MINERAL PROCESSING LABORATORY MANUAL

Mineral Processing Laboratory Coordinator

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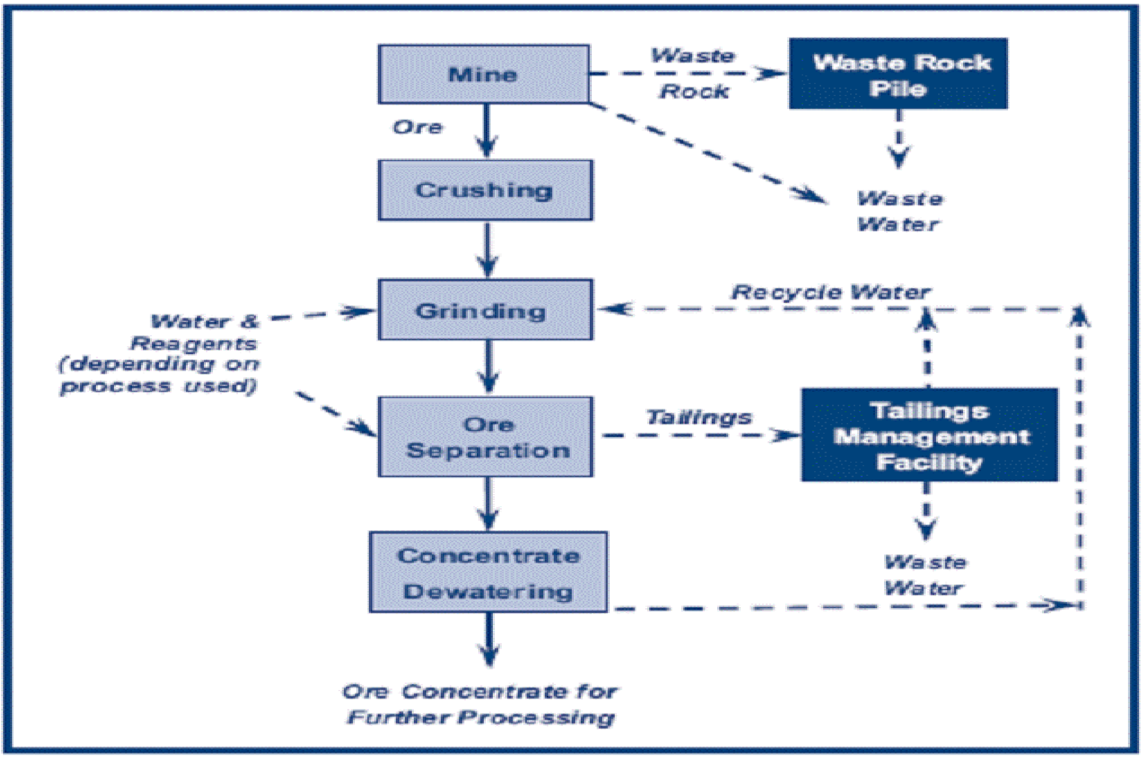

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EXPERIMENT-1

AIM OF THE EXPERIMENT:

To determine, and analyze the size distribution of a fixed granular solid by using a Test Sieve Stack.

MATERIALS / APPARATUS REQUIRED:

1. Sand / rock granular solid particles
2. Different sieves of ASTM size.
3. Stopwatch
4. Weight balance

THEORY:

Sieve analysis is a technique, which is used for particles distribution on the basis of their size and shape. There are two types of sieves used in general

- US STANDARD
- BSS / TAYLOR (ASTM) STANDARD

➢ **Mesh Number:**

It is defined as the number of square openings present per linear inch.

$$\text{Mesh number} \ \alpha \ (1/\text{size of screen}) \ \alpha \ \text{Thickness of wire} \ \alpha \ \text{Fineness}$$

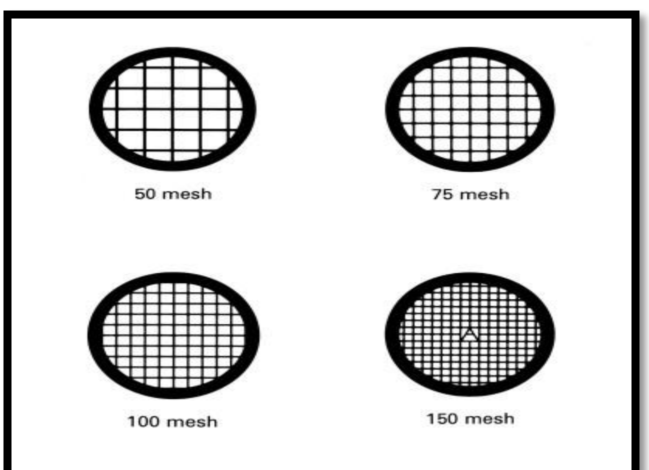

Fig. 1: Sieves of different mesh numbers

- **Size of the Screen:**

  It is the distance between two consecutive wires.

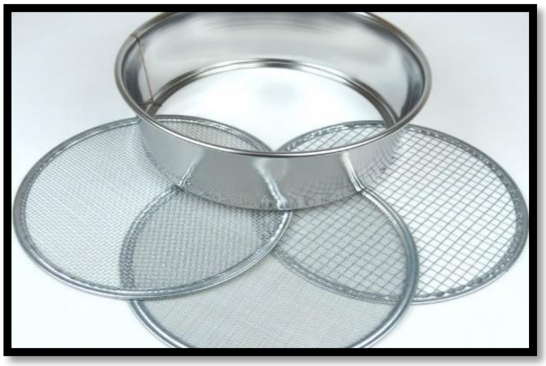

Fig.2: Test Sieves of different sizes

- **Sieve Shaker:**

Many natural and manufactured products or materials occurred in a dispersed form, it may consist of different sizes, and shapes of particles. The particles size distribution is responsible for physical, chemical, and mechanical properties.

- **Sieve Analysis:**

It is carried out to determine the particle size by using different methods.

  - **Manual sieving:** The sieve analysis is done manually.
  - **Mechanical sieving:** The sieve analysis is done automatically with the help of Ro-Tap sieve shaker.

- **Mass Fraction:**

It is defined as the ratio of mass retained to that of the total mass taken. Cumulative mass fraction is the sum of all the previous mass fraction values.

PROCEDURE:

1. Initially 500 gm of dry sand / rock sample was taken by using digital electronics weight balance
2. Then, the amount of sample was sieved in the smallest mesh number.
3. The mass retained on the smallest mesh no. was weighted, and kept aside.
4. The sample sieved in this mesh was again sieved with a sieve of higher mesh number. (Ex: -16, 22, 72, 85, 100, and 150 respectively).
5. The mass retained on each mesh number was weighted, and sieving is carried out for 15 min.
6. The results obtained was recorded, and plot a graph by using the table below.

TABULATION:

Sl. No.	Sieve No	Sieve opening	Avg. Particle size (Dpi)	Mass Retained	Mass Function	Cumulative Mass function	Reciprocal of Avg. Particle Size (1/Dpi)

GRAPH:

A graph between reciprocal of avg. particle size (1/Dpi) Vs cumulative mass fraction is plotted.

CALCULATION:

The area under the avg. particle size (1/Dpi) Vs cumulative mass fraction graph is calculated, and the reciprocal of that area gives the avg. product size.

CONCLUSION:

From the above experiment, we plot the graph between reciprocal of average particle size (1/Dpi) Vs cumulating mass fraction, and avg. product size was calculated manually.

EXPERIMENT-2

Aim of The Experiment:

To determine and analyze the size distribution of a fixed granular solid by using a Vibratory Sieve Shaker.

MATERIALS / APPARATUS REQUIRED:

1. Sand / rock granular solid particles
2. Different sieves of ASTM size.
3. Weight balance
4. Ro-Tap sieve shaker

THEORY:

Sieve analysis is a technique which is used for particles distribution on the basis of its size and shape. There are 2 types of sieves used in general

1. US STANDARD

2. BSS / TAYLOR

- **Mesh number:**

  It is defined as number of openings per linear inch.

  Mesh number α 1/size of screen α thickness of wire α fineness

- **Size of the screen:**

  It is the distance between 2 consecutive wires.

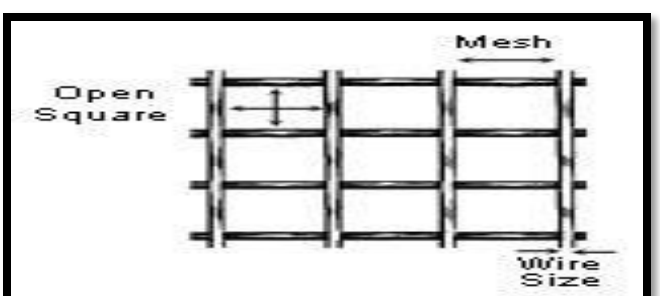

Fig. 3: Illustration of square openings

Sieve Shaker:

Many natural and manufactured products or materials occurred in a dispersed form, it may consist of different shape and size of particles. The particles size distribution is responsible for physical, chemical, and mechanical properties.

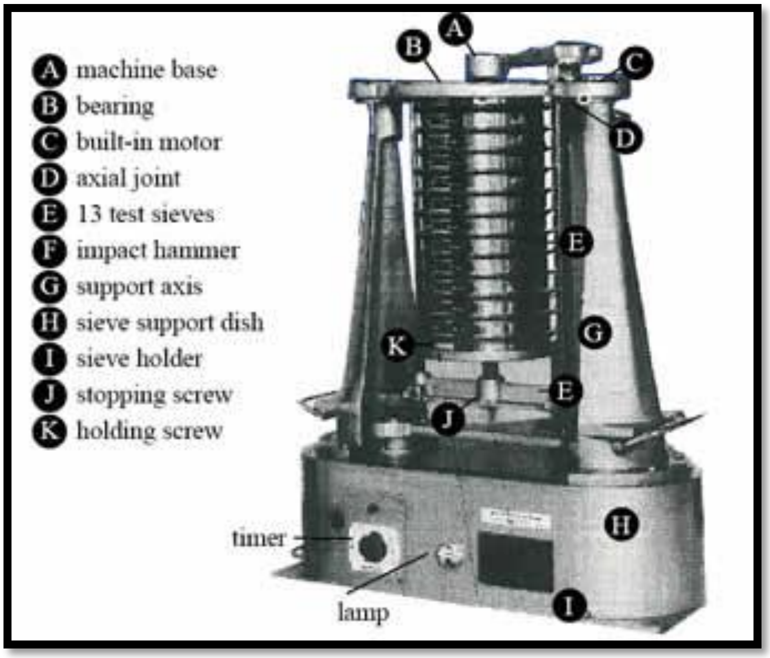

Fig. 4: Illustration of a Ro-Tap Sieve Shaker

Sieve Analysis:

It is carried out to determine the particle size by using different method.

1. Manual sieving
2. Mechanical sieving

Throw Action:

It is a 3-D movement of powder sample which is used to determine the percentage of oversized and undersized particles. The amplitude of throw action varies 0 – 2 mm or 0 - 3 mm.

Horizontal Sieving:

It is the moment of particles in a circular manner based on a 2-D plane. It is used to separate out different shape of particles. Ex: - needle shape, flattered, spherical or irregular shape.

- **Mass Fraction:**

It is defined as the ratio of mass retained to the total mass taken. The cumulative mass fraction is the sum of all the previous mass fraction values.

PROCEDURE:

1. First of all 500 gm of dry sample was taken through a weight balance and was fed in to a Ro-Tap sieve shaker.

2. The Ro-Tap sieve shaker has 7 no. of sieves with mesh no. 8, 16,22,72,85,100 and 150.

3. The sieves are arranged in ascending order so that 16 mesh no. was placed at the top and mesh no. 150 at the bottom.

4. At the bottom most, the pan was placed.

5. The machine was then started by switching on the knob at bottom and the timer was fixed at 15 min.

6. After the completion of 15 min, the machine is automatically switched off.

7. The residue on different sieves were collected and weighted.

TABULATION:

Sl. No.	Sieve No	Sieve opening	Avg. Particle size (Dpi)	Mass Retained	Mass Function	Cumulative Mass function	Reciprocal of Avg. Particle Size (1/Dpi)

GRAPH:

A graph between reciprocal of avg. particle size (1/Dpi) Vs cumulative mass fraction is plotted.

CALCULATION:

The area under the avg. particle size (1/Dpi) Vs cumulative mass fraction graph is calculated, and the reciprocal of that area gives the avg. product size.

CONCLUSION:

From the above experiment, we plotted the graph between reciprocal of avg. particle size (1/Dpi) Vs cumulating mass fraction, and calculated the avg. product size mechanically.

EXPERIMENT-3

AIM OF THE EXPERIMENT:

To crush the of Ore (iron ore pellets) in a Primary Jaw Crusher (Blake Jaw Crusher), and to determine the average product size by sieving.

MATERIALS / APPARATUS REQUIRED:

1. Ore (iron pellet)
2. Different sieve screens of ASTM size
3. Black jaw crusher
4. Weight balance
5. Ro-Tap sieve shaker

THEORY:

Blake Jaw Crusher: It has its moving jaw pivoted at the top. It is classified on the basis of single or double toggle type. A jaw crusher has 2 jaws said to form a V-shaped at the top through which feed is admitted. One of the jaw is fixed in to the main frame and other is movable. The crushing faces are usually made of hard field Mn steel (12-14%Mn, 1%C). The jaw crusher speed varies from 100-400RPM.

- **Gape:** It is the distance between jaw plates at the fixed opening end.
- **Set:** The distance between the jaw plates in the discharge end.

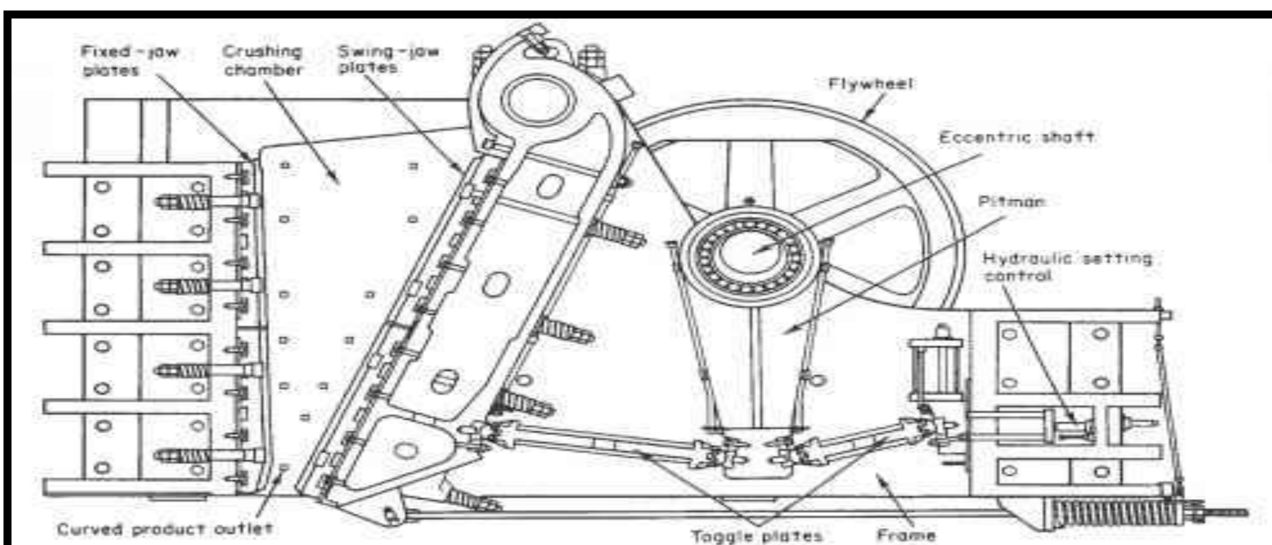

Fig. 5: Schematic diagram of Blake Jaw Crusher

PROCEDURE:

1. Initially 1 kg of dry feed was taken through a weight balance, and fed into the jaw crusher, and start the crusher.

2. The time taken for crushing, and no. of revolution was noted down (i.e energy meter reading).

3. The product size of each case was determined, and then the crushed product is fed into a stack of sieve vertically arranged in such a way that, the sieve having larger openings are at top, and the finer openings are at the bottom.

4. The mass retained on each screen get calculated, and product size is measured graphically.

TABULATION:

Sl. No.	Sieve No	Sieve opening	Avg. Particle size (Dpi)	Mass Retained	Mass Function	Cumulative Mass function	Reciprocal of Avg. Particle Size (1/Dpi)

GRAPH:

A graph between reciprocal of avg. particle size (1/Dpi) Vs cumulative mass fraction is plotted.

CALCULATION:

The area under the avg. particle size (1/Dpi) Vs cumulative mass fraction graph is calculated, and the reciprocal of that area gives the avg. product size.

CONCLUSION:

From the above experiment we studied the operation of Blake jaw crusher, and plot the graph between reciprocal of avg. feed size (1/Dpi) Vs cumulative mass fraction, and avg. product size was calculated mechanically.

EXPERIMENT-4

AIM OF THE EXPERIMENT:

To crush the of coal in a Primary Jaw Crusher (Blake Jaw Crusher), and determination of average product size by the use sieve shaker.

MATERIALS / APPARATUS REQUIRED:

1. Coal
2. Different sieve screens of ASTM size.
3. Black jaw crusher
4. Weight balance
5. Ro-Tap sieve shaker

THEORY:

Blake Jaw Crusher: It has its moving jaw pivoted at the top. It is classified on the basis of single or double toggle type. A jaw crusher has 2 jaws said to form a V-shaped at the top through which feed is admitted. One of the jaw is fixed in to the main frame and other is movable. The crushing faces are usually made of hard field Mn steel (12-14%Mn, 1%C). The jaw crusher speed varies from 100-400RPM.

- **Gape:** It is the distance between jaw plate at the fixed opening end.
- **Set:** the distance between the jaw plate in the discharge end.

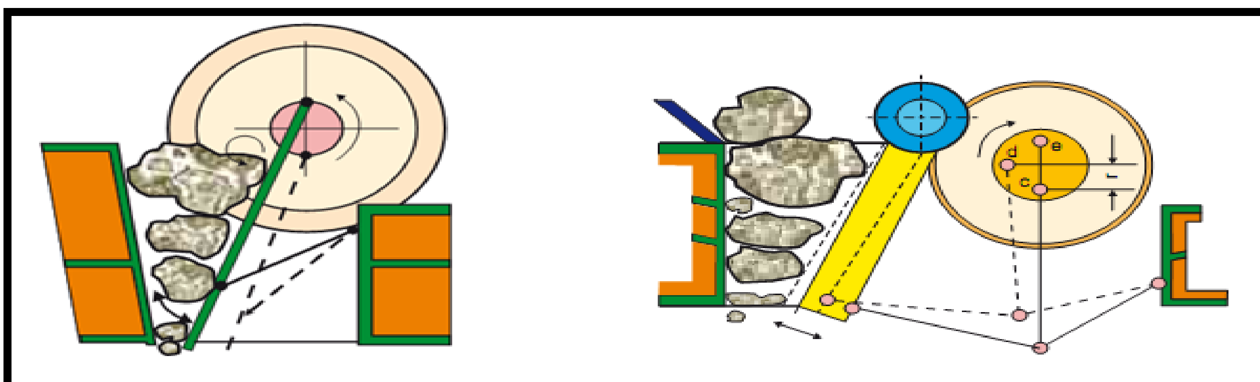

Fig. 6: Schematic Diagram of Crushing Operation in Blake Jaw Crusher

- **Operational Principle:** Initially the large lump is caught at the top and is broken. The broken fragments drop to the narrower bottom space and is crushed again when the jaws close in next time. This action continues until the feed comes out at the bottom. The crushing force is least at the start of the cycle and highest at the end of the cycle. In this machine an eccentric drives the pitman. The circular motion of the main shaft is converted to up and down motion of the pitman via the eccentric and finally the up and down motion is converted to reciprocating (to and fro) motion with the help of two toggles.

PROCEDURE:

1. First of all 1 kg of dry coal was taken through a weight balance, and was fed into a jaw crusher, and start the crusher.

2. The time taken for crushing, and number of revolution was noted down (i. e. energy meter reading).

3. The product size of each case was determined, and then the crushed product is fed to a stack of sieve vertically arranged in such a way that, the sieve having larger openings are at top, and finer openings are at bottom.

4. The mass retained on each screen get calculated and product size is measured graphically.

TABULATION:

Sl. No.	Sieve No	Sieve opening	Avg. Particle size (Dpi)	Mass Retained	Mass Function	Cumulative Mass function	Reciprocal of Avg. Particle Size (1/Dpi)

GRAPH:

A graph between reciprocal of avg. particle size (1/Dpi) Vs cumulative mass fraction is plotted.

CALCULATION:

The area under the avg. particle size (1/Dpi) Vs cumulative mass fraction graph is calculated, and the reciprocal of that area gives the avg. product size.

CONCLUSION:

From the above experiment we studied the operation of Blake jaw crusher, and plot the graph between reciprocal of avg. feed size (1/Dpi) Vs cumulative mass fraction, and avg. product size was calculated mechanically.

EXPERIMENT-5

AIM OF THE EXPERIMENT:

To study the Blake Jaw Crusher, and determination of the actual capacity, reduction ratio, and Verification of Rittinger's law of Crushing.

MATERIALS / APPARATUS REQUIRED:

1. Coal / Ore

2. Different sieve screens of ASTM size.

3. Black jaw crusher

4. Weight balance

5. Ro-Tap sieve shaker

THEORY:

- **Reduction ratio (R):** It is the ratio between avg. feed size with respect to product size. It is always greater than one. For black jaw crusher it varies from 4-7.

Reduction Ratio = avg. feed size / avg. product size

- **Capacity:** Capacity mainly depends on the length and width of the receiving opening and width of the discharge.

  Mathematically capacity of a Blake Jaw Crusher is given by

  $$\boxed{T = 0.6\ LS}$$

  Where, T= capacity per tons per hours

  L= length of the receiving opening in inches

  S= width of the discharge opening

- **Rittinger's Law:** Rittinger stated that, "Energy expanded during comminution is proportional to the new surface area created as a result of particle fragmentation''.

Mathematically, the statement can be represented as:

$$E = K_R(S_2 - S_1)$$

Where, K_R is called Rittinger's constant or work index, and S_2 & S_1 are the final & initia1 specific surface areas respectively. In terms of particle diameter, it becomes

Mathematically

$$E = P/M = K_R\,[1/D_2 - 1/D_1]$$

Where, P= power required for crushing

M= mass feed rate

D_2= avg. product size

D_1= avg. feed size

K_R= Rittinger's law constant

PROCEDURE:

1. First of all, 1 kg of dry coal / ore was taken through a weight balance, and was fed into the Blake jaw crusher, and start the crusher.
2. The time taken for crushing and no. of revolution was noted down (i.e. energy meter reading).
3. The product size of each case was determined, and then the crushed product is fed to a stack of sieve vertically arranged in such a way that the sieve having larger openings are at top, and finer openings are at bottom.
4. The mass retained on each screen get calculated and product size is measured graphically.

TABULATION:

TABLE-1

Sl. No.	Sieve No	Sieve opening	Avg. Particle size (Dpi)	Mass Retained	Mass Function	Cumulative Mass function	Reciprocal of Avg. Particle Size (1/Dpi)

TABLE-2

Sl No.	Feed Size	QTY	Time for Crushing	Energy Meter Reading		Energy Consumed for Crushing
				Crushing	Dry Run	

GRAPH:

A graph between reciprocal of avg. particle size (1/Dpi) Vs cumulative mass fraction is plotted.

CALCULATION:

- The area under the avg. particle size (1/Dpi) Vs cumulative mass fraction graph is calculated, and the reciprocal of that area gives the avg. product size.
- Power consumption calculated on basis of effective number of revolution of the rolls.
- Mass feed rate calculated by dividing the total feed mass with total time required for crushing.
- Rittinger’s constant calculated using the crushing formula mentioned under Rittinger’s crushing law.

CONCLUSION:

From the above experiment we studied the jaw crusher and capacity, reduction ratio, and Rittinger’s constant was calculated.

EXPERIMENT-6

AIM OF THE EXPERIMENT:

To crush the of Ore in the roll crusher, and determination of average product size using sieve shaker.

MATERIALS / APPARATUS REQUIRED:

1. Ore
2. Different sieve screens of ASTM size.
3. Roll crusher
4. Weight balance
5. Ro-Tap sieve shaker

THEORY:

Roll crusher consists of pair of heavy cylindrical rolls revolving towards each other. Rolls are 600 mm long with 300 mm diameter. Roll speed ranges from 50-300 RPM. The feed size varies from 12-75 mm and products varies from 12-20 mm.

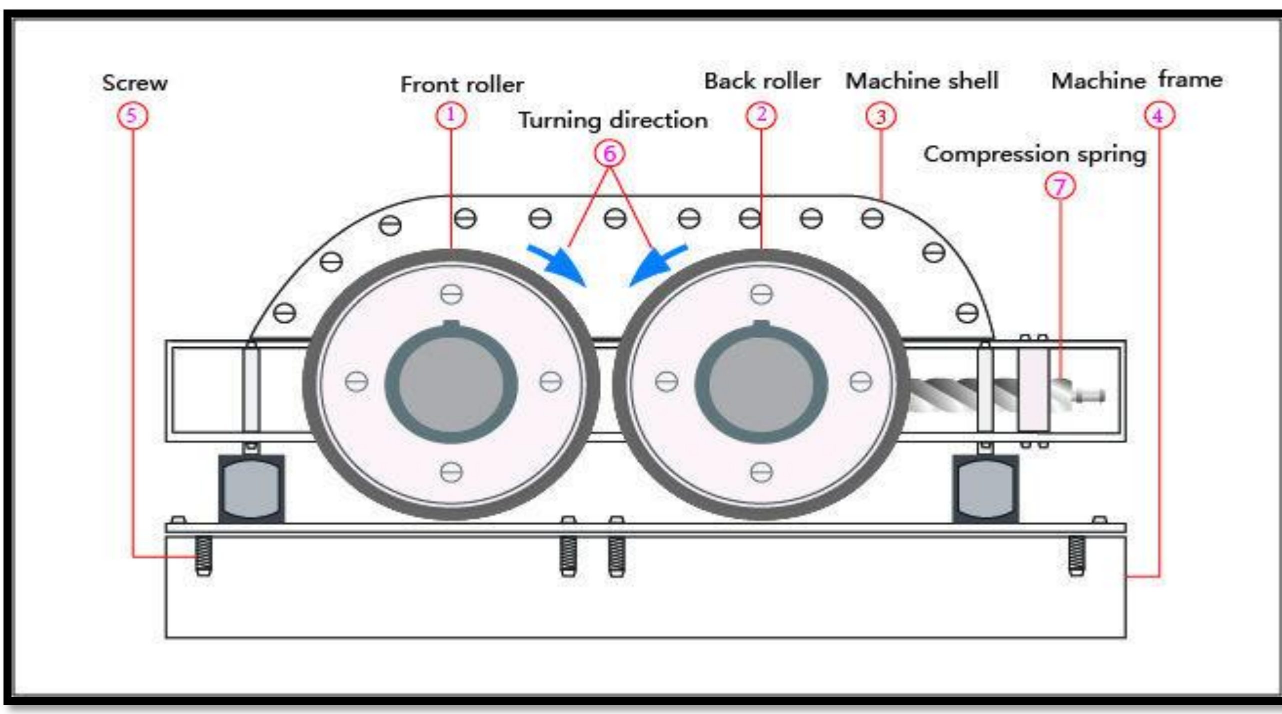

Fig. 7: Schematic Diagram of Roll Crusher

- **Reduction ratio (R):** It is the ratio between avg. feed size with respect to product size. It is always greater than one. For roll crusher it varies from 3-4.

R= avg. feed size/ avg. product size

- **Capacity:** Capacity of roll crusher mainly depends on the speed of revolution (N), width of face (W), diameter of the roll (D), inter roll distance (S), and specific gravity of rock (ρ).

  Mathematically it is given by

$$C = 0.0034\, NDWS\rho$$

  Where, C= capacity per kg per hour

- **Nip Angle:** It is defined as the angle subtended between the two tangents drawn at the points of contact of the rolls and the particle to be crushed. Angle of nip is also termed as angle of bite. Crushing is performed only when the ore particles are nipped properly by the rolls.

PROCEDURE:

1. First average feed size was calculated by using digital Vernier caliper.
2. 1 kg of dry ore was taken through a weight balance and was fed in to a roll crusher and start the crusher and feed.
3. The time taken for crushing and no. of revolution was noted down (i.e. energy meter reading)
4. The product size of each case was determined and then the crushed product is fed to a stack of sieve vertically arranged in such a way that the sieve having larger openings are at top and finer opening are at bottom.
5. The mass retained on each screen get calculated and product size is measured graphically.

TABULATION:

Sl. No.	Sieve No	Sieve opening	Avg. Particle size (Dpi)	Mass Retained	Mass Function	Cumulative Mass function	Reciprocal of Avg. Particle Size (1/Dpi)

GRAPH:

A graph between reciprocal of avg. particle size (1/Dpi) Vs cumulative mass fraction is plotted.

CALCULATION:

The area under the avg. particle size (1/Dpi) Vs cumulative mass fraction graph is calculated, and the reciprocal of that area gives the avg. product size.

CONCLUSION:

From the above experiment, we studied the roll crusher, and plot the graph between reciprocal of avg. feed size (1/Dpi) Vs cumulative mass fraction, and avg. product size was calculated mechanically.

EXPERIMENT-7

AIM OF THE EXPERIMENT:

To determine the reduction ratio, theoretical capacity, and actual capacity of a roll crusher.

MATERIALS / APPARATUS REQUIRED:

1. Ore / coal
2. Different sieve screens of ASTM size.
3. Roll crusher
4. Weight balance
5. Ro Tap sieve shaker

THEORY:

- **Theoretical Capacity:**

The theoretical capacity of a roll crusher is given by

$$\text{Theoretical Capacity } (C) = 60\pi D\,(S)\,B\,\rho\,N$$

Where, D = Diameter of roll (m)

S = Spacing between rolls (m)

B = breadth of the rolls (m)

N = Speed of rotation (rpm)

ρ = Density of material (2000 kg/m^3)

➢ **Actual Capacity:** The actual capacity is obtained by dividing the amount of material crushed by the time taken for crushing.

Mathematically it is given as,

$$\text{Actual capacity} = \frac{\text{mass taken}}{\text{total time}}$$

➢ **Reduction Ratio:** The reduction ratio is the ratio of feed size to the product size. It is always greater than one. For roll crusher it varies from 3-4.
Mathematically it is given by,

R= avg. feed size/ avg. product size

PROCEDURE:

1. **Determination of theoretical capacity:**
   Measure the breadth, and the spacing between the rolls. Also calculate the diameter of the roll by measuring the circumference. For measurement of RPM of rolls, note down the time taken for a fixed number of revolution (Say 20) or take the RPM reading from the RPM meter.
2. **Determination of actual capacity:** Take 500gm stone, and note down the total time required for crushing.
3. **Determination of reduction ratio:** Measure the avg. feed size, and other things calculate after sieving is done.
   The crushed product is feed to a stack of sieve vertically arranged in such a way that the sieves having the larger opening are at the top & the finer are at the button.
   - Measure the mass retained in each screen.
   - Graphically calculate the product size.
   - Calculate the reduction ratio.

TABULATION:

Sl. No.	Sieve No	Sieve opening	Avg. Particle size (Dpi)	Mass Retained	Mass Function	Cumulative Mass function	Reciprocal of Avg. Particle Size (1/Dpi)

GRAPH:

A graph between reciprocal of avg. particle size (1/Dpi) Vs cumulative mass fraction is plotted.

CALCULATION:

- The area under the avg. particle size (1/Dpi) Vs cumulative mass fraction graph is calculated, and the reciprocal of that area gives the avg. product size.
- Calculate the theoretical capacity from the above formula mentioned in the theory.
- Calculate the actual capacity from the above formula mentioned in the theory.
- Calculate the reduction ratio by dividing the avg. feed size with avg. product size.

CONCLUSION:

From the above experiment, we studied the roll crusher, and also calculated the theoretical capacity, actual capacity, and reduction ratio.

EXPERIMENT-8

AIM OF THE EXPERIMENT:

To study the effect of grinding with grinding time in Ball mill.

MATERIALS / APPARATUS REQUIRED:

1. Ore / coal
2. Different sieve screens of ASTM size.
3. Ball mill
4. Weight balance
5. Ro-Tap sieve shaker

THEORY:

Ball mill is a tumbling mill, where in size reduction occurs as a result of impact of the balls and by attrition. The ball mill consists of a cylindrical shell rotating about it axis. Cylindrical mills are classified according to the mode of product discharge taking place from the mill.

Different parts of ball mills are:

1. Cylindrical shell
2. Inner surface or liner
3. Grinding media
4. drive

1. Cylindrical Shell:

It is the rotating hollow cylinder partially filled with the balls. The ore to be crushed is fed through the hollow trunnion at one end & the product is discharged through a similar trunnion at the other end. The material of construction for this hollow shell is usually high strength steel. The shell axis is either horizontal or at a small angle to the base. Large ball mills have a length of 4 - 4.25 mts, diameter of 3mts. They use hardened steel balls of size varying between 25-125 *mm*.

2. Inner Surface or Liners:

As the grinding process involves impact and attrition the interior of the ball mills is lined with replaceable wear resisting liners. The liners are usually high manganese alloy steels, stones or rubber. Least wear takes place on rubber lined interior. As the coefficient of friction between balls and steel liner is specifically, large, the balls are carried up taken to a higher height along the inner wall of the shell and dropped down onto the ore with a larger impact force resulting in a better grinding.

3. **Balls (Grinding Media):**

The balls are usually cast steel unless otherwise stated. In some cases, flint balls may be used. The diameter of the grinding media varies from 1-5inches. The optimum size of the ball is proportional to the square root of the feed size. The ball and liner wear are usually in the range of 450 – 1250, and 0.50 – 250 grams per ton of ore ground.

4. **Drive:**

The mill is rotated by electric motors connected through reduction gear box - ring gear arrangement.

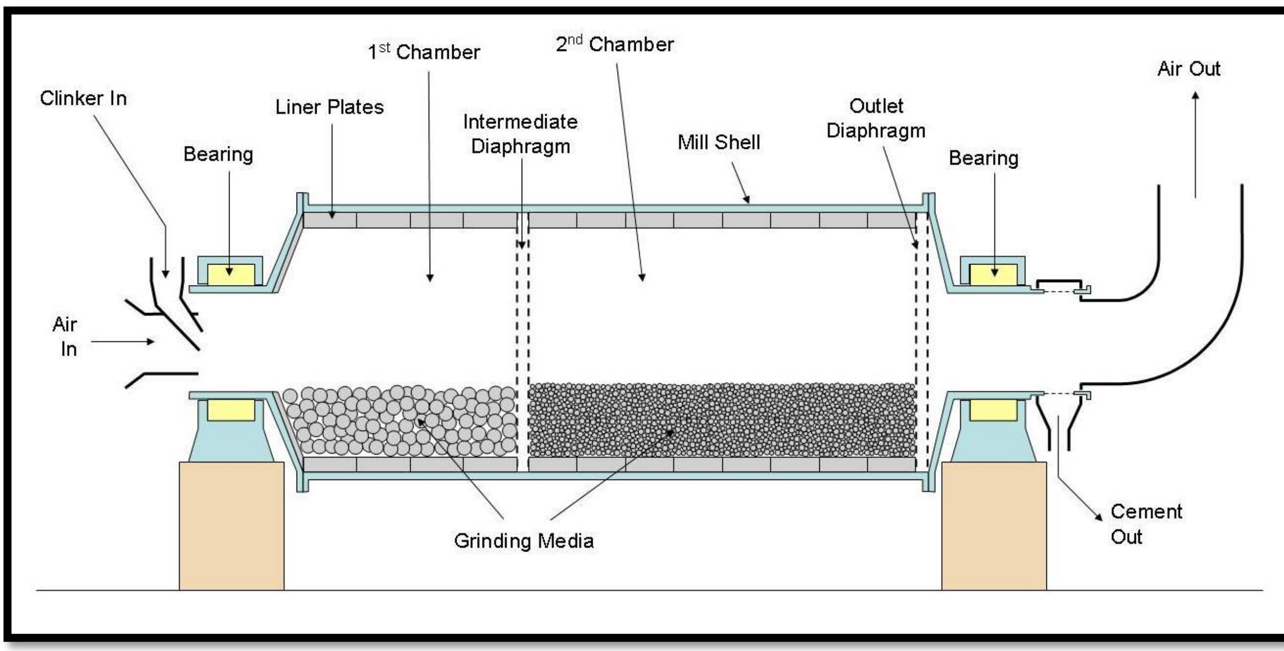

Fig. 8: Schematic Diagram of a Cylindrical Ball Mill

Ball Mill Operation:

Ball mills may be continuous or batch type in which grinding media and the ore to be ground are rotated around the axis of the mill. Due to the friction between the liners–balls & liners–ore lumps, both the ore and balls are carried up along the inner wall of the shell nearly to the top from where the grinding media fall down on the ore particles below creating a heavy impact on them. This usually happens at the toe of the ball mill.

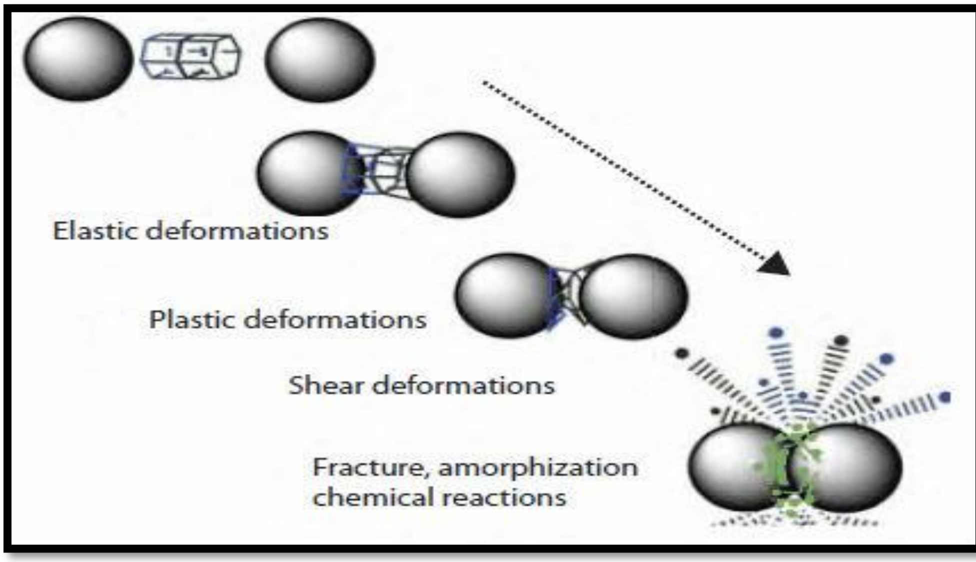

Fig. 9: Schematic Diagram of Different forms of Deformation during Ball-powder Interaction

The energy expanded in the lifting up the grinding media is thus utilized in reducing the size of the particles as the rotation of the mill is continued.

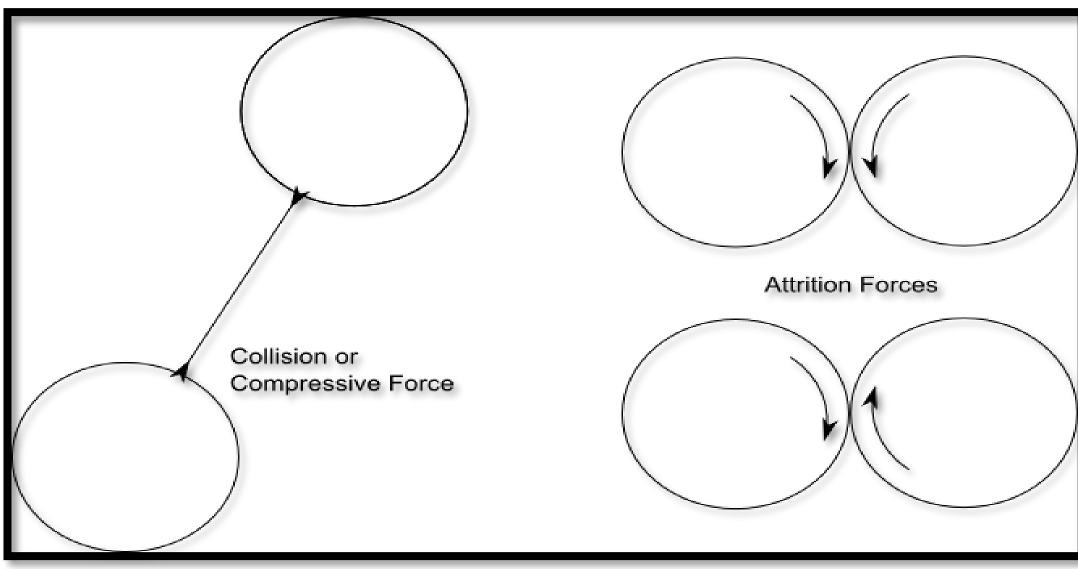

Fig. 10: Schematic Diagram of Different Type of forces during Ball Mill Operation

PROCEDURE:

1. Take 1 kg of feed (-1/2” to + ¼”) in the ball mill.
2. Place 10 numbers of balls in it. Allow the machine to run for 10minutes.
3. After 10 min remove the material, and screen it through a 200- mesh screen the amount of fines obtained is noted.
4. Then take the same material mix it, and add it to the ball mill. Grind it for another 5 min. then again screen it.
5. This gives the amount of fines obtained for a grinding time of 15 min. Repeat the same for 20-30 min.

TABULATION:

Sl. No.	Sieve No	Sieve opening	Avg. Particle size (Dpi)	Mass Retained	Mass Function	Cumulative Mass function	Reciprocal of Avg. Particle Size (1/Dpi)

GRAPH:

- Plot a graph between reciprocal of avg. particle size (1/Dpi) vs cumulative mass fraction is plotted.
- Plot a graph between % fines vs time of grinding.

CALCULATION:

The area under the avg. particle size (1/Dpi) Vs cumulative mass fraction graph is calculated, and the reciprocal of that area gives the avg. product size.

CONCLUSION:

From the above experiment, we plotted the graph between reciprocal of avg. feed size (1/Dpi) Vs cumulative mass fraction, and avg. product size was calculated mechanically, and also concluded that fineness increases with increase in crushing time and hence strength of materials also increases.

EXPERIMENT-9

AIM OF THE EXPERIMENT:

To study the effect of grinding with frequency (RPM) in Ball mill.

MATERIALS / APPARATUS REQUIRED:

1. Ore / coal
2. Different sieve screens of ASTM size.
3. Ball mill
4. Weight balance
5. Ro-Tap sieve shaker

THEORY:

Ball mill is a tumbling mill, where in size reduction occurs as a result of impact of the balls, and by attrition. The ball mill consists of a cylindrical shell rotating about it axis. Cylindrical mills are classified according to the mode of product discharge taking place from the mill. Different parts of ball mills are:

1. Cylindrical shell
2. Inner surface or liner
3. Grinding media
4. Drive

The grinding process is attributed to 3 different stages of ball mill working.

i. Cascading
ii. Cataracting
iii. Centrifuging

If the speed of the ball mill is too low then only cascading occur, and particle lead to rolling down of the ball and limiting grinding will occur. On the other hand, if the speed of the ball is very high (greater than critical speed) centrifuging occur leading to little or no grinding. So the mill is to be operated between two extreme speed i. e below critical speed of the mill.

Critical Speed of the Ball Mill:

The minimum rotational speed at which centrifuging occurs in a ball mill is defined as its critical speed. It has already been noticed that no grinding takes place in the ball mill when it centrifuges. So the operating speed of the mill should always be less than its critical speed enabling the media to deliver impacts at the toe or knee of the mill to result in grinding.

Mathematically, critical speed is given by

$$Critical\ Speed\ (N_c) = \frac{1}{2\pi}\sqrt{\frac{g}{R-r}}$$

The effective speed of the ball mill should be 65-80% of the theoretical critical speed. The lower value is for wet grinding while the higher value is opted for dry grinding.

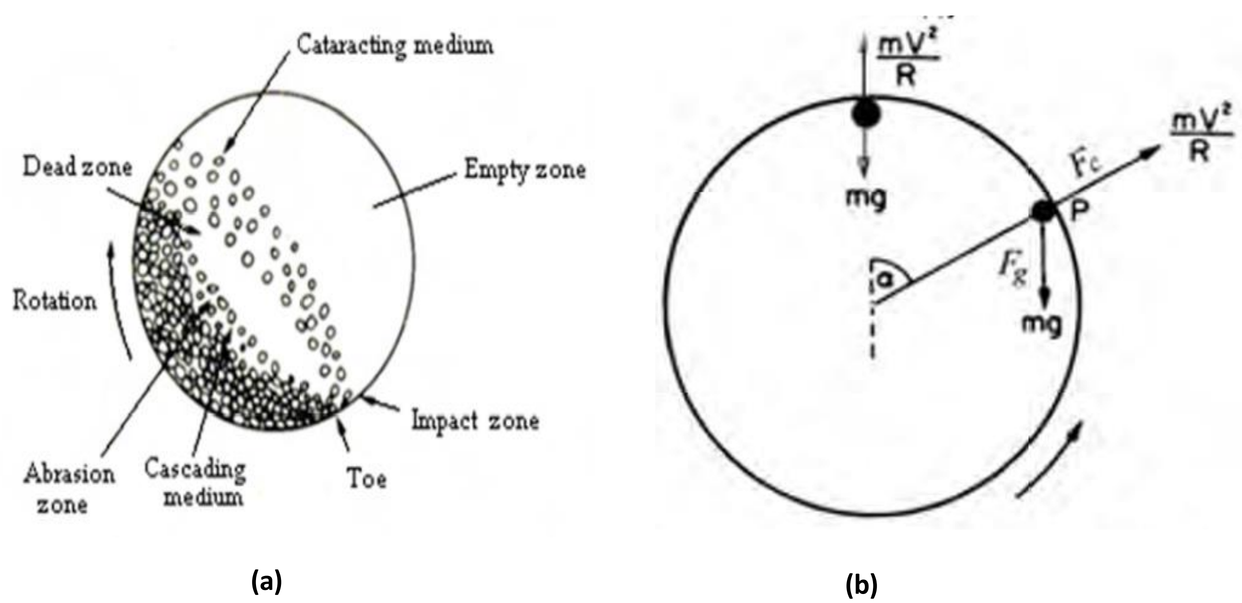

Fig. 11: (a) Different Stages & zones of a Ball mill (b) Forces working on the Grinding media

PROCEDURE:

- Take 1 kg of feed (-1/2” to + ¼”) in the ball mill. Place 10 numbers of balls in it. Allow the machine to run for 10minutes.
- After 10 min remove the material and screen it through a 200- mesh screen the amount of fines obtained is noted.
- Then take the same material mix it and add it to the ball mill.
- Grind it for another 5 min. then again screen it. This gives the amount of fines obtained for a grinding time of 15 min. Repeat the same for 20-30 min.

TABULATION:

Sl. No.	Sieve No	Sieve opening	Avg. Particle size (Dpi)	Mass Retained	Mass Function	Cumulative Mass function	Reciprocal of Avg. Particle Size (1/Dpi)

GRAPH:

- Plot a graph between reciprocal of avg. particle size (1/Dpi) vs cumulative mass fraction is plotted.
- Plot a graph between % fines vs frequency of grinding.

CALCULATION:

The area under the avg. particle size (1/Dpi) Vs cumulative mass fraction graph is calculated, and the reciprocal of that area gives the avg. product size.

CONCLUSION:

From the above experiment, we plotted the graph between reciprocal of avg. feed size (1/Dpi) vs cumulative mass fraction, and avg. product size was calculated mechanically, and also concluded that fineness increases with increase in crushing frequency up to critical speed, and above critical speed there is no grinding takes place.

EXPERIMENT-10

AIM OF THE EXPERIMENT:

To separate a mixture of two minerals of different densities by gravity concentration using Wilfley Table, and determine the efficiency of Tabling process.

MATERIALS / APPARATUS REQUIRED:

1. Ore / coal
2. Different sieve screens of ASTM size
3. Ball mill
4. Weight balance
5. Wilfley Table
6. Water

THEORY:

- Tabling takes place on the Shaking or Wilfley table. The Shaking or Wilfley table essentially consist of a substantially plane surface called the deck. The table is slightly inclined to the horizontal from the left to right and shaken with an asymmetrical motion in the direction of the long axis. Asymmetrical motion makes the stroke of the table faster in one of the directions and slower in reverse.
- Usually a slow forward with a rapid return is used during the operation of the Wilfley table. This causes the mineral particles to crawl along the longitudinal cleats or riffles that are fixed on the table surface in the direction of the table movement. The wash water flows over the table at right-angles to the direction of jog. A feed of 25% solids by weight is introduced through the feed box at the upper corner of the table, and as the feed particles hit the deck they are fanned out by a combination of differential motion, and transversely flowing water.
- The jolt during the return stroke causes the heavier particles to work-down the bed to form the bottom layer. The lighter gangue materials are thrown into suspension, and are discharged out over the edge of the table opposite to the feed box by the wash water.

- The heavier minerals finally arrange themselves on the smooth unriffled proportion of the table when they encounter the full force of the wash water. The middlings are collected in that portion of the table intermediate between concentrate & tailings. A finer feed requires a higher reciprocating speed but a smaller stroke length while a coarser feed requires larger stroke length with reduced reciprocating speed. Hence the stroke length along with the reciprocating speed of the table can be adjusted as per the feed material to be classified on the table.

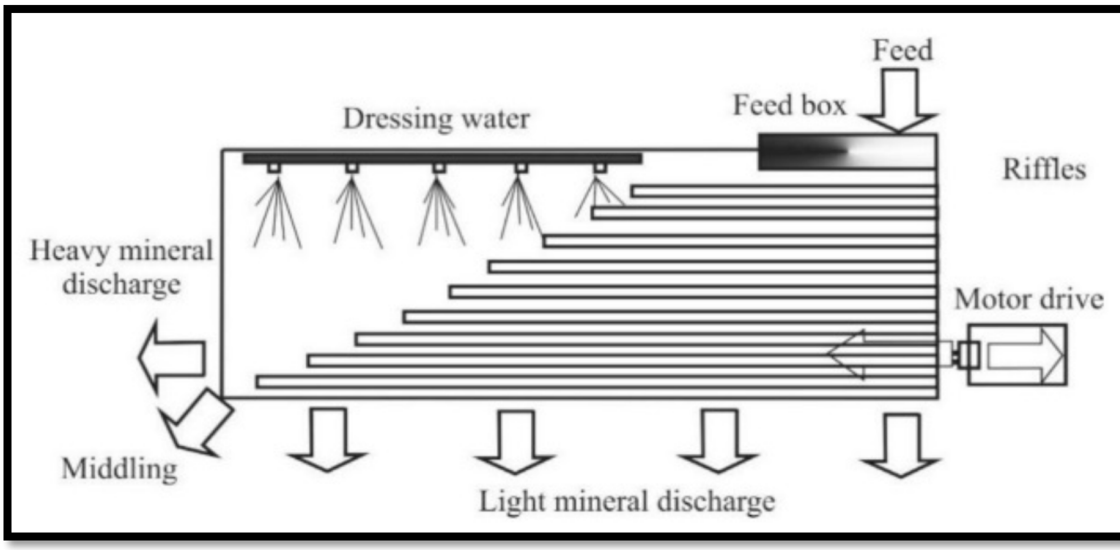

Fig 12: Schematic Diagram of Wilfley Table

PROCEDURE:

- Weigh accurately 25 gm of (-35, +60 mesh) coal, and add 25 gm of sand. Then mix it up thoroughly using Ball mill for 15-30 min. Then, prepare a slurry of fluid out of this mixture.
- Charged the slurry along with water at a particular flow rate in the feed point. Collect the sand in a collection tray at the heavy mineral discharge end, Collect the coal at the tailing / light mineral discharge end, and recycles the middling obtained.
- Dry the collected coal and sand. Then weigh it.
- Repeat the same procedures for different flow rates.

CALCULATION:

The efficiency of the Tabling process gets calculated by using the following mathematical formula

$$Efficiency\ (in\ \%) = \left\lfloor \frac{wt\ of\ the\ collected\ coal}{Amount\ of\ coal\ in\ the\ feed} \times 100 \right\rfloor$$

CONCLUSION:

Hence, the coal and sand was separated out from the mixture, and efficiency was calculated.

EXPERIMENT-11

AIM OF THE EXPERIMENT:

Beneficiation of Ore pulp mix using Froth Floatation Cell.

MATERIALS / APPARATUS REQUIRED:

1. Ore / coal
2. Different sieve screens of ASTM size
3. Froth Floatation Cell
4. Weight balance
5. Water
6. Pine oil

THEORY:

Froth Flotation Process:

- Flotation is the most widely used method of wet concentration of ores for separating the valuable constituent of the ore from the worthless gangue. The process is primarily a surface phenomenon based on the adhesion of some mineral particles to air, and simultaneous adhesion of other particles to water in the pulp.

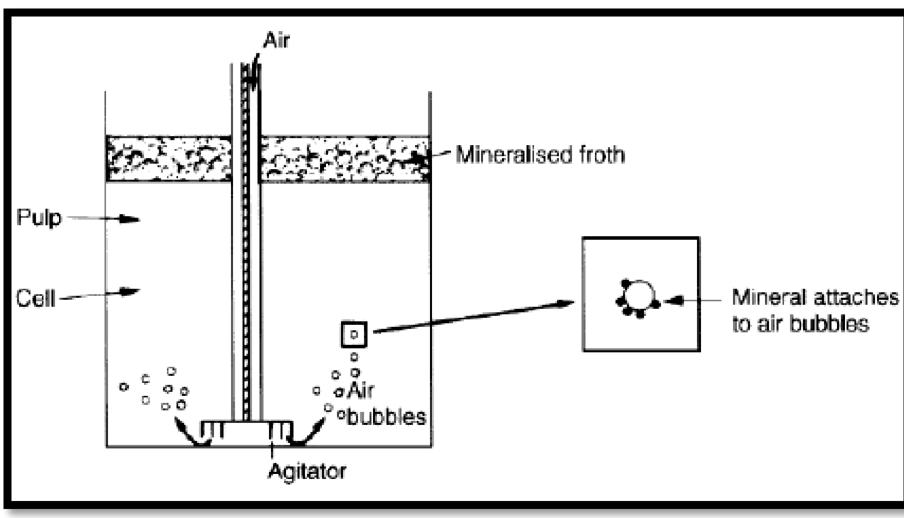

Fig. 13: Schematic Diagram Flotation Process

- Flotation process is the most efficient, but is the most complex of all ore beneficiation processes. In this process adhesion is made between air bubbles, and small mineral particles in such a way that they rise in that pulp. The floating mineralized froth is then skimmed off while the other minerals are retained in the pulp. This fact is well-known flotation proper.
- Floatation Cell Function of aeration element is based on step diffuser design. Acceleration in the aeration tube generates a vacuum, which sucks the necessary process air, which forms bubbles in the stock. Bubbles remove the particles from the stock suspension.
- Floatation Cell Dirt laden bubbles rise to the top of the cell, forming a foam layer. The foam layer gets skimmed off into the foam collecting chamber.
- Froth flotation is employed widely in metallurgical industries and coal.
- In the pneumatic flotation cells compressed air is directly blown into the pulp while in the sub-aeration cell a rotating impeller serves as a pump, which draws in air through the hollow shaft of the impeller and distributes the same into the pulp to produce the froth. In the laboratory, usually a rotating, hollow impeller type sub-aeration cell is used.

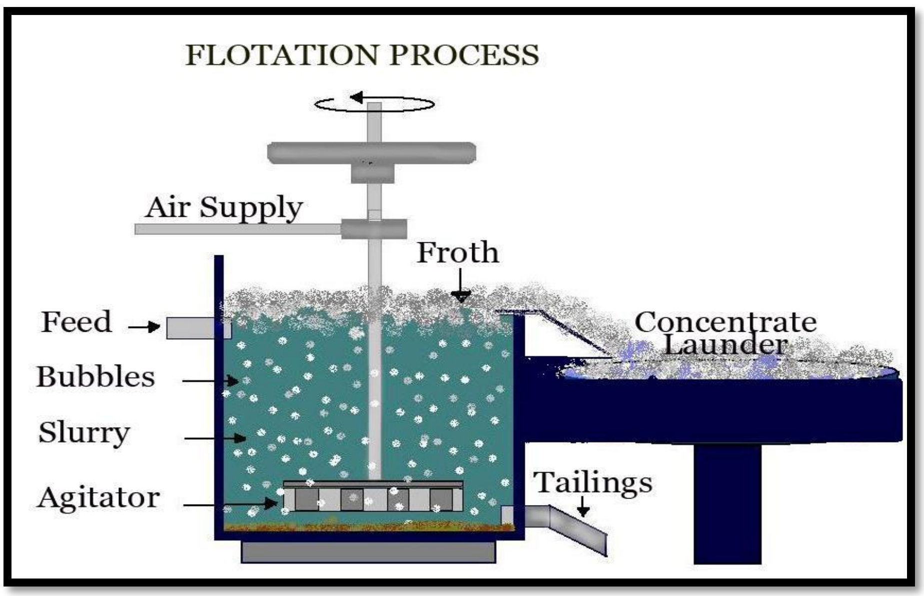

Fig. 14: Froth Flotation Cell Operation

PROCEDURE:

- Take 45gm weight of finely ground coal, and 5gm weight of sand. Mix it thoroughly.
- Add 5 ltr of water to the cell and start the unipellets. Then, add 2/3 drops of pine oil (floating agent collector), and a pinch of detergent to create a stable froth.
- Now, add the coal & sand mixture into the flotation cell, Skim off the froth, and collect the same through the reservoir.
- Then, dry the collected froth, and find out the separation efficiency.

OBSERVATION & CALCULATION:

Measure the following parameters

- Weight of initial coal taken (W_1)
- Weight of sand taken (W_2)
- Weight of sand dried froth taken (W_3)
- Weight of filter paper
- Total weight of filter, and coal
- Weight of the dried coal (W_4)

So, using the above data, we can calculate the separation efficiency using the following formula

$$\text{Separation efficiency (in \%)} = \left[\frac{W_4}{W_2} \times 100\right]$$

CONCLUSION:

Hence, we have studied about froth flotation cell, and the efficiency of the machine was found out.

EXPERIMENT-12

AIM OF THE EXPERIMENT:

To study about the magnetic separator, and the effect of magnetic field on efficiency of the process.

MATERIALS / APPARATUS REQUIRED:

1. Ore
2. Different sieve screens of ASTM size.
3. Magnetic separator
4. Weight balance

THEORY

It is a technique which is used to separate the mineral particles from gangue particles on the basis of its magnetic properties. Actually there are three types of magnetic materials,

1. Ferro magnetic – strong magnetic field
2. Para magnetic – weak magnetic field
3. Dia magnetic – no magnetic field

Type:

- ✓ On the basis of magnetic intensity
  - o Low intensity magnetic separator
  - o High intensity magnetic separator
- ✓ Again, on the basis of medium
  - o Dry magnetic separator
  - o Wet magnetic separator

Basic Principle of Magnetic Separation Process

It works on the principle of mutual attraction of unlike charges, and mutual repulsion of like charges (Coulomb's law). On the basis of electrostatic charge, a body is said to be positively charged if it is deficient in electrons and is said to be negatively charged if it has excess of electrons.

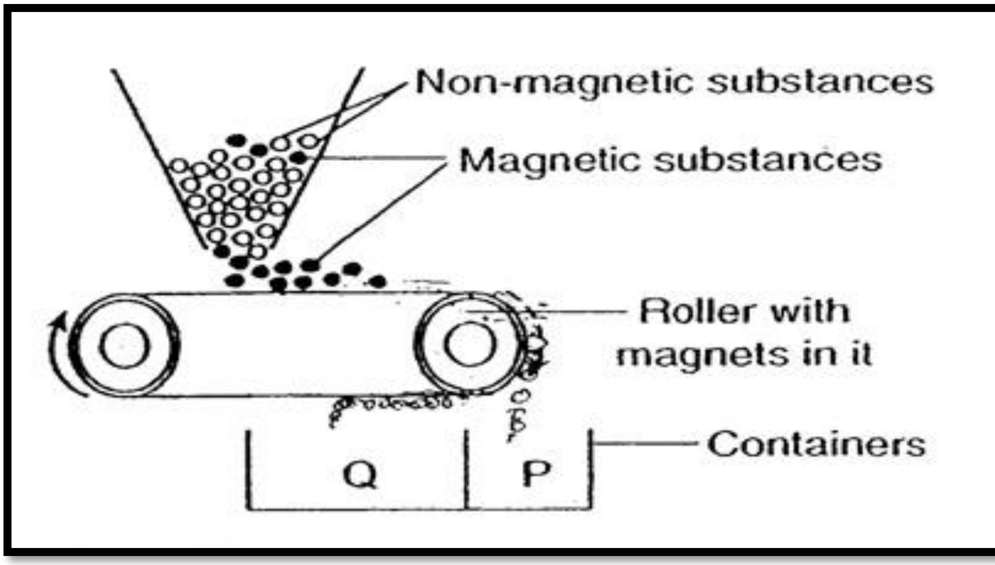

Fig 15: Schematic Diagram of Magnetic Separation

Fundamental concept of magnetic separation:

1. Low intensity magnetic separator are used for the separation of highly magnetic materials.
2. High intensity magnetic separator are used for the separation of weak magnetic materials.

PROCEDURE:

- Weight 5-6 kg of feeding ore of particular size by a digital weight balance.
- Switch on the impeller motor, and also the motor of the rake.
- Allow addition of the feed sample through the feed at a steady rate.
- Collect the ore under the flow of magnetic field thrown away from the separator
- Also collect the free flow placed nearer to the separator, and switch off the machine.
- Calculate the efficiency.

CALCULATION:

The efficiency of the magnetic separation calculated by using the formula given below

$$Efficiency\ (in\ \%) = \left[\frac{Weight\ of\ the\ collected\ magnetic\ materials}{Weight\ of\ the\ total\ feed\ mateerials} \times 100\right]$$

CONCLUSION:

Hence, we studied about the magnetic separator, and also calculated the efficiency of magnetic separation.

TABLE – 1

Sieve Number to Sieve Size Conversion

Sieve Mesh Chart			
APERTURE SIZE			
B.S.S(410/1969)	**A.S.T.M. (11-70)**	**I.S. (469/1972)**	**MICRONS**
4	5	4.00mm	4000
5	6	3.35mm	3353
6	7	2.80mm	2812
7	8	2.36mm	2411
8	10	2.00mm	2057
10	12	1.70mm	4000
12	14	1.40mm	1405
14	16	1.18mm	1204
16	18	1.00mm	1204
18	20	0.850mm	850
22	25	0.710mm	710
25	30	0.600mm	600
30	35	0.500mm	500
36	40	0.425mm	420
44	45	0.355mm	355
52	50	0..300mm	300
60	60	0.250mm	250
72	70	0.212mm	210
85	80	0.180mm	180
100	100	0.150mm	150
120	120	0.125mm	120
150	140	0.106mm	105
170	170	0.090mm	90
200	200	0.075mm	75
240	230	0.063mm	63
300	270	0.053mm	53
350	325	0.045mm	45
400	400	0.037mm	37
500	500	0.025mm	25

TABLE – 2

Peak Gauss at Poles with Variable Voltage

Sl. No.	DC VOLTAGE	DC CURRENT	GAUSS ($\pm$ 10%)
1	30	0.8	520
2	60	1.5	1040
3	90	2.2	1530
4	110	2.7	1900