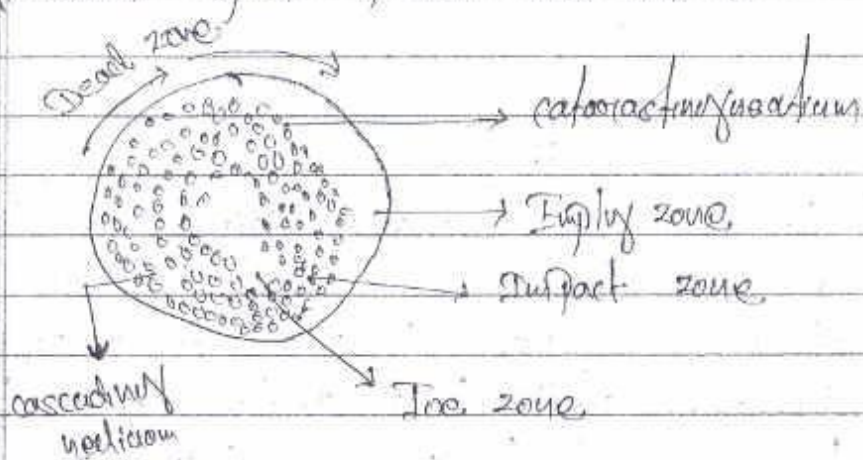
→ The effective grinding depends on the rotational speed of the ball mill. If the ball mill operates at a low speed balls will be carried up along the inner wall to a certain height but not large enough to provide sufficient large impact force. In this case the grinding is takes place by the balls in the way of slip. So this type of operational condition is known as cascading.

→ After cascading if the speed of the ball mill is increased. The ball starts moving up further along the inner wall and suddenly fall from a greater height and impacts sufficiently large impact force at the top of the mill. The impact is largely responsible for most of the grinding in the ball mill. This condition is known as catacting.

iii) → If the rotation becomes too high the balls are carried over and over again along the inner lining. This operational condition, hardly causes any grinding. The condition is known as centrifuging of the ball mill. As no grinding is occurs when the mill rotate the speed at which the mill starts centrifuging is termed is called.



critical speed of the ball mill.



→ Tyler series and ASTM standard screens  
 Tyler mathematical series is most widely used to designate the aperture size of the screen while manufacturing ASTM standard screens. The screens are made from brass or stainless steel wire, woven into a screen cloth having square opening size of the screen wires with a factor  $\sqrt{2}$ . The lowest screen opening available under this series is 37  $\mu\text{m}$ . In the ASTM standardization, mesh or ranges from 3 to 400.

Mesh No.	Aperture (In $\mu\text{m}$ )
3	6.680
4	6.699
6	3.362
8	2.362
10	1.651
14	1.168
20	0.833



28	0.529
35	0.417
48	0.295
65	0.208
100	0.147
150	0.104
200	0.0874
270	0.052
400	0.037

7. Open circuit and close circuit grinding and what is dry wet grinding.

Open circuit grinding

In open circuit grinding, the mill receives feed and grinds to the desired product size in one pass.

Open circuit grinding is employed in the following cases :-

- i) For coarse grinding.
- ii) To grind the wet cement-gravel mix.
- iii) When heavy overloads and extreme.

It can be followed

Run of mine (ROM)

↓

Jaw crusher  
↓  
crushing Rolls



Ball mill



Fine Product.

closed circuit grinding

→ In closed circuit grinding the mill discharge is fed to a sizing device to separate out the oversize material which is recycled to the grinding mill. closed circuit grinding requires less skilled operators to give a constant product size analysis.

closed circuit grinding is used in most mineral processing industries.

Run of Mine



Jaw crusher



Screening



Crushing rolls



Screening

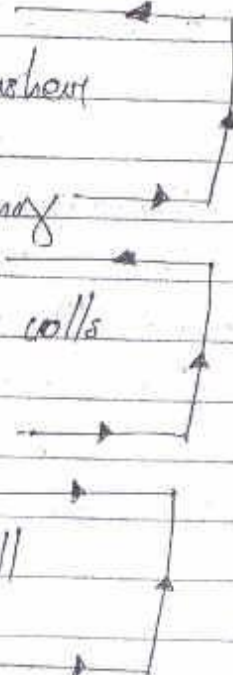


Ball mill



Screening

Final Product.





### Dry and wet grinding

→ The materials should be ground when either wet enough to form a slurry (wet grinding) or partially dry (dry grinding). Since the grinding in the most and sticky state is difficult and requires extremely high energies.

→ Dry grinding is preferred where the subsequent concentration process is done in the wet where water is scarce. Dry grinding is employed in cement industry due to the nature of the material. Dry grinding requires the consideration following point.

- (i) Feed material should be low in moisture content.
- (ii) It requires closed circuit system.
- (iii) costly filtering and drying equipments are not required.
- (iv) A single stage system is required.
- (v) Power consumption is lowered by 10-30% over wet grinding position of product.

→ Wet grinding is used in mineral processing industry since most subsequent processes such as flotation, magnetic separation, leaching etc. are done wet.

Wet grinding requires the consideration of following points:



- It requires less power per tonne of material than doing manually.
- It requires less space than doing manually.
- It does not require a lot of complex equipment.
- It requires large quantity of water.
- Partly maintenance is high.

### 6/ Mechanism of screening

When the crushed product is fed to the screen, a portion of the product passes through and the rest is returned on the screen. The fraction of the material passing through the screen is known as underflow while the portion of known as over flow. So the basic part attached to screening is the passage of uncrushed material through the screen. The factors which affects screening are listed below.

- The relative size of the particle to that of screen aperture.
- The absolute size of the screen aperture or aperture.
- The percentage of open area available for screening with respect to the total surface area of the screen.
- The angle at which the particles strikes the screen surface.



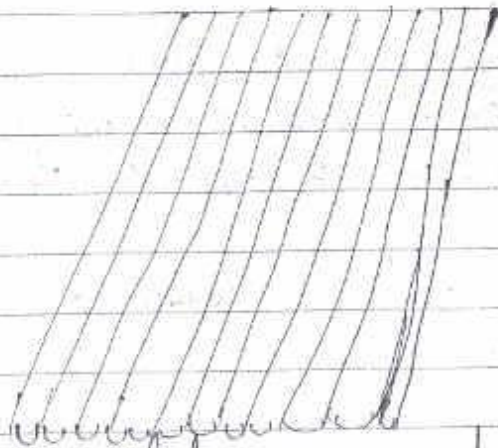
v) The speed with which the particles strikes the screening surface.

7/ classification of screens

- 1) stationary.
- 2) moving.

stationary screens

→ These screens are of limited use but are not too faulty absolute. These screens are grizzlies. They consist of parallel rods bars or woven wire mesh set at an angle to the ground. The bars are held together at right angles to their length. Spaced at the desired distance using sleeves and bolts. A slope is generally provided so that the materials feed on to the surface would roll down automatically due to force of gravity. The disadvantage of this type of screen is clogging.



stationary screen



Q/ Moving screens are -

- i) Moving grizzlies
- ii) Travelling or Revolving screens.
- iii) Shaking screens.
- iv) Vibrating screens.

Moving Grizzlies :-

→ This grizzlies is made up of rods and is stationary grizzly. In moving grizzlies alternate bars or rods rise and subside alternatively. The feed material move forward gently with sufficient tumbling over there are different grizzlies such as :-

- i) Moving bar grizzly
- ii) chain grizzly
- iii) Travelling grizzly
- iv) Disc or Roller type grizzly
- v) vibrating grizzly
- vi) Shaking grizzly

Advantage of Grizzlies :-

- i) Lower floor space is required for installation.
- ii) They act as feeders to intermediate crushers.
- iii) They results in better screening than stationary screens.



### Rotamels or Revolving Screens :-

- Revolving screens or rotamels are used more widely than any other moving screen. However, they are being replaced by vibrating screens.
- It consists of stationary cylindrical, conical, conical or pyramidal shells made up of punched plates or thick woven wires. When the rotamel has only one shell it is known as single rotamel. Commonly the rotamel has a diameter of 3-4 feet and a length 5-10 feet. It is driven by a central shaft attached to it by 4 or 6 curved supports.

### Advantage

- Require smaller floor space.
- Larger capacity per unit screening area.
- cheap to operate both on dry and wet feed.
- several fractions are obtained in one go.
- screening operation is quite efficient.

### Shaking Screens :-

It is essentially a shallow rectangular box whose length is at least 24 times the width. It is open at one end and is fitted with a screen bottom. It is shaken by means of a suitable mechanism. Speed, stroke and length of the stroke should be adjusted to produce rapid stratification of the feed with a forward motion so that minimum blocking of screen surface to take place. It is widely used for screening coal. It looks very similar to the



vibrating screen.

(vibrating screens)

→ Vibrating screens are essentially developed and have standard work of the other screening machines absolute. It is essentially a flat screen surface, which made from punched plates or woven wire, secured rigidly on a steel frame. The frame is attached to certain mechanical device, to impart a reciprocating and down motion in a direction either normal or at a high angle to the screen surface. These screens can be driven electrically or mechanically, the underflow and overflow continuously get discharged at the other end of the screen.

8). Factors which affecting classification

→ Specific Gravity:-

Particle having the highest specific gravity will settle faster than other particles of same size and lower specific gravities.

→ Size:-

Among the particles of same specific gravity, the largest particle will settle fastest.

→ Specific gravity of the fluid:-

For fluids of different specific gravities the particle will settle fastest in the lightest fluid.

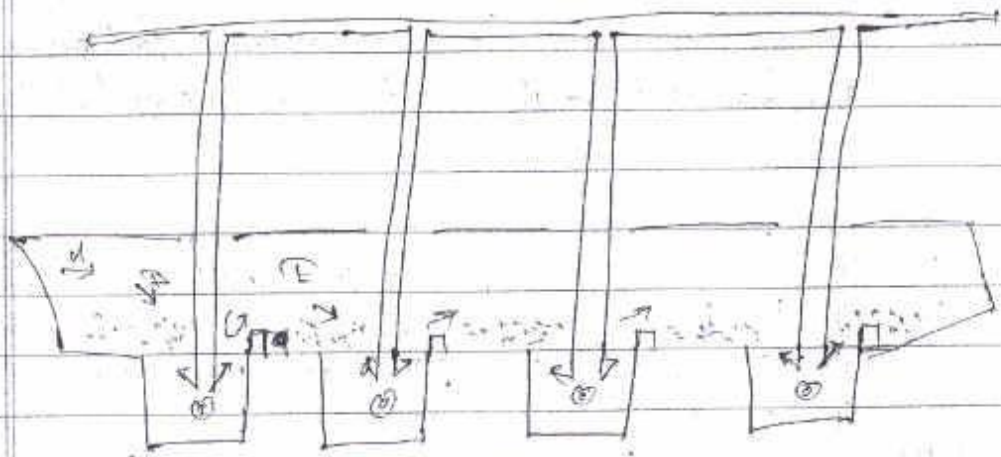


→ Air bubble :-

Advance of air bubbles to the solid particles would lower the settling speed.

9). Evans classifier :-

→ A schematic Evans classifier is shown in figure below. It is a sloping launder of capacity to this launder several rectangular boxes. BC are attached. To these rectangular sprouts. C are fitted which discharge out the sorted particles. Pipes are suspended from a main pipeline into the rectangular boxes. Water is introduced into the boxes through the suspended pipe and its flow is controlled by valve P.



“Evans classifier”

The working of the classifier is simple. As water is introduced the finest particles settle into the boxes standing with the finest one from left and the coarsest settling over flow of  $T_1$  to the next box in the

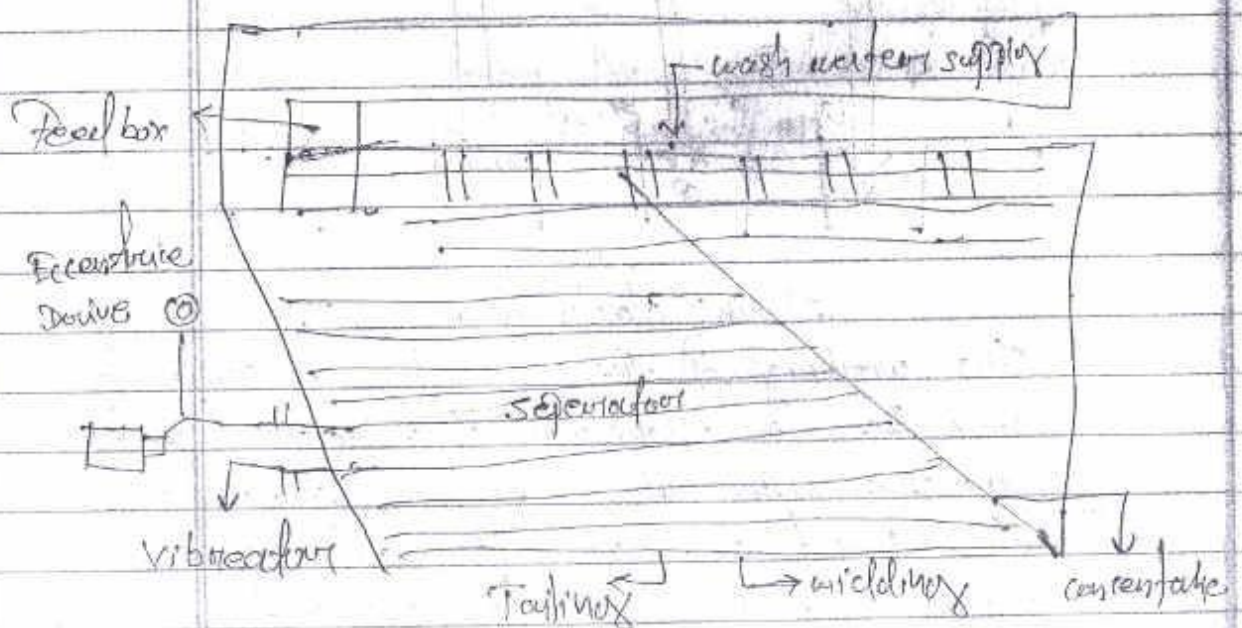


launder. The settled particles are discharged out through the spigots fitted to the boxes.

Baffles are fitted to the launder to restrict the overflow of particles to the same box from the overflow. Depending on the number of rectangular boxes attached to the launder several products are obtained as the flow rate in each successive pipe is reduced as the size of particles settling get reduced successively.

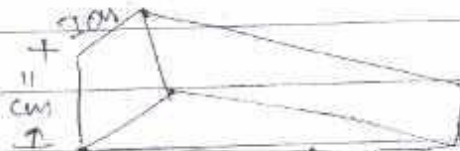
#### 10) Construction of Wilfley table

The table is made up of wood or similar such materials. The table surface is deated. specific discussion on deats or ruffles is required as they wear out frequently and require changing the working of the Wilfley table





The cleats are usually made from wood with a maximum height and width of one centimeter each. The cleat highest tapers down from left to right.



→ They are placed longitudinally parallel to each other so as to form channels of less width and depth at the extreme left side and which tapers down to zero depth at the right side opposite end. All the cleat ends along the imaginary diagonal line on the waffle table which divides has total surface area of the table in a ratio of 2:1 approximately.

→ This means 2/3<sup>rd</sup> of the total surface area of the table is cleared (washed) and over 1/3<sup>rd</sup> position is unworked. The inclination provided increases the area handling capacity of the table. The inclination is limited to maximum of 3° as further increase will hamper the efficiency of classification. For majority over a slope of 0.75 - 1.25 is used.

### Important uses of waffle table,

- i) To concentrate cassiterite on tin ore.
- ii) To concentrate free milled gold ores.
- iii) To beneficiate of nonmetals like glass and sand.
- iv) To beneficiate chromite and tungsten ores.



- v) To recover a part of galena and sphalerite in coarse aggregate of lead-zinc ores.
- vi) To clean zinc coal.
- vii) To beneficiate particular types of iron ores
- viii) Adopted as a pilot plant to guide flotation plants.

ii) What is jigging describe the principle of jigging.

Jigging :- Jigging is one of the most ancient method for concentrate ores. It is a special form of hindered settling which promotes stratification of particles into layers of different specific gravities followed by removal of stratified layers.

Principles of Jigging

There are three physical factors responsible for stratification of particles during jigging are:-

- i) Hindered settling classification.
- ii) Differential acceleration of the beginning of the fall
- iii) consolidation touchiness of the end of fall

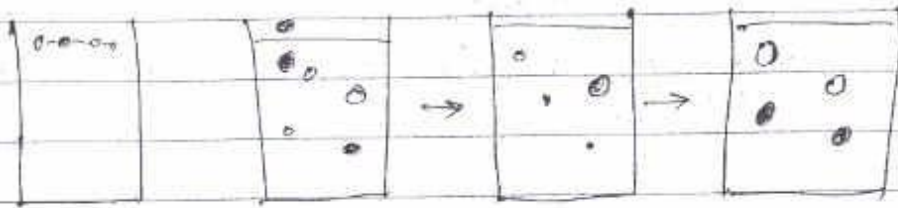
i) Hindered settling classification :-

→ The essential difference in hindered settling in jig and classifiers that in jigging the



Fluid mixture is very thick and if approximates with industrial fluid.

→ The thick solid-fluid suspension under in jars and be maintain for a long length of time and also does not allow sufficient play between the particles for their complete rearrangement.



### \* Differential acceleration.

→ In this particles are allowed to move and get rearranged only when they are a acceleration.

→ The heavy particles have a greater into a acceleration and speed than the lighter particles.

### iii) consolidation trickling.

→ In this principle, with little vibration to the stratified bed. the finer particles now down through the interstitial space avail. in the bed of coarse particles under influence of gravity. This phenomenon is known as consolidation trickling.

→ During pulsion stage, when the bed is open is essentially controlled by frictional setting and initial differential acceleration.



→ During the suction stage, when the heel is high to the stratification is controlled by consolidation during.

## 12/ Flotation Reagents:-

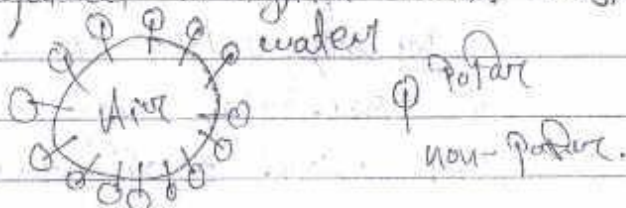
→ Froth Flotation being a physico-chemical process requires a no of chemical reagents for its success. Basically the flotation reagents can be classified under following categories:-

- i). Frothers
- ii). collectors
- iii). modifiers.

### Frother :-

→ Frothers are heterogeneous surface active organic molecules capable of being on the air-water interface. The adsorption of frother at the bubble-water interface reduces the surface tension and stabilizes the air bubble.

→ In the froth bubble the polar group is oriented towards the water phase providing the necessary water repellency to the bubble as required a typical froth bubble is shown below





### ii) Collectors,

The collector is the most important reagent in flotation. Each molecule of the collector contains a polar and a non-polar group. It gets adsorbed on the mineral surface and forms a continuous heteropolar surface film all around the particle.

→ The heteropolar film is so formed that the polar part is attached to the mineral surface and non-polar group is projected outwards by providing hydrophobicity to the mineral surface.

These of two types:-

- i) Anionic collectors.
- ii) Cationic collectors.

### iii) Modifiers,

→ Sometimes it may be necessary to use a modifier before the collector can be a modifier before the collector can be made to function effectively.

It is possible to accomplish the following by the use of a modifier.

- Utilize collectors under optimum conditions.
- prevent or control mutual mineral interaction.
- prevent or control action of atmospheric air and the aquatic impurities on the mineral surfaces.



→ modifying favourably or adversely the ability of some mineral to quince. Placability.

According to their function the modifying agents may be classified to the following categories.

- i) PH regulators
- ii) Activators
- iii) Depressants or Des pressants.
- iv) Dispersants.

13/ Heavy media separation process

→ If a fluid is available with specific gravity inter mediate between two solids which are to be separated from each other then the simplest process will be to suspend the mixed mass in the fluid under consideration.

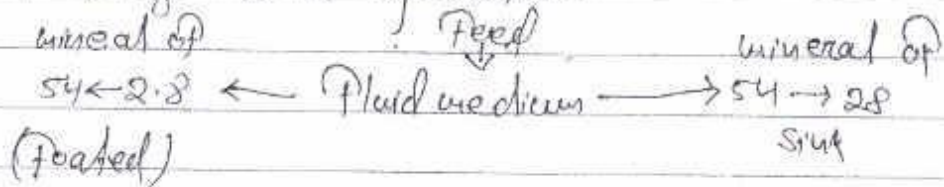
principle of heavy media separation

→ The basic principle is involved in the gravity concentration process is the float and sink. This is carried out by using a fluid whose specific gravity lies two mineral particles in the ore.

→ As the most of the mineral heavier than the water it is used a suitable medium to carry out heavy media separation.



→ For the process to be effective, fluids heavier than water are required. In the following figure, the basic principle of scheme involved in heavy media separation.



### Heavy media separation circuit

→ A simple heavy media separation circuit essentially consists of the following:

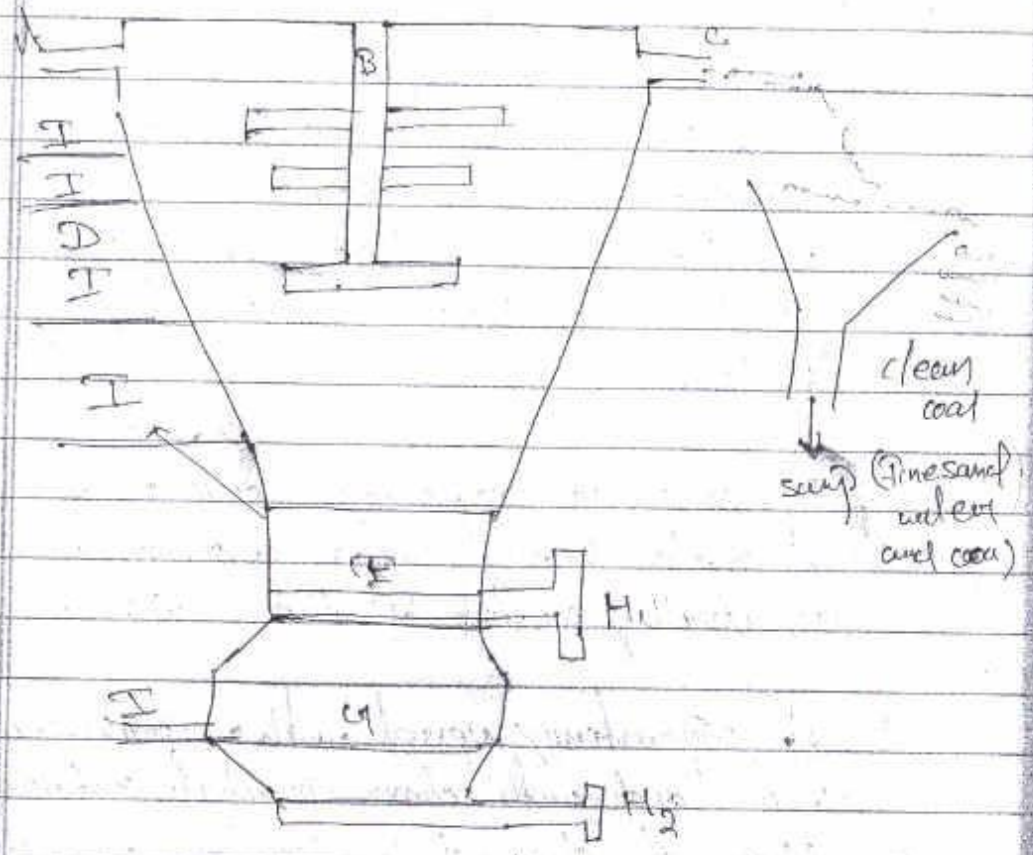
- i). A separating vessel with a provision to adjust feed and with draw product continuously.
- ii). Means to clean the separate product remove the media and circulate the same to the vessel for further utilization.

### Chance Process

→ Chance process is in the use for last 150 yrs. for cleaning coal:

→ where the particles fluid is suspension of 200 quartz or sand particles in water in the size range of 40 to 180.





- where, A = Feed chute (Raw coal)
- B = mechanical stirrer
- C = Discharge (clean coal)
- D = water line
- E = separating cone
- F = classifying column
- G = Refuse chamber

H<sub>1</sub> and H<sub>2</sub> - Air parallel discharge

I = Denoising screen  
 → It consist of a spirally fast on a cone separator in which the sand suspension moves up gently.



- An agitator is used to stir the suspension to prevent its packing.
- The overflow of clean coal and sand passes over to the cleaning screens which desand and elevate the coal.
- spray water is used for elevating the specific gravity of fluid is adjusted varying the proportion of sand in the suspension.
- Anthracite coal requires heavier fluid compared to bituminous coal.

### \* Liberation,

#### classification :

- classification is a process by which particles of various size, shapes and specific gravities are separated into different groups by allowing them to settle in a fluid medium. The coarse heavier grains settle faster than the finest and light grains - usually, air or water or suspension may be regarded primarily as a mineral beneficiation process based on Newton's laws of sedimentation or settling.