

Size Reduction

Size Reduction

- Size reduction is the process of decreasing the size of solid materials.
- It is essential across industries like pharmaceuticals, food, mining, and chemicals for enhancing processing, efficiency, and product quality.

Objectives of Size Reduction

1. Increase Surface Area

- Boosts reaction rates.
- Improves solubility and mixing.

2. Improve Handling & Processing

- Facilitates storage and transport.
- Ensures better mixture uniformity.

3. Control Particle Size Distribution

- Achieves specific product characteristics.
- Ensures consistent quality.

4. Facilitate Separation Processes

- Aids mineral separation.
- Improves filtration and sedimentation.

Mechanisms of Size Reduction

1. **Compression** – Material crushed between two rigid surfaces (e.g., jaw crushers, roll crushers).
2. **Impact** – Rapid force shatters the material (e.g., hammer mills, impact crushers).
3. **Attrition** – Friction wears down particles (e.g., ball mills, rod mills).
4. **Cutting** – Shearing slices material (e.g., knife cutters, shredders).

Factors Affecting Size Reduction

1. Material Characteristics

- **Hardness:** Harder = more energy.
- **Toughness:** May deform rather than break.
- **Moisture:** High content can cause clogging.

- **Friability:** Fragile materials break easily.

2. Type of Equipment

- Choice of crushers, grinders, mills, etc., affects performance.

3. Feed Size

- Larger input size requires more energy and stronger equipment.

4. Desired Product Size

- Finer output requires more precise or multiple stages of reduction.

5. Operating Conditions

- Includes temperature, pressure, and feed rate.

6. Foreign Materials

- Can reduce efficiency and damage equipment.

Laws Governing Size Reduction

- Several empirical laws describe the energy required for size reduction:



Laws Governing Size Reduction

1. Rittinger's Law:

- Suggests that the energy required for size reduction is directly proportional to the new surface area generated.

$$E = K_R \left(\frac{1}{D_1} - \frac{1}{D_2} \right)$$

- **Where**

- E = energy required
- Kr = Rittinger's constant
- D1 = initial particle size

- D2 = final particle size
- Applicable for fine grinding where the creation of new surface area is significant.

2. Kick's Law:

- Proposes that the energy required for size reduction is proportional to the size reduction ratio.

$$E = K_K \ln \left(\frac{D_1}{D_2} \right)$$

Where

- E = energy required
- k = Kick's constant
- D1 = initial particle size
- D2 = final particle size
- Best for coarse crushing where the size reduction ratio is small

3. Bond's Law:

- Combines the aspects of Rittinger's and Kick's laws and states that the energy required is proportional to the reduction in particle size based on the work index of the material.

$$E = K_B \left(\frac{1}{\sqrt{D_1}} - \frac{1}{\sqrt{D_2}} \right)$$

where

- E = energy required
- Kb = Bond's constant
- D1 = initial particle size
- D2 = final particle size
- Suitable for intermediate grinding processes.

Hammer Mill

Principle:

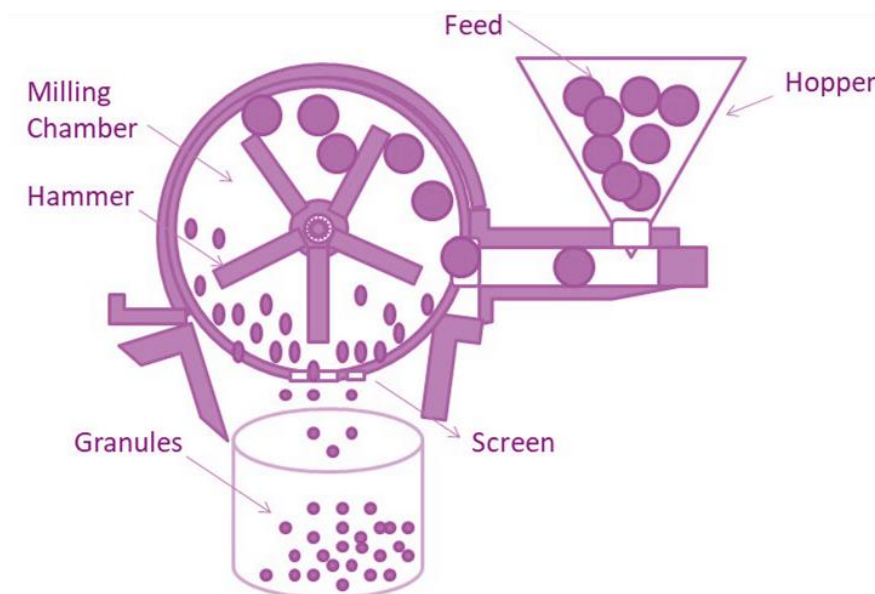
- Operates on the principle of impact and attrition.
- Material is fed into a grinding chamber where it is struck by hammers attached to a rotating shaft, resulting in size reduction through impact and shearing forces.

Construction:

1. **Grinding Chamber:** Cylindrical chamber where material is introduced.
2. **Hammers:** Swinging or fixed blades attached to a rotating shaft.
3. **Screen:** Perforated metal sheet allowing only particles of desired size to pass.
4. **Feed Mechanism:** Hopper for material input.
5. **Discharge Mechanism:** Outlet for processed material.

Working:

- Material is fed into the chamber and struck by rapidly rotating hammers.
- Size reduction occurs by impact and attrition.
- Desired particle size is achieved by passing through the screen.
- Processed material exits through the discharge mechanism.



Uses:

- Size reduction of a wide range of materials including grains, spices, pharmaceuticals, and chemicals.

Merits:

- Simple and robust construction.
- High throughput and efficiency.
- Capable of handling a wide variety of materials.

Demerits:

- High noise levels.



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