Government Polytechnic, Sonepur

LECTURE NOTE

SUBJECT NAME- MINERAL PROCESSING

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Crushings

Crushing operations are a crucial step in various industries, including mining, construction, and recycling. They involve reducing the size of materials like rocks, ores, and waste products through mechanical force. This size reduction is essential for subsequent processes like grinding, milling, or further processing.

Common Crushing Operations

- **Primary Crushing:** This is the initial stage where large rocks or ore chunks are broken down into smaller pieces. **Jaw crushers** and **Gyratory crushers** are commonly used for primary crushing.
- **Secondary Crushing:** In this stage, the material from primary crushing is further reduced in size. **Cone crushers** and **Impact crushers** are often employed for secondary crushing.
- **Tertiary Crushing:** This is the final stage of crushing, where the material is reduced to the desired size for subsequent processes. **Roll crushers** and **Hammer mills** are typically used for tertiary crushing.

Construction and Working Principle of Dodge Jaw Crusher

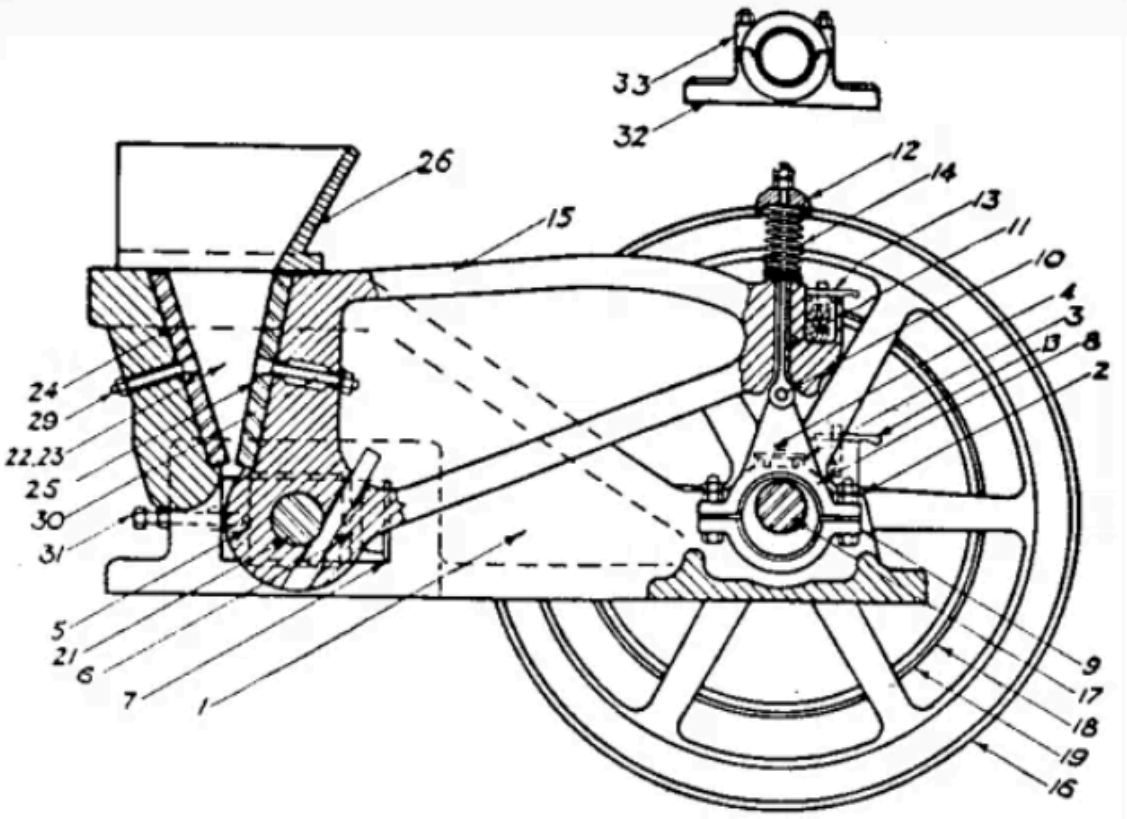
The Dodge jaw crusher is a type of crusher that utilizes a unique mechanism to crush materials. Its design and operational principles distinguish it from other types of jaw crushers, such as the Blake jaw crusher.

Construction

The main components of a Dodge jaw crusher include:

- **Fixed Jaw**: This stationary part of the crusher provides a surface against which the material is crushed.
- **Moving Jaw (Swing Jaw)**: This component pivots at the bottom, allowing it to move back and forth to crush the material against the fixed jaw.
- **Toggle Plate**: This part connects the moving jaw to the main shaft and helps in transferring motion.
- **Pitman**: The pitman is a component that connects the toggle plate to the moving jaw, facilitating its movement.
- **Flywheel**: A heavy wheel that stores kinetic energy, providing the necessary inertia for crushing action.

- **Crushing Chamber**: The space between the fixed and moving jaws where the crushing takes place.



Dodge-type crusher parts: (1) Frame, 12) Main bearing cop, (3) Oil well cover, (4) Oil well cover spring, (5) Swing jaw shaft box, (6) Breaking plate, (7) Shim, (8) Pitman, (9) Pitman cap, (10) Pitman pin, (11) Pitman eye bolt, (12) Pitman jaw spring cop, (13) Swing jaw and Pitman oil well cover, (14) Swing jaw spring, (15) Swing jaw, (16) Flywheel, (17) Eccentric shaft, (18) Loose pulley, (19) Tight pulley, (21) Swing jaw shaft, (22) Left hand side liner, (23) Right hand side liner, (24) Plain stationary jaw plate, (25) Plain swing jaw plate, (26) Hopper, (29) Stationary jaw plate bolt, (30) Swing jaw plate bolt, (31) Dog bolt, (32) Outboard bearing, (33) Outboard bearing cap

Working Principle

The working principle of the Dodge jaw crusher is based on the reciprocating motion of the moving jaw. Here’s how it operates:

- **Material Feeding**: Material is fed into the crushing chamber from the top through a feed opening. The larger opening allows for larger feed sizes.
- **Crushing Action**: As the flywheel rotates, it causes the pitman to move up and down. The movement of the pitman pushes the moving jaw towards and away from the fixed jaw. The maximum movement occurs at the top of the crushing chamber, while minimum movement occurs at the discharge point.
- **Compression and Crushing**: When the moving jaw approaches the fixed jaw, it compresses and crushes the material between them. The angle between

the two jaws widens during this process, allowing crushed material to fall through as it becomes smaller than the discharge opening.
- **Discharge of Crushed Material**: As the swing jaw moves back, crushed material is discharged from the bottom of the crusher. The size of this material is determined by the gap between the jaws at their closest point.
- **Efficiency Considerations**: While Dodge jaw crushers are simple in design and easy to maintain, they tend to choke due to limited discharge area, which can restrict their capacity compared to other types like Blake crushers[

Advantages and Limitations

- **Advantages**:
  - Simple design with fewer moving parts makes maintenance easier.
  - Lower cost compared to more complex designs.
- **Limitations**:
  - Lower capacity due to choking tendencies.
  - More suitable for smaller operations or softer materials due to its design constraints

Construction and Working Principle of Blake Jaw Crusher

The Blake jaw crusher, named after its inventor Eli Whitney Blake, is one of the most common types of jaw crushers used in the mining and aggregate industries. Its design and functionality have made it a standard in primary crushing applications.

Construction

The Blake jaw crusher consists of several key components:

- **Frame**: The entire structure is built into a rectangular frame that provides stability and support.
- **Crushing Chamber**: Located at one end of the frame, it contains two jaws—the **fixed jaw** and the **swing jaw**. The fixed jaw is stationary, while the swing jaw is movable.
- **Swing Jaw**: Suspended from a cross-shaft at its upper end, this jaw moves back and forth to crush material.
- **Eccentric Shaft**: This shaft, supported in bearings on both sides of the frame, drives the swing jaw's motion through a pitman mechanism.

- **Pitman**: A component that connects the swing jaw to the eccentric shaft, transmitting motion from the shaft to the jaw.
- **Toggle Plates**: These plates are crucial for transferring the motion from the pitman to the swing jaw and maintaining its position.
- **Flywheel**: A heavy wheel that stores kinetic energy, helping to maintain a consistent motion of the swing jaw.

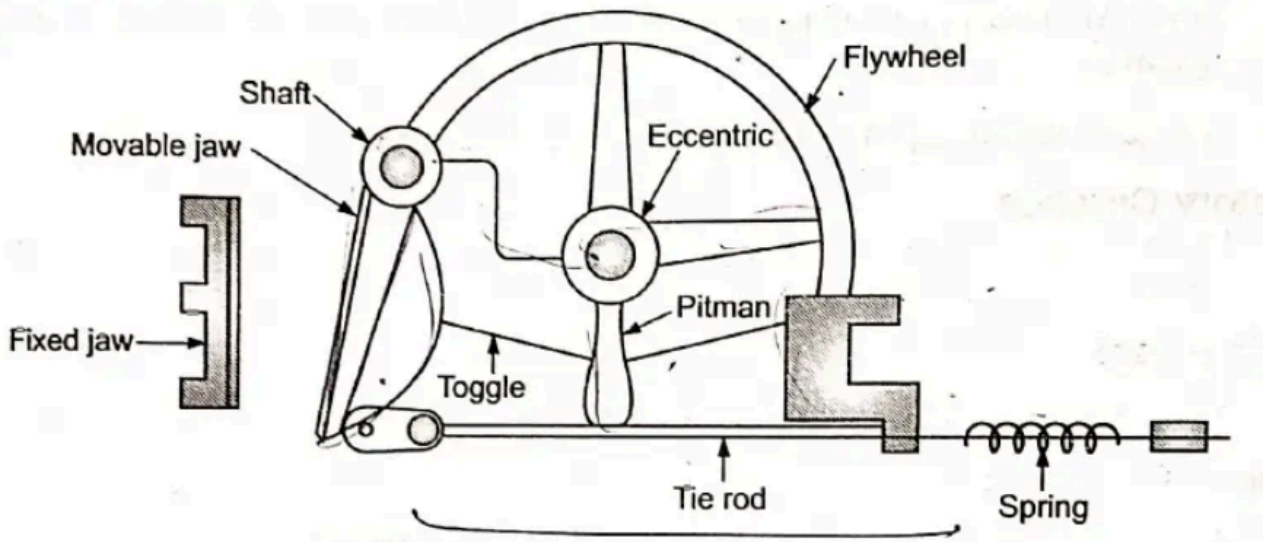


Fig. 2.1 : Blake Jaw Crusher

Working Principle

The working principle of the Blake jaw crusher revolves around its unique design that allows for efficient crushing:

- **Material Feeding**: Material is fed into the top of the crushing chamber through a feed hopper. The space between the jaws at this point is called the "gape."
- **Crushing Action**: As the swing jaw moves downward (during its forward stroke), it creates a larger gap between itself and the fixed jaw, allowing material to enter. When the swing jaw moves upward (during its return stroke), it compresses and crushes the material between the two jaws.
- **Size Reduction**: The crushing action occurs as the material is progressively crushed into smaller sizes. The design ensures that as materials move downwards in the chamber, they are crushed more finely due to decreasing space between the jaws.
- **Discharge**: Crushed material exits through a discharge opening at the bottom of the chamber. The size of this opening can be adjusted to control product size.

Advantages

- **Robust Design**: The Blake jaw crusher's construction provides strength and durability, making it suitable for heavy-duty applications.
- **High Efficiency**: Its design allows for effective crushing with minimal downtime.
- **Adjustable Discharge Size**: Operators can easily adjust the discharge size to meet specific requirements.

Difference between Blake and Dodge jaw Crusher

Blake and Dodge jaw crushers are two distinct types of jaw crushers used primarily in the mining and aggregate industries. They differ significantly in their design, operation, and suitability for various applications.

Design and Mechanism

- **Blake Jaw Crusher**:
  - The **swing jaw** is pivoted at the **top** of the crusher. This design allows for a fixed receiving area and a variable discharge area.
  - The greatest amount of motion occurs at the **bottom** of the V-shaped crushing chamber, which minimizes the tendency to choke on material[
- **Dodge Jaw Crusher**:
  - In contrast, the **swing jaw** is pivoted at the **bottom**, resulting in maximum movement at the top and minimum movement at the bottom.
  - This configuration leads to a more uniform product but can cause choking due to limited discharge area

Crushing Action and Output

- **Blake Jaw Crusher**:
  - It is known for its ability to handle larger feed sizes and produce fewer fines, making it suitable for primary crushing applications.
  - The design results in a more efficient crushing action with a higher throughput capacity[
- **Dodge Jaw Crusher**:
  - The Dodge crusher typically produces more fines and is less efficient in terms of capacity compared to the Blake type.
  - It is generally used for softer materials due to its tendency to choke, limiting its application scope[

Applications

- **Blake Jaw Crusher**:
  - Commonly used in both primary and secondary crushing stages across various industries, including mining, metallurgy, and construction.
  - Its robust design allows it to handle tougher materials effectively[
- **Dodge Jaw Crusher**:
  - More suited for smaller operations or where softer materials are processed.
  - Its simplicity in design makes it easy to maintain but limits its use in larger scale operations due to lower capacity

Feature	Blake Jaw Crusher	Dodge Jaw Crusher
Pivot Point	Top	Bottom
Motion	Maximum at bottom	Maximum at top
Feed Size Handling	Larger feed sizes	Smaller feed sizes
Tendency to Choke	Low	High
Output Fines	Fewer	More
Typical Applications	Primary & secondary crushing	Softer materials

Capacity and Reduction Ratio of crusher

Understanding the **capacity** and **reduction ratio** of crushers is essential for selecting the right equipment for specific crushing tasks in various industries, including mining and construction.

Capacity of Crushers

Definition: The capacity of a crusher refers to the maximum amount of material that can be processed within a given timeframe, typically measured in tons per hour (TPH).

Factors Affecting Capacity:

1. **Gape Size (G)**: The distance between the jaws at the top of the crushing chamber.
2. **Width of Crusher (W)**: The width of the crushing chamber.
3. **Closed Single Setting (CSS)**: The smallest gap between the jaws when they are closed, which determines the maximum size of material that can pass through.

Calculation: The capacity of a jaw crusher can be calculated using the formula:

$$C_{JC} = \frac{G \cdot W}{CSS}$$

Where:

- C_{JC} = Capacity of Jaw Crushers
- G = Gape Size
- W = Width of Crusher
- CSS = Closed Single Setting

For example, if the gape size is 10, width is 8, and CSS is 14, then:

$$C_{JC} = \frac{10 \cdot 8}{14} = 5.71 \text{ TPH}$$

Reduction Ratio

Definition: The reduction ratio is a measure of how much the crusher reduces the size of the material being processed. It is defined as the ratio of the size of the input material to the size of the output material.

Importance: A higher reduction ratio indicates that the material is being crushed to a smaller size, which can be crucial for achieving desired specifications for further processing.

Calculation: The reduction ratio can be expressed as:

$$\text{Reduction Ratio} = \frac{\text{Size of Input Material}}{\text{Size of Output Material}}$$

For example, if a crusher reduces a material from 12 inches to 2 inches, the reduction ratio would be:

$$\text{Reduction Ratio} = \frac{12}{2} = 6$$

Summary

- **Capacity** measures how much material a crusher can process in a specific time frame, influenced by factors like gape size, width, and closed setting.
- **Reduction Ratio** indicates how effectively a crusher reduces material size, essential for determining suitability for specific applications.

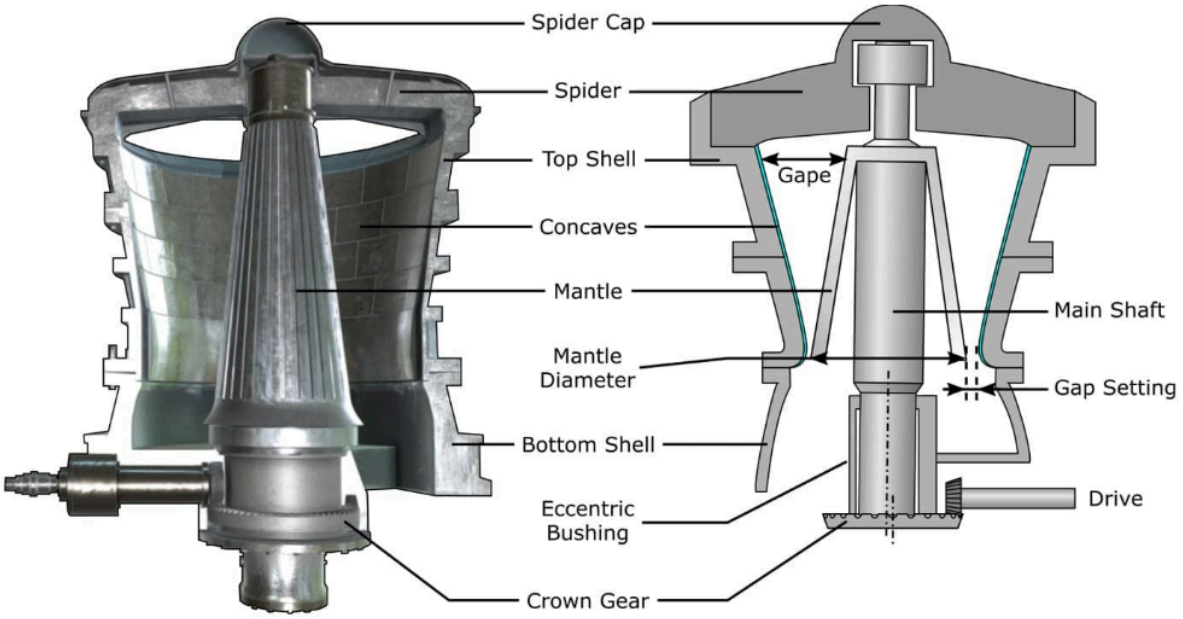
Gyratory Crusher and Roll Crushers

Gyratory Crushers

Construction

A gyratory crusher consists of several key components:

- **Frame**: A heavy-duty structure that supports the entire machine.
- **Crushing Chamber**: Composed of a concave surface (fixed) and a conical head (movable) that crushes material.
- **Main Shaft**: The central component that supports the crushing head and is driven by an eccentric mechanism.
- **Eccentric Mechanism**: Converts rotary motion into the gyratory motion of the crushing head.
- **Mantle and Concaves**: The mantle is the moving part that crushes the material against the stationary concave liners.



Gyratory Crusher Components

Working Principle

The working principle of a gyratory crusher involves:

- **Material Feeding**: Material is fed into the top of the crushing chamber.
- **Gyratory Motion**: The electric motor drives the eccentric sleeve, causing the main shaft to gyrate. This motion allows the mantle to move closer to and farther from the concave surface, creating a crushing action.

- **Crushing Action**: As material falls into the chamber, it is crushed by compression between the mantle and concaves. The crushed material then exits through a discharge opening at the bottom due to gravity.

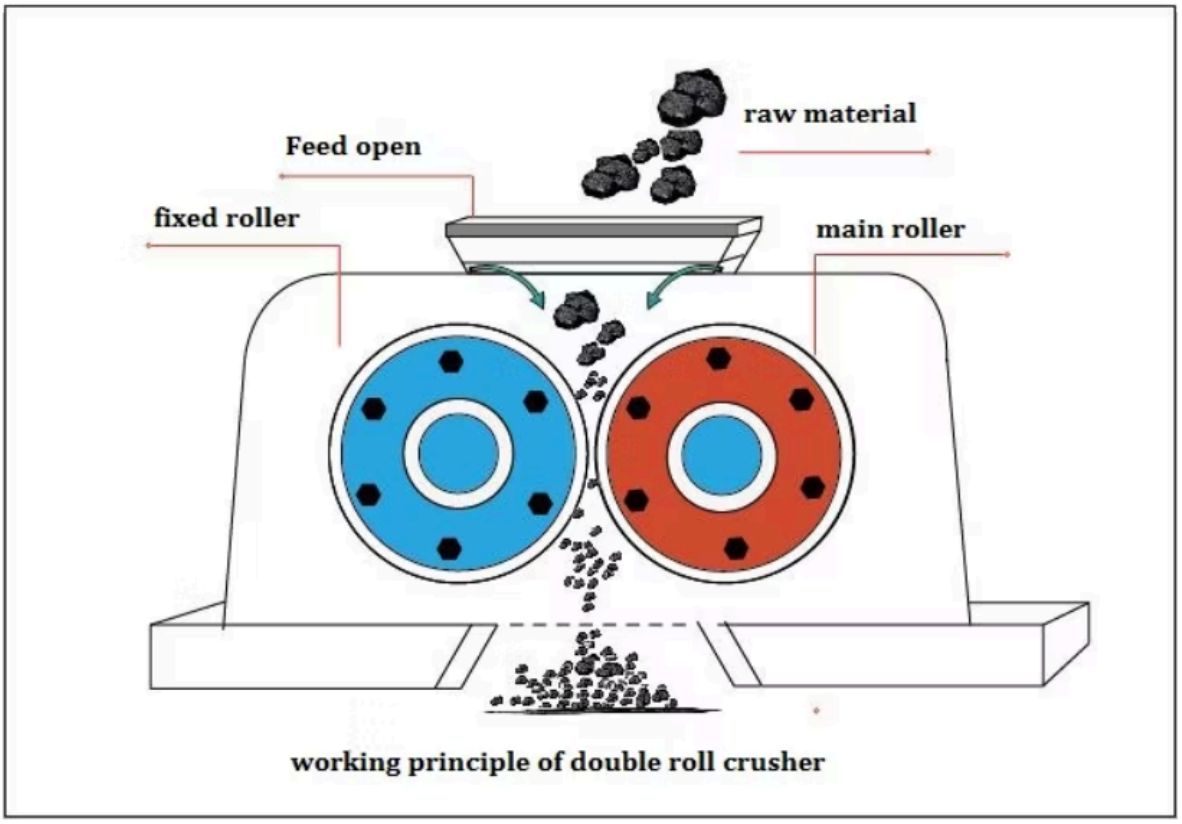
Roll Crushers

Construction

Roll crushers consist of:

- **Frame**: A sturdy structure that supports the rolls.
- **Two Parallel Rolls**: The primary components that crush material. These rolls can be smooth or have ridges (teeth) to enhance crushing efficiency.
- **Drive Mechanism**: Typically includes gears or belts that rotate the rolls in opposite directions.

High efficiency crushing machine of double roll crusher for coal disintegrating



Working Principle

The operation of roll crushers is based on:

- **Material Feeding**: Material is fed between two rotating rolls.
- **Crushing Action**: As the rolls turn, they pull material into the gap between them. The material is crushed by compression as it passes through this narrowing space.

- **Output**: Crushed material exits from the bottom of the rolls.

Roll crushers are particularly effective for reducing materials with moderate hardness and are often used in secondary or tertiary crushing stages. They can produce a more uniform product size compared to other types of crushers

Comparison of Gyratory and Roll Crushers

Feature	Gyratory Crusher	Roll Crusher
Design	Conical head with a fixed concave	Two parallel cylindrical rolls
Crushing Mechanism	Gyratory motion (oscillation)	Compression between two rolls
Capacity	High capacity, suitable for large rocks	Moderate capacity, efficient for smaller sizes
Application	Primary crushing in large-scale operations	Secondary or tertiary crushing
Product Shape	More varied product size	More uniform product size

Grinding

Classify different types of grinding equipment?

Grinding equipment can be classified into several categories based on their design, application, and operation. Here are the main types:

1. **Ball Mills**:
   - Used for grinding materials into fine powder.
   - Consists of a rotating cylindrical shell filled with balls.
2. **Rod Mills**:
   - Similar to ball mills but use long rods instead of balls.
   - Effective for coarse grinding and producing uniform particle size.
3. **Hammer Mills**:
   - Utilize rotating hammers to crush and grind materials.
   - Common in the agricultural and food industries.
4. **Roller Mills**:
   - Use cylindrical rollers to crush and grind materials.
   - Often used in grain processing and mineral industries.
5. **Impact Mills**:
   - Use high-speed impact forces to break materials.
   - Includes devices like air classifiers and pin mills.
6. **Stirred Mills**:
   - Utilize a stirring mechanism to enhance grinding efficiency.
   - Suitable for fine and ultra-fine grinding.
7. **Jet Mills**:
   - Use high-velocity jets of air or steam to grind materials.
   - Ideal for producing very fine particles.
8. **Surface Grinders**:
   - Used for precision grinding of flat surfaces.
   - Typically use a rotating grinding wheel.
9. **Cylindrical Grinders**:
   - Designed for grinding cylindrical parts.
   - Can be manual or automatic.
10. **Belt Grinders**:
    - Use an abrasive belt to grind or polish materials.
    - Common in metalworking applications.

11. **Angle Grinders**:
    - Handheld power tools for grinding, cutting, and polishing.
    - Versatile for various materials and applications.

Gravity Concentration

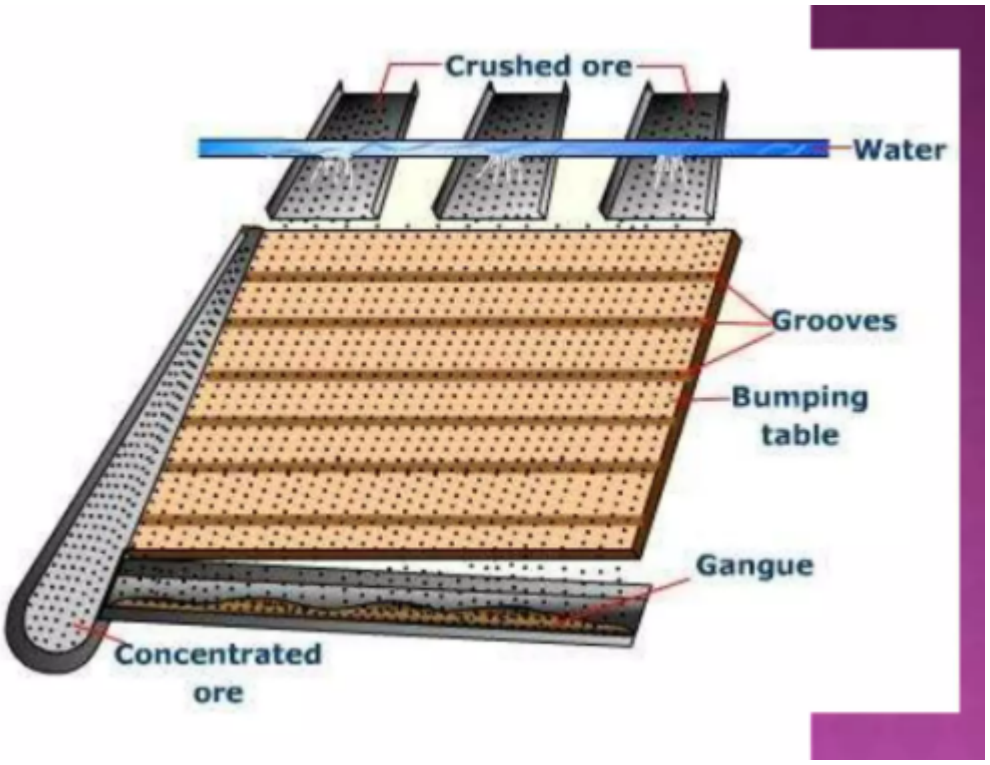
Flowing film concentration is a separation technique that leverages the principle of gravity to separate particles based on their specific gravity and size. It involves creating a thin, flowing film of liquid over a surface, allowing particles to settle within this film.

Key Principles

- **Gravity Separation:**
  - **Particle Settling:** Heavier particles settle faster than lighter ones due to gravity.
  - **Film Thickness:** A thin film enhances the separation process by minimizing the distance particles need to travel to settle.
- **Fluid Flow:**
  - **Laminar Flow:** The liquid flows in a laminar manner, ensuring smooth and predictable particle movement.
  - **Velocity Control:** The flow velocity is carefully controlled to optimize particle separation.
- **Surface Properties:**
  - **Surface Roughness:** The surface texture can influence particle behavior, affecting settling patterns.
  - **Surface Inclination:** The angle of inclination of the surface determines the flow rate and separation efficiency.

Wilfley Table

A Wilfley table is a gravity separation device commonly used in mineral processing to separate minerals based on their specific gravity. It's a classic example of a shaking table, where a slurry of minerals is fed onto a vibrating, inclined surface.



Operations of a Wilfley Table

- **Feed Preparation:**
  - **Crushing and Grinding:** The ore is first crushed and ground to liberate the valuable minerals from the gangue. The desired particle size typically ranges from 50 microns to a few millimeters.
  - **Slurry Creation:** The ground material is mixed with water to create a slurry, which helps transport the material onto the table.
- **Table Setup:**
  - **Inclined Surface:** The Wilfley table has a flat surface inclined at a slight angle to facilitate the flow of water.
  - **Riffles:** The surface is equipped with riffles or grooves that create turbulence and help capture heavier particles.
- **Feeding the Table:**
  - **Slurry Introduction:** The slurry is fed onto the table at a controlled rate. The feed is typically spread evenly across the width of the table to ensure consistent separation.
- **Water Flow:**
  - **Water Addition:** Water flows over the table's surface, creating a wave-like motion. This motion is essential for separating materials based on density.
  - **Adjustment of Water Flow:** Operators can adjust the flow rate of water to optimize separation, ensuring lighter materials are carried away while heavier materials settle.

- **Separation Process:**
  - **Gravity Action:** As the water flows over the inclined table, lighter particles (e.g., silica) are lifted and carried towards the discharge end, while heavier particles (e.g., gold, cassiterite) move down the table due to gravity.
  - **Concentration of Heavy Minerals:** The riffles help trap heavier minerals, allowing for the accumulation of concentrated valuable minerals along the grooves.
- **Collection:**
  - **Product and Tailings Collection:** The separated materials are collected from designated discharge points: the concentrate (heavier minerals) from one side and the tailings (lighter waste material) from the other.
- **Recovery and Recycle:**
  - **Recycling Water:** The water used in the process can be recycled to minimize waste and reduce operational costs.

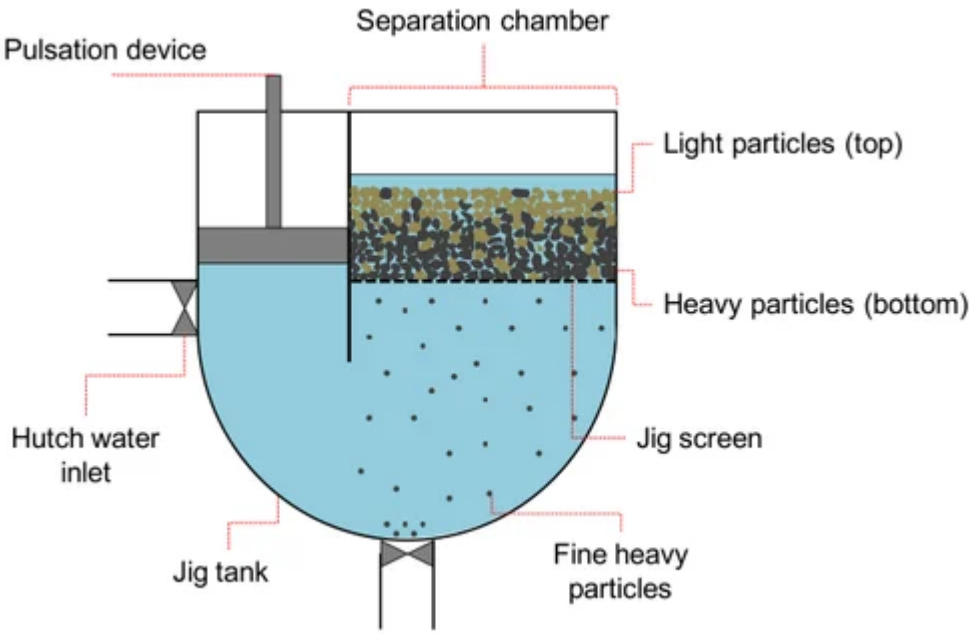
Applications of Wilfley Tables

- **Mineral Processing:**
  - Widely used for the separation of precious metals like gold and silver, as well as for tin, tungsten, and other heavy minerals.
  - Effective in concentrating ores that contain a small percentage of valuable minerals.
- **Coal Industry:**
  - Used for coal cleaning, separating high-quality coal from waste materials and improving the overall quality of coal products.
- **Recycling:**
  - Applied in the recycling of materials, such as separating metals from non-metallic waste in electronic scrap and automotive recycling.
- **Environmental Remediation:**
  - Can be used to recover valuable metals from contaminated soils and sediments, aiding in environmental cleanup efforts.
- **Laboratory and Pilot Testing:**
  - Utilized in laboratories for testing and pilot-scale operations to evaluate the viability of new mineral deposits.

Jigging

Jigging is a gravity separation technique that utilizes a pulsating water flow to separate minerals based on their specific gravity. Here's how it

works:



Principle of Jigging

- **Pulsating Water Flow:** A jigging machine generates a series of upward and downward pulses in a water column.
- **Particle Movement:** During the upward pulse, the lighter particles are lifted higher in the water column compared to the heavier ones.
- **Particle Separation:** As the water level drops during the downward pulse, the heavier particles settle through the lighter ones and are collected at the bottom of the jigging machine.

Mechanism and Working of Jigging

Jigging is a gravity separation technique widely used in mineral processing to separate particles based on their density differences. Here’s a comprehensive explanation of its mechanism and working:

Basic Principles of Jigging

- **Gravity Separation:** Jigging relies on the principle that denser particles will settle faster than lighter particles when subjected to gravitational forces.
- **Pulsation and Fluidization:** The jigging process introduces pulsation, creating variations in fluid velocity. This helps in separating heavier particles from lighter ones by allowing the heavier particles to sink while lighter ones are kept afloat.

Jig Structure

- **Tank:** A jig consists of a tank that is usually rectangular or circular, filled with water.
- **Screen or Perforated Plate:** Located at the bottom, this allows water to flow through while retaining the particles. The screen plays a crucial role in the separation process.

Working Mechanism

- **Feed Preparation:**
  - The ore is crushed and ground to liberate valuable minerals. The resulting material is mixed with water to create a slurry, typically containing particles ranging from fine to coarse.
- **Slurry Introduction:**
  - The slurry is introduced into the jig tank, where it is spread evenly across the surface to ensure optimal separation.
- **Pulsation Action:**
  - The jig generates a pulsating action either mechanically (through a plunger or piston) or pneumatically (using air). This action consists of alternating upward and downward movements:
    - **Upward Stroke:** During this phase, water and lighter particles are pushed upwards, allowing denser particles to momentarily suspend.
    - **Downward Stroke:** In this phase, the jig descends, and gravity pulls the heavier particles downwards, allowing them to settle at the bottom.
- **Fluidized Bed Formation:**
  - The pulsating motion creates a fluidized bed within the jig, where the particles are suspended in the water. Lighter particles are kept afloat while heavier particles settle down.
- **Separation Process:**
  - **Heavy Mineral Accumulation:** Heavier minerals accumulate at the bottom of the jig as lighter materials are carried upward.
  - **Cyclic Operation:** This separation process continues in cycles, effectively differentiating between heavier concentrates and lighter tailings.

End Working of Jigging

- **Concentrate Discharge:**
  - The heavier particles that settle at the bottom are periodically discharged through a designated outlet, collecting the concentrate.
- **Tailings Discharge:**

    - The lighter, unwanted material (tailings) overflows from the top of the jig and is collected separately.
- **Operational Adjustments:**
    - Operators can adjust parameters such as water flow rate, jig frequency, and stroke length to optimize separation efficiency and recovery rates.
- **Water Recycling:**
    - The water used in the jigging process can often be recycled back into the system, reducing water consumption and minimizing waste.
- **Final Processing:**
    - The concentrated materials may undergo further processing techniques (e.g., flotation, smelting) to extract the desired minerals before being prepared for market.

Factors affecting stratification in jigs

Stratification in jigs refers to the process of separating particles based on their density and size, leading to the formation of distinct layers or strata. Several factors can affect stratification in jigging operations. Here are the key factors:

Particle Size:

- **Size Distribution:** The size range of particles affects how they behave during the jigging process. Larger particles tend to settle more quickly than smaller ones, leading to better stratification.
- **Uniformity:** A more uniform particle size can enhance separation efficiency, while a wide size distribution can lead to poorer stratification.

Density Differences:

- **Specific Gravity:** Greater differences in density between particles lead to more effective separation. Heavy minerals will settle faster in a fluidized bed than lighter ones.
- **Density Ratio:** The greater the density ratio between the valuable minerals and gangue, the better the stratification.

Water Flow Rate:

- **Pulsation Frequency:** The frequency and amplitude of the jig’s pulsation influence the stratification process. Higher frequencies can improve the lifting of lighter particles while allowing heavier ones to settle.

- **Water Velocity:** An optimal water flow rate is crucial; too high can cause mixing, while too low may not provide sufficient lift for lighter materials.

Jig Design:

- **Type of Jig:** Different jig designs (e.g., mechanical, pneumatic) can affect the efficiency of stratification. The design of the screen or riffle configuration also plays a significant role.
- **Angle of Inclination:** The angle at which the jig is set can influence particle movement and settling rates.

Feed Rate:

- **Slurry Concentration:** A higher concentration of solids can lead to interference between particles, reducing the effectiveness of stratification. An optimal feed rate ensures efficient separation without overcrowding.
- **Distribution of Feed:** How the feed is distributed across the jig affects how particles interact and settle.

Time:

- **Residence Time:** The time particles spend in the jig affects their ability to stratify. Longer residence times may improve separation but can lead to reduced throughput.

Viscosity of the Slurry:

- **Fluid Characteristics:** The viscosity of the slurry can influence the movement of particles. Higher viscosity can hinder particle mobility and affect the efficiency of stratification.

Riffle Design and Configuration:

- **Riffle Height and Spacing:** The height and spacing of the riffles on the jig surface can impact how particles are captured and how effectively stratification occurs.
- **Surface Texture:** The texture of the jig’s surface can also affect how particles interact with the riffles.

Operational Parameters:

- **Pulsation Timing:** The timing of the upward and downward strokes can influence the stratification process, affecting how effectively heavier

particles settle.
- **Adjustments During Operation:** Real-time adjustments based on observed stratification can enhance the efficiency of the process.

Clasification of Jigs

They are of Two types

- Hand Jigs
- Mechaical Jigs

Hand Jigs

This is the simplest of all Jigs. It consists of a framed sieve held by hand and actuated by the operator with a reciprocating vertical motion. Generally a perforated cylindrical shape conntainer is used for this purpose. after filling up the vessel with nimerals up to the desidred level it is closed tightely. With a rope and pully arrangement it is made to move up and down in a water tank to attain the condition of pulsion and section of water in the mineral bed.
The process is repeated for several times complete statification takes place. This type of Jig is mainly used in the lab to demonstrate the effect of jigging operation.

Mechaical Jigs

Mechaical Jigs are of verious type.

- Fixed sieve Plunger jig
- Fixed sieve Pulsator jig
- Pneumatic or Baum jig

Fixed sieve plunger jig

A fixed sieve plunger jig is a type of gravity concentration equipment used in mineral processing to separate minerals based on their specific gravity. It's a relatively simple yet effectiv

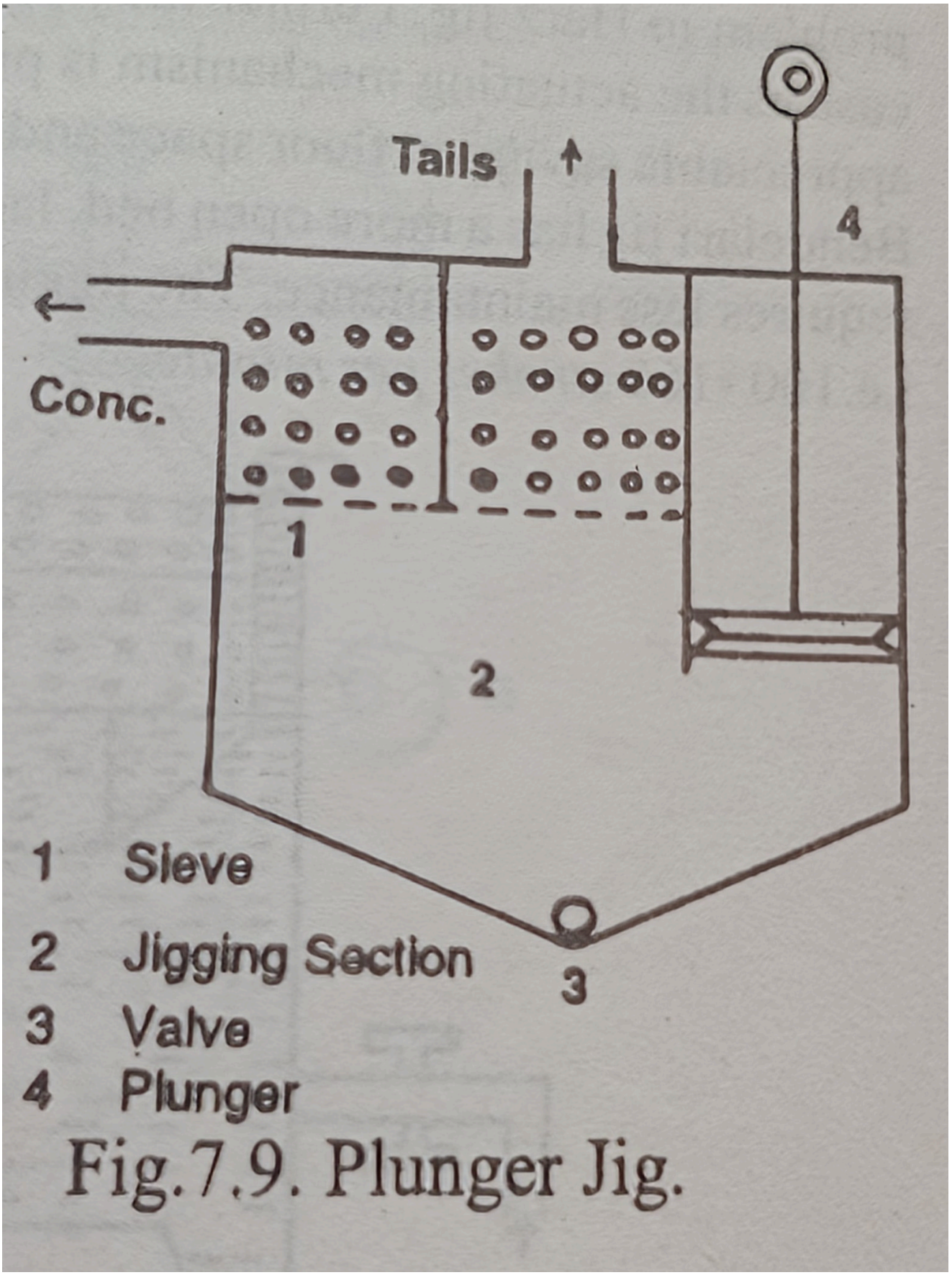


Fig.7.9. Plunger Jig.

e device that has been used for many years in the mining industry.

How it Works:

- **Feed Preparation:**
  - The ore is crushed and sized to a suitable particle size, typically between 10 and 100 mesh.

    - The prepared ore is fed into the jig's feed box.
- **Plunger Action:**
    - A mechanical plunger, located beneath the sieve, moves up and down in a rhythmic pattern.
    - The downward motion of the plunger compresses the bed of ore on the sieve, forcing water and lighter particles upward through the sieve openings.
    - The upward motion of the plunger allows water to flow downward through the bed, carrying heavier particles deeper into the bed.
- **Stratification:**
    - As the plunger cycles repeatedly, the heavier particles settle to the bottom of the bed, forming a stratified layer.
    - Lighter particles remain near the top of the bed and are carried away by the upward flow of water.
- **Product Discharge:**
    - Heavier particles, concentrated at the bottom of the bed, are periodically discharged through a hutch or launder.
    - Lighter particles, which remain near the top of the bed, are discharged through an overflow.

Key Components of a Fixed Sieve Plunger Jig:

- **Feed Box:** Receives the prepared ore.
- **Sieve:** A perforated plate that retains the ore while allowing water to pass through.
- **Plunger:** A mechanical device that moves up and down to create a pulsating flow of water.
- **Hutch:** A compartment at the bottom of the jig where the heavier particles accumulate.
- **Overflow:** A channel through which lighter particles are discharged.

Fixed sieve Pulsator jig

A fixed sieve pulsator jig is a type of gravity separation equipment used in mineral processing. It operates on the principle of differential settling of particles in a fluid medium. Here’s a brief overview of how it works:

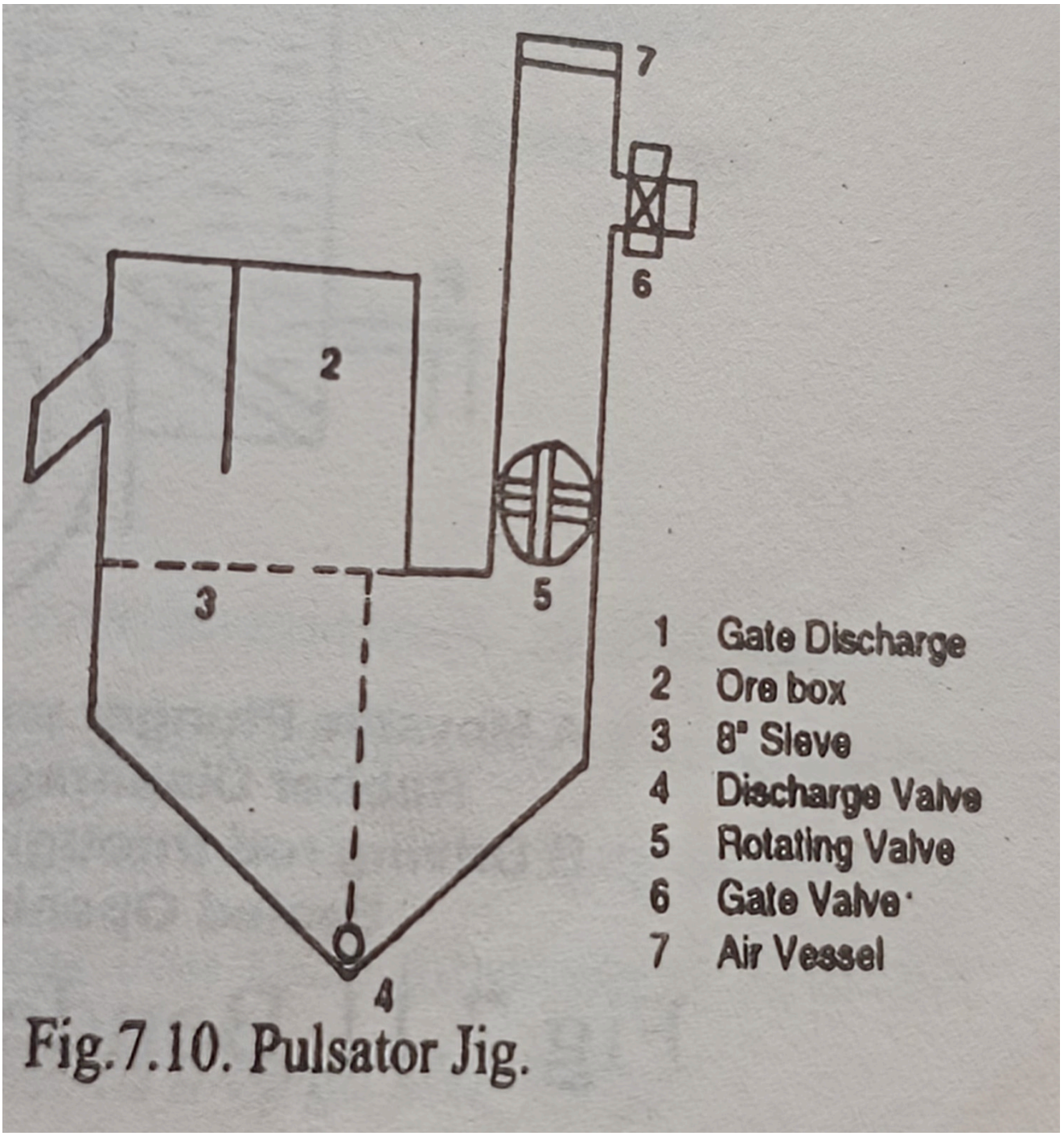


Fig.7.10. Pulsator Jig.

Working Principle

- **Feed Introduction**: The material (usually a slurry of ore and water) is introduced into the jig through a feed box.
- **Pulsation**: The jig has a pulsating mechanism that creates a vertical oscillation. This is often achieved using a piston or air chamber, which causes the slurry to be agitated.
- **Separation**:
  - **Sieve or Screen**: The jig features a fixed sieve or screen that retains larger particles while allowing smaller particles and lighter materials to pass through.
  - **Density Stratification**: As the slurry is pulsed, heavier particles (like gold or other minerals) sink and stratify at the bottom, while lighter materials are lifted and can be washed away.

- **Collection**: The separated materials are collected at different outlets. Heavier concentrates are typically found at the bottom, while lighter fractions are discharged from the top.
- **Continuous Operation**: The jig can operate continuously, allowing for a steady feed of materials and efficient separation.

Pneumatic or Baum jig

A Baum jig is a type of gravity concentration device that utilizes a pulsating water flow to separate minerals based on their specific gravity. It's a popular choice in the mining industry due to its simplicity, efficiency, and versatility.

How it Works:

- **Feed Preparation:**
  - Ore is crushed and sized to a suitable particle size, typically between 10 and 100 mesh.
  - The prepared ore is fed into the jig's feed box.
- **Pulsation Generation:**
  - Compressed air is introduced into an air chamber located on one side of the U-shaped jig vessel.
  - This creates a pulsating water flow that moves up and down through the bed of ore on the sieve.
- **Stratification:**
  - During the upward stroke of the water, lighter particles are carried upward through the sieve openings.
  - During the downward stroke, heavier particles settle deeper into the bed.
  - This repeated cycle of upward and downward flow causes the particles to stratify based on their specific gravity.
- **Product Discharge:**
  - Heavier particles, concentrated at the bottom of the bed, are periodically discharged through a hutch or launder.
  - Lighter particles, which remain near the top of the bed, are

discharged through an overflow.

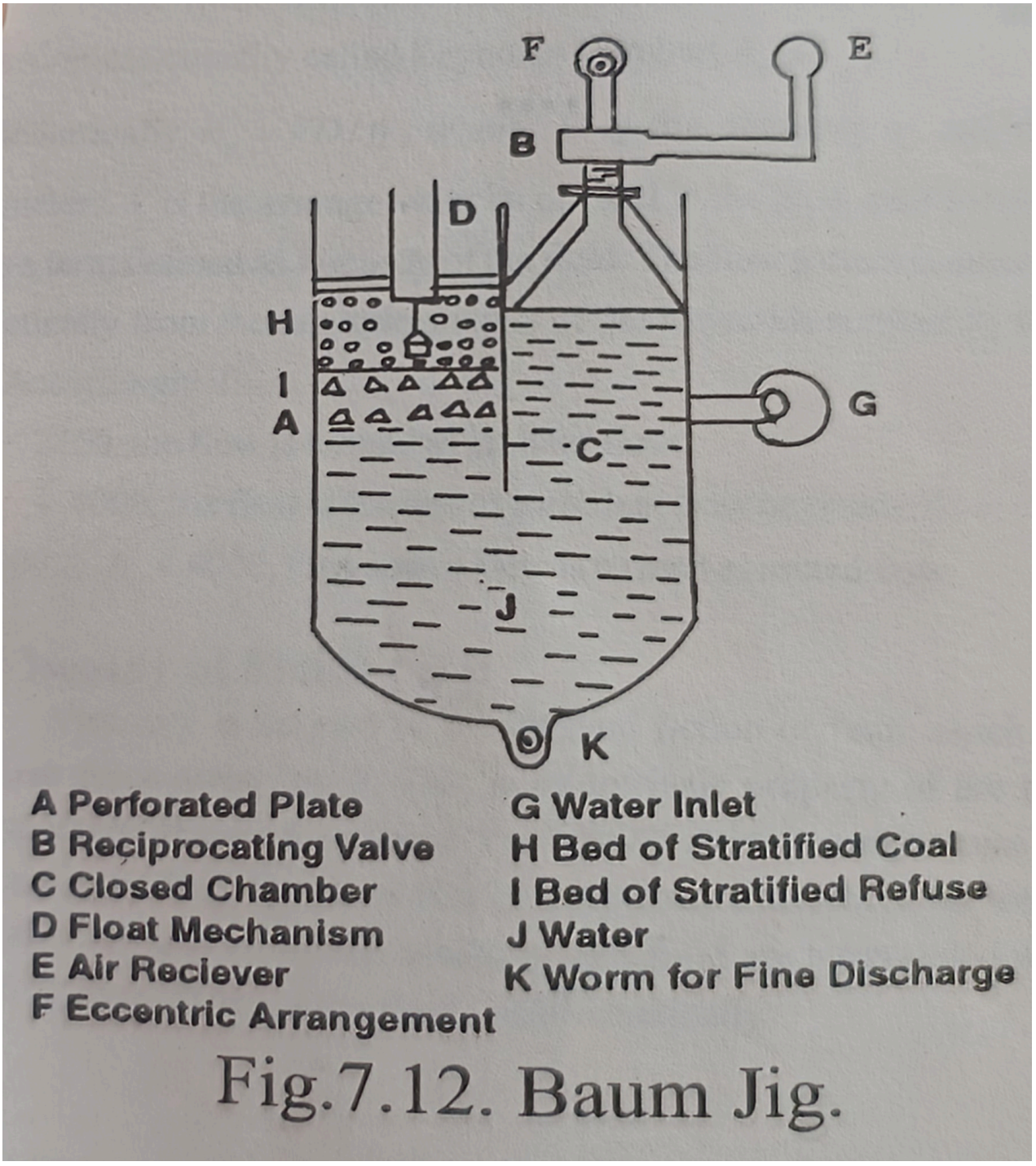


Fig.7.12. Baum Jig.

Application of Jig

Jigs are versatile gravity separation devices widely used in the mineral processing industry. They are particularly effective for separating minerals based on their specific gravity, especially when dealing with coarse-grained materials.

Here are some of the primary applications of jigs:

1. Mineral Processing:

- **Metallic Minerals:**

    - Gold
    - Silver
    - Copper
    - Lead
    - Zinc
    - Tin
- **Non-Metallic Minerals:**
    - Coal
    - Diamonds
    - Industrial minerals (e.g., barite, fluorite)

2. Recycling Industries:

Jigs can be used to recover valuable materials from various waste streams, such as:

- **Electronic waste:** Separating metals like copper, gold, and silver.
- **Construction and demolition waste:** Recovering aggregates and other valuable materials.
- **Municipal solid waste:** Separating recyclable materials like glass, plastic, and metal.

3. Other Applications:

- **Food processing:** Separating food products based on size and density.
- **Chemical processing:** Separating different particle sizes and densities of chemicals.
- **Ceramic processing:** Separating clay particles based on size and density.

Heavy Media Separations

The fundamental principle of **heavy media separation (HMS)**, also known as **dense media separation (DMS)**, relies on using a dense liquid or suspension as a medium to separate minerals or particles based on their density differences. This process is widely used in the mining and mineral processing industries, particularly for separating valuable minerals from gangue (unwanted material).

Here's a breakdown of the HMS process:

1. **Dense Medium Creation**: A suspension or liquid medium with a specific density is prepared, typically using finely ground, high-density materials (such as magnetite or ferrosilicon powder) suspended in water. The density of this medium is carefully controlled and adjusted as needed.
2. **Feeding the Material**: A mixture of materials to be separated is fed into the dense medium. The particles in this mixture typically include materials with both higher and lower densities relative to the medium density.
3. **Separation**: Due to differences in density, materials behave differently in the medium:

   - Particles **heavier than the medium** sink.
   - Particles **lighter than the medium** float.

   This creates a natural split, separating the valuable (denser) particles from the lighter gangue.
4. **Collection and Recycling**: The separated materials are collected as distinct products, one containing the denser material and the other containing the lighter material. The medium is often recycled for reuse in the process to reduce costs and environmental impact.

Industrial Processes Using Heavy Liquids

Three different processes have been developed until now using true heavy liquids. The processes are:

- Lessing Process.
- Bertrand Process.
- Du Pont Process.

Lessing Process

Lessing process is used to clean coal in a solution of calcium chloride having an approximate specific gravity of 1.4. It is most useful in separating **coal from clay & slate**.
Lessing's Settling Tank: Settling takes place in a cylindrical tank of 30 ft height & 6-10 ft. diameter with a conical bottom as shown schematically in the figure.

Graded raw coal freed from dust and fines is introduced into the tank through a central pipe to mix up with the separating solution thoroughly. As per "float & sink" principle cleaned coal floats up and is removed from the tank by a chain scrapper or any such mechanical arrangement.
The slate, shale and sand drop to the 'conical bottom and are removed by the help of a bucket conveyor. Both cleaned coal and slate are delivered to the draining towers. After draining, they are washed clean of the $CaCl_2$ solution. The wash liquor is returned to the concentration tank for recalculation $CaCl_2$ solution to the settling tank. 320 liters of $CaCI_2$ 1iquor is withdrawn from the separating tank after each ton of raw coal cleaned.
During cleaning of coal the specific gravity of the parting solution drops to 1.2 from 1.4 due to addition of wash water and inherent moisture in the coal. 320 liters of parting liquid withdrawn from the tank is made-up to 640 titers and concentrated to a volume to yield CaCl2 71 solution of specific gravity 1.4. Subsequently the solution is recirculated to the

separating tank for further cleaning of coal.

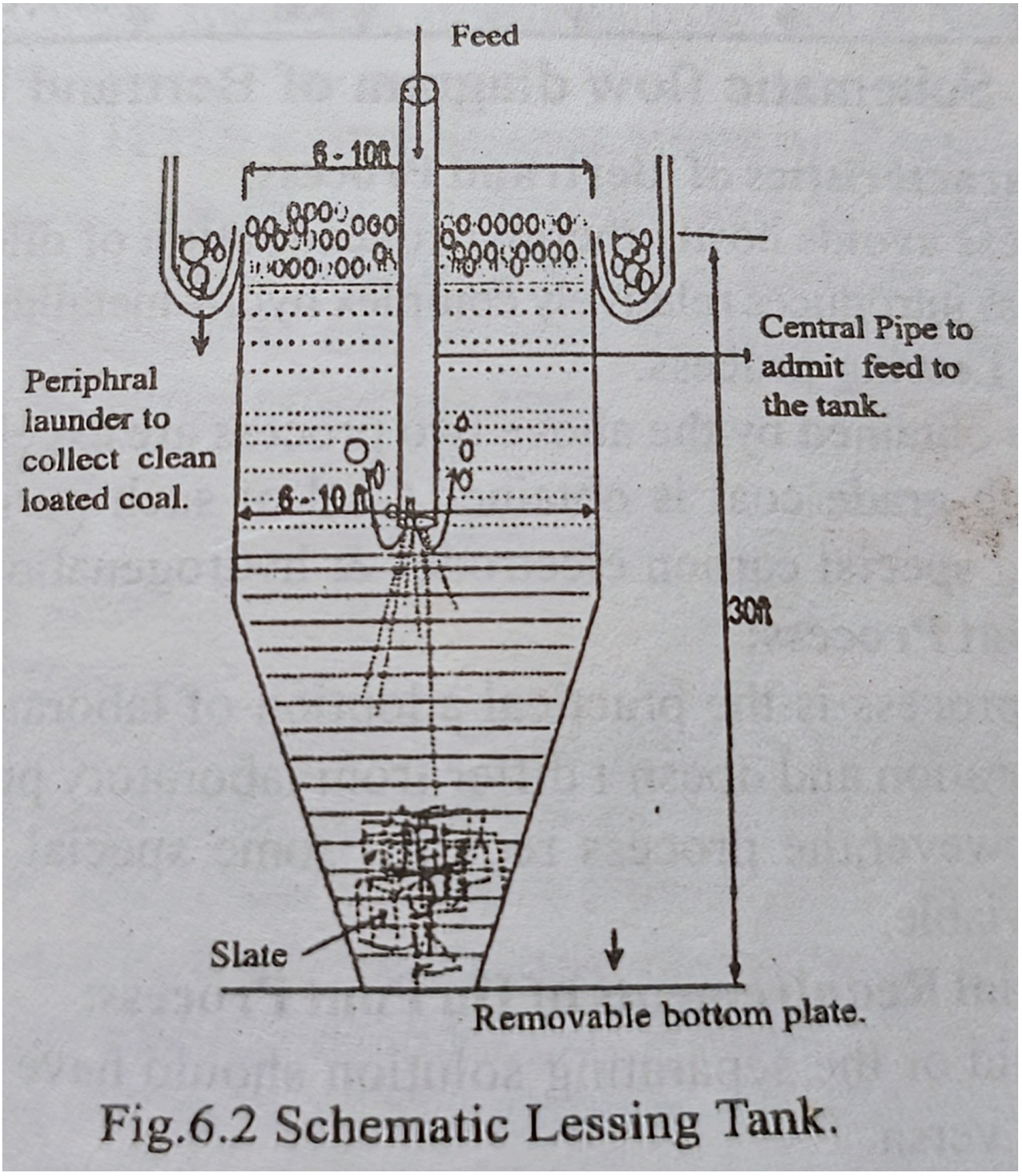


Fig.6.2 Schematic Lessing Tank.

Process Characteristics:

- The loss of calcium chloride solution during washing of coal is in the order of 2-3 liters per ton of raw coal cleaned.
- The process produces extremely clean coal.
- Because the process constitutes a costly thermal concentration process, widespread adoption of this process has been restricted.

Bertrand Process

Bertrand process also uses calcium chloride solution as separating medium and is applicable only to deslimed coal. The process is mainly utilized for washing of coal of 1-5mm size. This process is different to Lessing process with respect to feeding method. Here the feed material is charged into the system in a counter current fashion starting from water to separating solution. Purified coal & waste are being withdrawn in a similar counter current fashion.

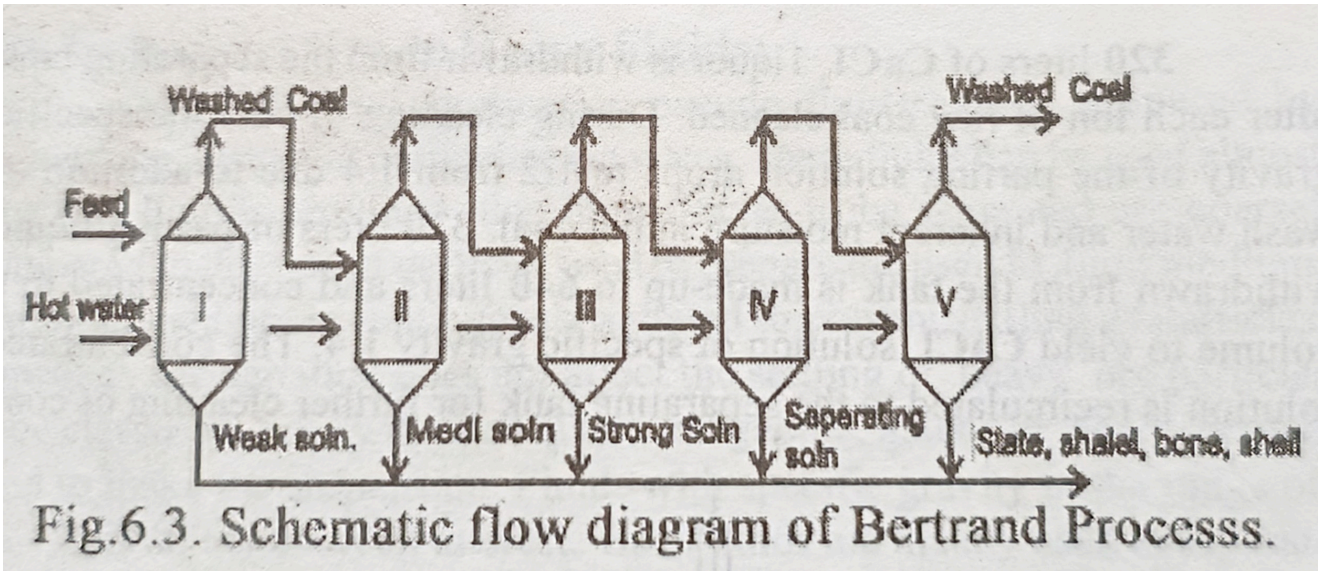


Fig.6.3. Schematic flow diagram of Bertrand Processs.

There are fivecirculating liquors such as hot water, weak solution, medium solution, strong solution & separating solution as shown schematically in the figure.

Characteristics of the process:

- This process avoids costly thermal concentration of dilute solution.
- This process introduces relatively complex hydro-metallurgical flow sheet compared to Lessing process.
- The results obtained by the above two process are excellent and coal of extremely high grade coal is obtained.

Chance Process

Chance Process is in use for last 100 years for cleaning coal. The parting fluid is a suspension of quartz or sand particles in water. The sand used here is in the size range of -40 to +80 #. The Chance Cleaner consists of a separating tank or a Cone Separator in which sand suspension moves up gently. An agitator is used for stirring the suspension to prevent packing. The overflow of clean coal and sand passes over to the cleaning screens which desand and dewater the coal. Spray water is used for desanding. The specific gravity of the fluid is adjusted by varying the proportions of sand and water. For cleaning anthracite coal a heavier fluid is used than compared to the fluid used for cleaning bituminous

coal. Figure shows the Chance process schematically.

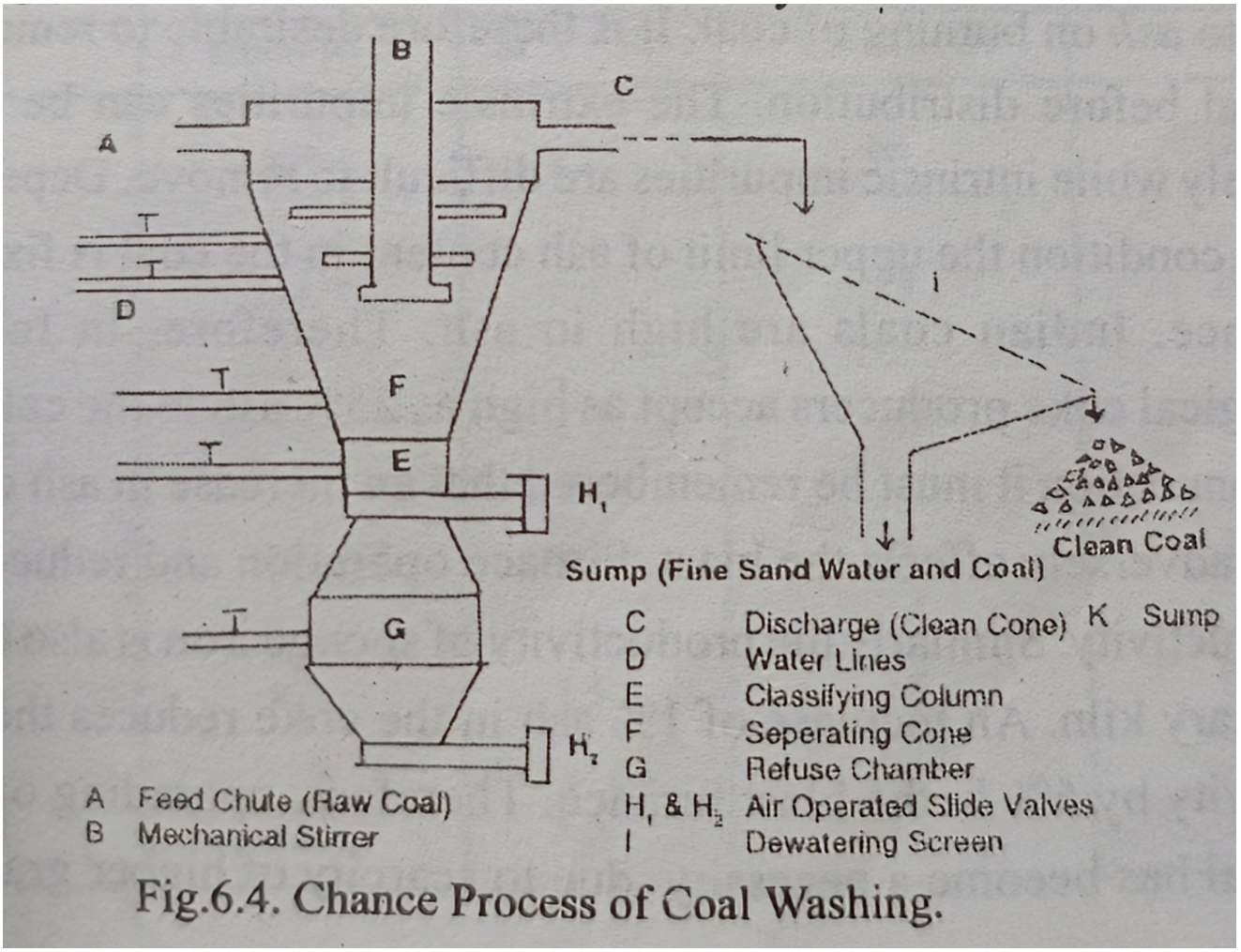


Fig.6.4. Chance Process of Coal Washing.

Flotation

Froth flotation and **skin flotation** are two methods of flotation used in mineral processing to separate valuable minerals from waste material based on differences in their surface properties.

Froth Flotation

Froth flotation is a widely used industrial process for the selective separation of hydrophobic (water-repelling) materials from hydrophilic (water-attracting) materials. This method relies on creating a froth at the surface of a flotation cell, where the target minerals attach to air bubbles and rise, forming a froth that can be skimmed off.

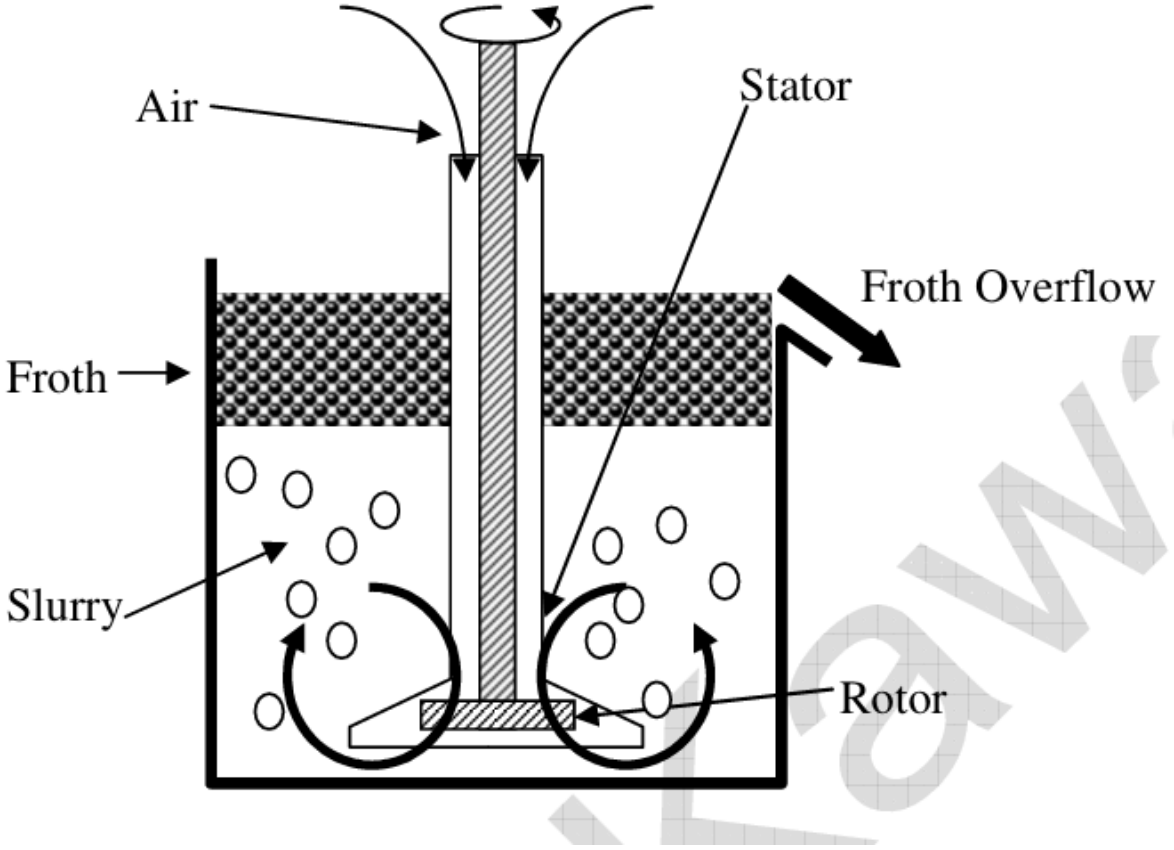
Skin Flotation

Skin flotation (or film flotation) is a type of flotation that relies on the selective adsorption of minerals onto the surface (or "skin") of bubbles rather than froth. It is generally used for materials with low wettability and involves a thin, stable layer of bubbles where minerals adhere and form a “skin” that can be skimmed off.

Principles of Froth Flotation

- **Surface Chemistry**:
  - Minerals can either have a natural affinity for water (hydrophilic) or repel water (hydrophobic).
  - Froth flotation takes advantage of this difference by treating the ore with **reagents** that selectively modify the surface properties of the minerals:
    - **Collectors**: Make the mineral surface hydrophobic, promoting bubble attachment.
    - **Frothers**: Help stabilize bubbles so they do not burst prematurely.
    - **Depressants**: Prevent certain minerals from becoming hydrophobic, allowing selective separation.
- **Bubble Attachment**:
  - When air is bubbled through a slurry (a mixture of finely ground ore and water), hydrophobic particles attach to the air bubbles and rise to the surface.
  - Hydrophilic particles remain in the solution and are not carried by the bubbles.

- **Formation of Froth**:
  - The air bubbles carrying the hydrophobic particles rise to the top of the flotation cell, forming a froth layer.
  - This froth contains the valuable mineral particles, which can then be skimmed off.
- **Separation and Collection**:
  - The froth layer, containing the concentrated valuable minerals, is continuously removed, while the remaining gangue (waste material) stays at the bottom and is discarded.



Froth flotation being a physico-chemical process requires a number of chemical reagents for its successful operation. Broadly the flotation reagents can be classified under following categories:

- Frothers
- Collectors
- Modifiers.

Frothers

These are the group of compounds that help to stabilise the foam. Apart from stabilising the bubbles, they also help in the effective removal of foam and separation of gangue. The desired properties of a typical frother are that it should be able to generate foam so that minerals can be

separated. They must be easily soluble in water with a fair degree of homogeneity.

The most commonly used frothers are generally the compounds of the carbonyl group, hydroxyl group, amino group and carboxyl group. Alcohol-based frothers are the best types of frothers.

Frothers can be divided into two types:

- Natural frothers: For example, Pine Oil, Cresol, etc.
- Synthetic frothers: For example, MIBC (Methyl Isobutyl Carbinol), Cytec Oreprep 549. Natural frothers are generally used less often because of lesser availability and lower productivity.

Collectors

A collector is such a type of organic compound that selectively attaches to the surface of the minerals and adds water-repelling nature to the particles, a very critical factor for the adhesion of mineral particles to the air bubble.

Collectors are commonly divided into three types – nonionic, anionic or cationic.

Non-ionic collectors: These are simple hydrocarbon oils that are needed to increase the water-repelling nature of those minerals which have low hydrophobic strength, such as coal. This is done by selective adsorption of oils by the minerals.
Examples of non-ionic collectors are fuel oil and kerosene oil.

Anionic collectors: These collectors consist of a non-polar part and an ionic part in the anionic part of the compound, while the cationic part has no important function enhancement of hydrophobic nature.
Examples: Carboxylates (Oxyhydryls), also known as soaps.
Examples of carboxylates are salts of oleic acid and linoleic acid. Soaps generally are more beneficial compared to other ionic collectors because they have a long chain of fatty acids and can easily dissolve in water. These anionic collectors can be used for the separation of ores of alkali metals and alkaline earth metals like calcium, magnesium, barium, strontium, etc.

Cationic collectors: In such collectors, the cationic part of the compound plays a very important role in increasing the surface properties of the mineral. The ionic part is generally the nitrogen of the compound amines. They undergo physisorption and get bonded to the mineral through the

electrostatic force of attraction. Due to this reason, these cationic collectors have low adhesive force.

Activators

These reagents activate the mineral surface towards the action of the collectors by enhancing their chemical properties. Therefore, they are often called friends of collectors. Generally, they are easily ionisable soluble salts that react with the mineral surface. A very common example of an activator is in the case of the sphalerite ore, in which zinc is easily separated by the formation of zinc-xanthate.

Deactivators

These reagents deactivate the mineral surface towards the action of collectors by changing their chemical properties. Hence, they are also called the enemies of the collectors. They increase the selectivity of flotation by preventing one mineral from flotation while allowing another mineral to float unrestricted.

Depressants can be classified into two categories:

- Inorganic depressants such as sodium cyanide, zinc sulphate, etc.
- Organic depressants such as starch, tannin, quebracho, dextrin, etc.

pH Modifiers

pH is also a very important factor in the process of floatation. Even a slight change in the pH of the slurry can result in a loss of productivity and efficiency of the operation. Thus, to ensure the optimum use of the resources and production, maximum pH modifiers are used. Lime, sodium carbonate, sodium hydroxide and ammonia are often used to maintain the basic nature of the slurry, whereas sulphurous and sulphuric acids are used to maintain the acidic medium.

Industries in Odisha

Aluminium Industries in Odisha

1. **National Aluminium Company Limited (NALCO)**
   - NALCO is a public sector enterprise and a significant player in the aluminium sector. It operates a **bauxite mine** and an **alumina refinery** at Damanjodi, Koraput district, with a production capacity of **21 lakh tonnes per annum (TPA)** for alumina. Additionally, it has an aluminium smelter and a captive power plant at Angul with a capacity of **4.6 lakh TPA**[
2. **Vedanta Limited**
   - Vedanta's facility in **Jharsuguda** is notable as one of the world's largest single-location aluminium smelters, boasting a production capacity of **1.8 million tonnes per annum (MTPA)**. This plant significantly contributes to India's total aluminium production and employs around **3,500 direct and 15,000 indirect workers**
3. **Hindalco Industries**
   - Hindalco operates the **Aditya Aluminium** smelter in Lapanga, Sambalpur district, with a capacity of **360,000 tonnes**. This facility is supported by a captive power plant and sources alumina from Utkal Alumina, a subsidiary of Hindalco

Copper Industries

India is one of the major producers of copper, and the copper industry plays a significant role in the country's industrial and economic growth. The major copper industries in India are involved in mining, refining, and manufacturing copper products. Here are some of the key players and sectors within India's copper industry:

1. Hindustan Copper Limited (HCL)

- **Overview**: A public sector company and India's only vertically integrated copper producer.
- **Operations**: Involved in mining, beneficiation, smelting, refining, and casting copper.
- **Key Mines**: Khetri Copper Complex (Rajasthan), Malanjkhand Copper Project (Madhya Pradesh), Taloja Copper Project (Maharashtra).

2. Sterlite Copper (A Vedanta Group Company)

- **Overview**: One of India's largest private-sector copper producers.
- **Operations**: Operates a refinery and smelter in Thoothukudi, Tamil Nadu, with a significant share in refined copper production.
- **Controversy**: The Thoothukudi plant has been shut since 2018 due to environmental concerns and protests.

3. Hindalco Industries

- **Overview**: A flagship company of the Aditya Birla Group.
- **Operations**: Known for its copper division, it produces refined copper and by-products such as sulfuric acid and gold.
- **Plant**: Operates a state-of-the-art copper smelter in Dahej, Gujarat.

4. Birla Copper

- **Division of Hindalco Industries**.
- **Key Operations**: Focuses on copper refining, wire rods, and value-added products like continuous cast rods.

5. National Mineral Development Corporation (NMDC)

- **Role**: Although primarily involved in iron ore, NMDC is expanding into copper mining.

Tin industries

Electronics and Electrical Components

Tin is widely used for soldering in electronics. The demand is driven by the growing electronics manufacturing sector in India, with hubs like:

- Bengaluru, Karnataka.
- Chennai, Tamil Nadu.
- Noida, Uttar Pradesh.

Tinplate Manufacturing

Tinplate is extensively used in packaging industries, especially for food, beverages, and chemicals. Major players include:

- **Tinplate Company of India Limited (TCIL)**: Based in Jamshedpur, Jharkhand, a subsidiary of Tata Steel.
- **JSW Steel Limited**: Produces tin-coated steel products.

Zinc Industries

India is a major producer of zinc, and the most prominent zinc plant in the country is operated by **Hindustan Zinc Limited (HZL)**, a subsidiary of Vedanta Limited. Hindustan Zinc is one of the largest integrated producers of zinc, lead, and silver in the world.

Major Zinc Plants in India:

1. **Chanderiya Lead-Zinc Smelter (CLZS)**, Rajasthan:
   - Located in Chittorgarh, Rajasthan.
   - One of the largest zinc smelters in India.
   - Produces zinc, lead, and other by-products.
2. **Debari Zinc Smelter**, Rajasthan:
   - Situated near Udaipur, Rajasthan.
   - Focuses primarily on zinc production.
3. **Dariba Smelting Complex**, Rajasthan:
   - Located in Rajsamand district, Rajasthan.
   - Includes both lead and zinc smelters.
4. **Pantnagar Metal Plant**, Uttarakhand:
   - Focuses on value-added zinc products.
   - One of the newer plants contributing to HZL’s operations.
5. **Rampura Agucha Mine**, Rajasthan:
   - Not a processing plant but one of the world's largest zinc mines.
   - Supplies raw material to various smelters.

These plants collectively contribute significantly to India's zinc production and make the country a key player in the global zinc market.

Nickel Industries

India does not have a significant domestic production of nickel, as the country relies heavily on imports for its nickel needs. However, there are some notable facilities and developments related to nickel in India:

1. **Hindustan Copper Limited (HCL):**
   While primarily a copper producer, HCL has explored opportunities in extracting nickel from its copper ore processing.
2. **Nickel Refining at Ghatsila:**
   HCL operates a small-scale nickel plant at Ghatsila in Jharkhand. This plant focuses on recovering nickel from copper tailings. The production capacity is relatively limited and primarily caters to domestic demand for specific industries.
3. **Import and Processing:**
   Since India lacks significant nickel reserves, much of the nickel used

in stainless steel production and other industrial applications is imported. The raw material is then processed by private companies and steel manufacturers like Tata Steel and Jindal Stainless Limited.

4. **Future Developments:**
   India has been exploring the possibility of nickel mining and processing, particularly as nickel is a critical material for batteries in electric vehicles (EVs). The government has encouraged investments and exploration in this sector to reduce dependency on imports.

If you have a specific plant or project in mind, let me know for more tailored information!

Titanium Industries

India is a significant player in the titanium industry, given its abundant resources of titanium-bearing minerals, particularly ilmenite and rutile. The following are some major titanium industries and organizations in India:

1. Kerala Minerals and Metals Limited (KMML)

- **Location**: Chavara, Kerala
- **Overview**: KMML is a public sector company and one of the largest producers of titanium dioxide in India. It mines ilmenite and processes it to produce titanium dioxide pigment.
- **Products**: Titanium dioxide pigment, titanium sponge (used in aerospace and defense), and other value-added products.

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2. Indian Rare Earths Limited (IREL)

- **Location**: Various plants across India, including Kerala, Odisha, and Tamil Nadu.
- **Overview**: A Government of India enterprise under the Department of Atomic Energy, IREL is a major producer of ilmenite, rutile, zircon, and other minerals used for titanium production.
- **Products**: Ilmenite, rutile, and rare earth compounds.

---

3. V. V. Mineral

- **Location**: Tamil Nadu

- **Overview**: One of the largest private producers of heavy mineral sand in India, specializing in ilmenite, rutile, and zircon. The company exports titanium-bearing minerals worldwide.
- **Focus**: Mining and export of raw materials for the titanium industry.

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4. Mishra Dhatu Nigam Limited (MIDHANI)

- **Location**: Hyderabad, Telangana
- **Overview**: A public sector enterprise under the Ministry of Defence, MIDHANI manufactures high-performance metals and alloys, including titanium alloys for aerospace, defense, and other high-tech industries.
- **Products**: Titanium and titanium alloy products like plates, rods, and forgings.

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5. Tata Steel Mining Ltd.

- **Location**: Odisha
- **Overview**: Tata Steel Mining is involved in mining ilmenite and other minerals. The company focuses on sustainable mining practices and is investing in value-added production related to titanium.

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6. Trimex Sands

- **Location**: Andhra Pradesh
- **Overview**: Trimex Sands operates one of the largest mineral sand processing facilities in India. It produces ilmenite, rutile, and zircon, which are key raw materials for titanium production.
- **Products**: Heavy mineral concentrates and titanium-bearing minerals.

Gold Industries

India is one of the largest consumers of gold globally and has a substantial gold industry, including mining, refining, and jewelry production. Here are the key segments and major players in India's gold industry:

1. Gold Mining

- **Hutti Gold Mines Company Limited (HGML)**:
  - Located in Karnataka, HGML is the only primary gold producer in India.
  - It operates mines at Hutti, Uti, and Hirabuddini in Karnataka.
- **Bharat Gold Mines Limited (BGML)**:
  - Historically managed the Kolar Gold Fields in Karnataka, now defunct since 2001.
- **Gold Exploration by Private Players**:
  - Companies like Deccan Gold Mines Ltd. are involved in gold exploration, but large-scale mining is limited.

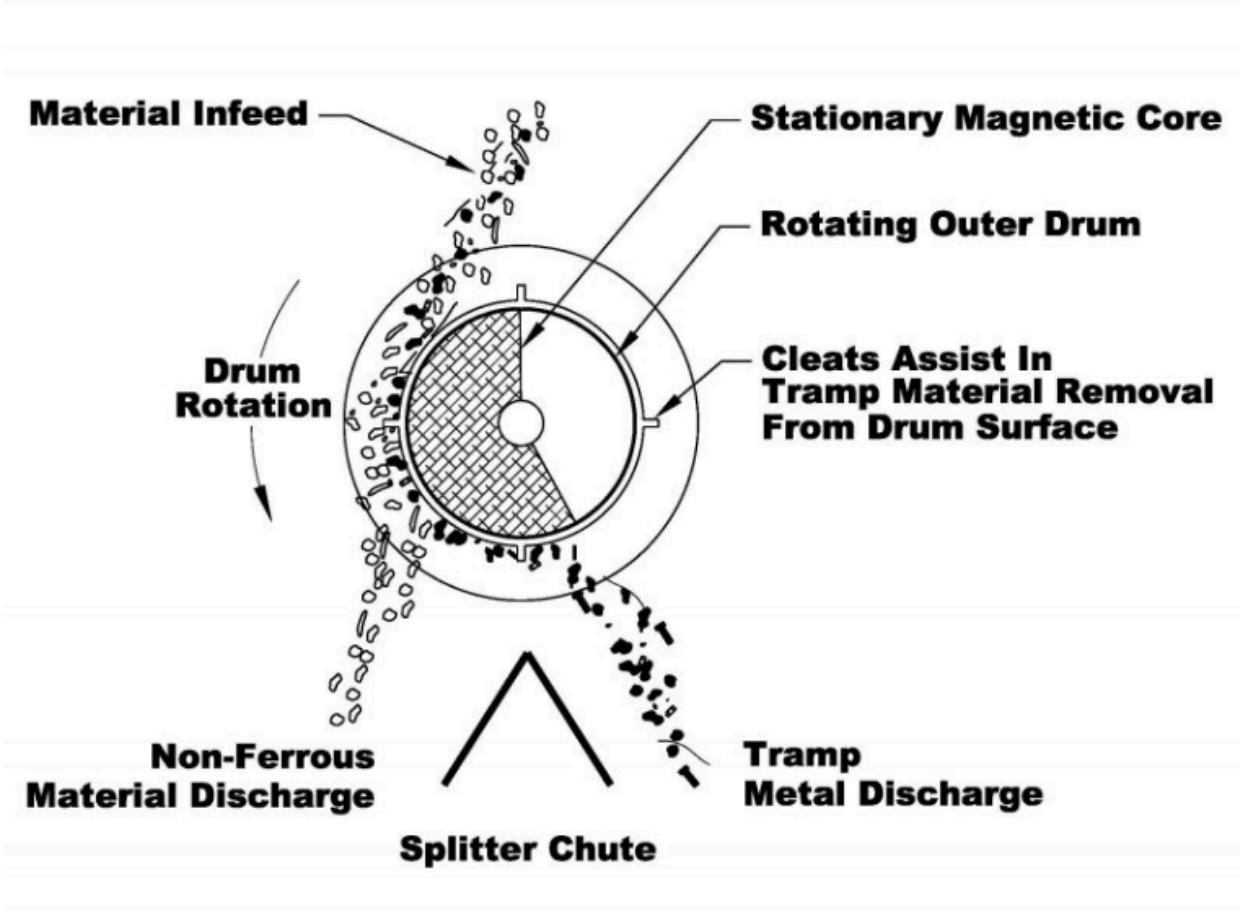
2. Gold Refining

- **MMTC-PAMP India Pvt. Ltd.**:
  - A joint venture between MMTC (a government entity) and PAMP (Switzerland-based).
  - Operates one of the largest gold refineries in India.
- **National India Bullion Refinery (NIBR)**:
  - A significant player in gold refining.
- Other major refineries:
  - Shirpur Gold Refinery, Kundan Gold Refinery, and others.

Magnetic & Electrostatic Separator

Magnetic Separation

Magnetic separation exploits the magnetic properties of materials to separate them from non-magnetic substances. When a magnetic field is applied to a mixture, magnetic materials are attracted to the magnetic source, while non-magnetic materials remain unaffected.



Components of a Drum Magnetic Separator

- **Magnetic Drum**: This is the primary component and contains magnets arranged in a specific pattern inside a cylindrical shell. The drum rotates and is responsible for attracting ferromagnetic particles as it passes through the material.
- **Non-Magnetic Shell**: The drum is typically encased in a non-magnetic shell, which allows the magnetic field to act on the materials outside the shell without interference.

- **Magnetic Field Source**: Magnets or an electromagnet inside the drum generate a magnetic field. Permanent magnets (usually ferrite or rare-earth magnets) are more commonly used in drums.
- **Feed Hopper/Chute**: The feed system introduces the material into the separator.
- **Discharge Systems**: These channels collect the separated materials: magnetic particles are separated and removed from non-magnetic materials through separate discharge outlets.

Working Principle of Drum Magnetic Separator

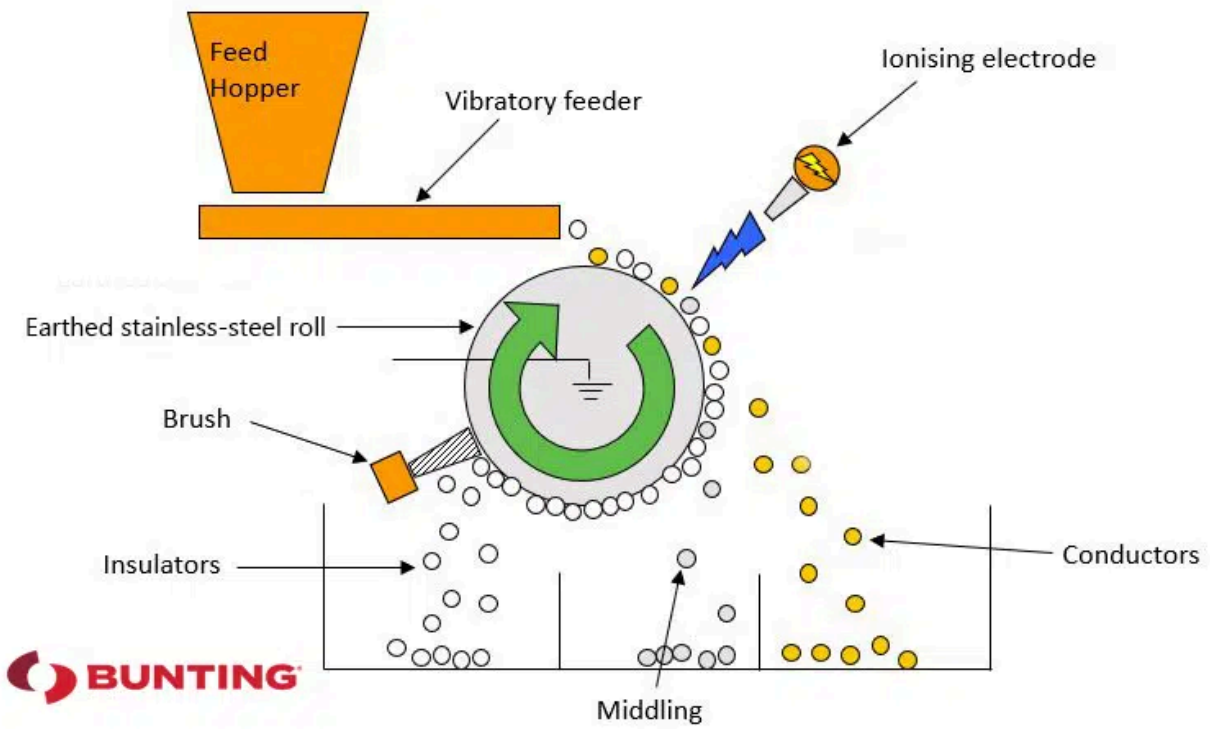
The working principle of a drum magnetic separator revolves around the magnetic field generated by the drum and the difference in magnetic properties between different materials.

- **Material Feeding**: The material to be separated is fed onto the surface of the rotating drum. This feed material may contain both magnetic (e.g., iron, magnetite) and non-magnetic materials.
- **Magnetic Attraction**: As the drum rotates, the magnetic particles are attracted to the drum's magnetic field, which holds them on the surface of the drum.
- **Separation Process**:
  - **Magnetic Particles**: Magnetic particles adhere to the drum due to the magnetic force as the drum rotates.
  - **Non-Magnetic Particles**: Non-magnetic materials, unaffected by the magnetic field, either fall off or move along a separate path due to gravity or centrifugal force.
- **Discharge**: As the drum continues rotating, magnetic particles are carried by the drum until they reach a point where the magnetic field becomes weak (usually due to a break in the magnetic circuit within the drum). Here, the magnetic particles are released into a separate discharge chute.

Applications of Drum Magnetic Separators

- **Mining**: Separating iron ores and other ferromagnetic minerals from crushed rock or crushed ore.
- **Recycling**: Removing iron particles from recycled materials to prevent equipment damage or increase the purity of the recycled products.
- **Food Processing**: Removing metal contaminants from foods to ensure safety and compliance.
- **Ceramics and Glass**: Purifying the raw materials by removing iron contaminants.

Electrostatic Separation



Basic Principle of Electrostatic Separation

Electrostatic separation is based on the electrical properties of materials. When two materials are rubbed together or subjected to a high-voltage field, they can become charged with opposite polarities (positive and negative). In electrostatic separation:

- **Conductive Materials**: Conductors, like metals, quickly lose their charge and thus don't retain an electrical charge for long.
- **Non-Conductive (Dielectric) Materials**: Non-conductors, like plastics and minerals, hold their charge longer and respond differently to an electric field.

Components of an Electrostatic Separator

- **Feeder**: The material is fed onto the separator via a vibratory feeder or other feeding mechanism, ensuring a thin, consistent stream.
- **High-Voltage Electrode**: This electrode creates an electric field by applying high-voltage power. The electrode may have a drum, plate, or wire design, depending on the specific application.
- **Separator Drum (or Roll)**: A rotating drum is typically used, which is charged with a high voltage. Materials pass through or near the drum, where conductive and non-conductive particles respond differently to the electric field.

- **Ground Electrode or Collecting Plates**: The separated materials are collected here after being influenced by the electric field.
- **Discharge Chutes**: These channels collect and direct the separated materials into designated bins or containers for further processing.

Working Principle of Electrostatic Separation

The process involves several steps where materials are subjected to a high-voltage electric field to achieve separation.

- **Material Charging**: The materials to be separated are usually fed in such a way that they come into contact with a charging device, which could be a high-voltage electrode or a charging drum. This step induces different charges on the materials.
- **Electric Field Application**: As the charged materials enter the electric field, they experience electrostatic forces based on their conductive properties.
  - **Conductive Particles**: Conductive materials quickly lose their charge when exposed to an electric field and are repelled by the high-voltage electrode. They are directed to a separate collection chute.
  - **Non-Conductive Particles**: Non-conductive particles retain their charge longer and are attracted to the oppositely charged electrode or fall under the influence of gravity into a different collection chute.
- **Collection of Separated Materials**: The separated materials are then collected through discharge chutes or by using additional equipment, like deflector plates, that directs the conductive and non-conductive materials into different collection points.

Applications of Electrostatic Separation

- **Mineral Processing**: Used for separating non-conductive minerals (such as quartz, feldspar) from conductive minerals (such as magnetite, ilmenite).
- **Recycling Industry**: Effective for separating metals from non-metals in scrap recycling and e-waste.
- **Plastic Recycling**: Separates different types of plastics or metals from plastics in recycling plants.
- **Food Processing**: Removing contaminants, such as shells or husks, from grains or seeds.