



## Size Reduction

1. Which of the following mills is based on the mechanism of impact and attrition for size reduction [GPAT-2024]

- (a) Roller mill            (b) Colloid mill            (c) Hammer mill            (d) Fluid energy mill

2. This given equation represents which law: [GPAT-2024]

$$E = K_k \ln(d_1/d_2)$$

- (a) Bond's law            (b) Fick's law            (c) Rittinger's law            (d) Kick's law

3. Rittinger's hypothesis relates [GPAT-2023]

[P] Energy used in size reduction

[Q] New surface area produced

[R] Equivalent shape

[S] Reynold's number

- (a) Pand Q            (b) Q and S            (c) P and R            (d) P and S

4. When adhesive attractions between molecules of different species exceeds cohesive attraction between like molecules, the deviation according to Raoult's law is said to be [GPAT-2020]

- (a) Partial            (b) Positive            (c) Neutral            (d) Negative

5. Hardinge mill is a variant of [GPAT-2019]

- (a) Fluid energy mill            (b) Ball mill            (c) Hammer mill            (d) Rotary cutter mill

6. Size reduction of a material with the addition of another material is called as [GPAT-2016]

- (a) Mixing            (b) Trituration            (c) Levigation            (d) Pulverization



# PHARMACEUTICAL ENGINEERING

## SIZE REDUCTION





### INTRODUCTION

- Size reduction is a process of **reducing large solid unit masses (vegetable or chemical substances) into small unit masses**, i.e., coarse or fine particles.
- It is also termed as **Comminution, Diminution or Pulverization**.
- The process of grinding a substance to a **very fine powder is called Trituration**

### □ FACTORS RELATED TO THE NATURE OF RAW MATERIAL

Factors	Description
<b>Moisture content</b>	<ul style="list-style-type: none"> <li>• Below 5% → Dry grinding</li> <li>• 5% - 50% → Wet grinding</li> </ul>
<b>Hard materials</b>	<ul style="list-style-type: none"> <li>• Iodine and pumice are hard and abrasive</li> <li>• Hammer mill or Fluid energy mill is used</li> </ul>
<b>Fibrous materials</b>	<ul style="list-style-type: none"> <li>• Liquorice (Glycyrrhiza), Rauwolfia, Ginger, etc.</li> <li>• They must be torn by Cutter mill</li> </ul>
<b>Friable materials</b>	<ul style="list-style-type: none"> <li>• Example: Sucrose, dried filter cake</li> <li>• Such materials are milled by mechanisms such as <b>attrition, impact or pressure</b> → e.g., Hammer mill, Fluid energy mill</li> </ul>
<b>Hygroscopic materials</b>	<ul style="list-style-type: none"> <li>• Example: Potassium carbonate (absorbs moisture readily)</li> <li>• Prepared in closed systems such as Porcelain Ball mill</li> </ul>
<b>Elastic materials</b>	<ul style="list-style-type: none"> <li>• Example: Synthetic gums, waxes, resins → become soft &amp; plastic during milling</li> <li>• Milled using Hammer mill, Colloid mill or Fluid energy mill</li> </ul>
<b>Thermolabile materials</b>	<ul style="list-style-type: none"> <li>• Substances undergo degradation reactions such as hydrolysis &amp; oxidation due to presence of moisture &amp; temperature</li> <li>• Vitamins and antibiotics are milled using Fluid energy mill and Ball mill</li> </ul>

### PRINCIPLES OF SIZE REDUCTION

Principle	Process	Mechanism	Example
<b>Cutting</b>		Sharp blades are used to cut	Cutter mill
<b>Compression / Nipping</b>		Pressure is applied to break material	Roller mill
<b>Impact</b>		A moving object strikes a stationary object	Hammer mill, Ball mill
<b>Attrition</b>		Material rubbed between surfaces moving relative to each other	Fluid energy mill, Edge runner mill

- **Ball mill** works on principle of Impact + Attrition
- **Hammer mill mechanism** = Impact
- **End runner mill principle** = Crushing and Shearing
- **Colloid mill** works on Shearing



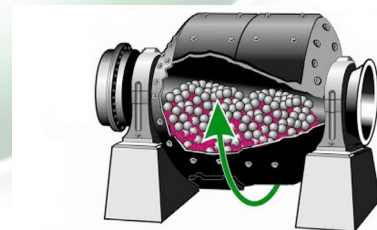
## □ THEORIES OF SIZE REDUCTION

<b>Rittinger's Theory</b>	<p>The energy required for size reduction is <b>directly proportional to the new surface area created.</b></p> <p>Where, <math>E=K_R (S_2 - S_1)</math></p> <ul style="list-style-type: none"> <li>• E = Energy required (kWh/ton)</li> <li>• <math>S_2</math> = Final surface area (<math>\mu\text{m}^2/\mu\text{m}^3</math>)</li> <li>• <math>S_1</math> = Initial surface area (<math>\mu\text{m}^2/\mu\text{m}^3</math>)</li> <li>• <math>K_R</math> = Rittinger's constant</li> </ul>
<b>Kick's Theory</b>	<p>The energy required for size reduction is <b>proportional to the ratio of the size reduction</b>, i.e., logarithmic relation of initial and final diameter.</p> <p>Where, <math>E=K_K \ln(d_1/d_2)</math></p> <ul style="list-style-type: none"> <li>• <math>d_1</math> = Initial diameter</li> <li>• <math>d_2</math> = Final diameter</li> <li>• <math>K_K</math> = Kick's constant</li> </ul>
<b>Bond's Theory</b>	<p>The energy required for size reduction is <b>proportional to the change in particle dimensions.</b></p> <p>Where, <math>E=2K_B(1/\sqrt{(d_2)}-1/\sqrt{(d_1)})</math></p> <ul style="list-style-type: none"> <li>• <math>d_1</math> = Initial diameter</li> <li>• <math>d_2</math> = Final diameter</li> <li>• <math>K_B</math> = Bond's work index constant</li> </ul>

Mill	Mechanism	Product size	Characteristics / Uses	Not used for
<b>Cutter mill</b>	Cutting	20–80 mesh	Fibrous crude animal & vegetable drugs	Friable material
<b>Roller mill</b>	Compression	20–200 mesh	Crushing & cracking of seeds before oil extraction, soft materials	Abrasive material
<b>Hammer mill</b>	Impact	4–325 mesh	Dry drugs, wet cake, ointments, slurries	Abrasive
<b>Ball mill (Pebble, Tumbling)</b>	Impact + Attrition	20–200 mesh	Brittle drugs, pigments, dyes, ophthalmic & parenteral products Variant = <b>Hardinge mill</b>	Soft material
<b>Fluid energy mill (Jet, Micronizer, Ultrafine grinders)</b>	Impact + Attrition	1–30 $\mu\text{m}$	Moderately hard, friable, antibiotics, vitamins	Soft & sticky material
<b>Edge runner mill</b>	Crushing + Shearing	20–80 mesh	Grinding tough materials to fine powder	Sticky
<b>End runner mill</b>	Crushing + Shearing	20–80 mesh	Almost all drugs	Sticky
<b>Colloid mill</b>	Shearing	3–75 $\mu\text{m}$	Preparing dispersions, emulsions, suspensions, ointments	Dry milling

## □ VARIANTS OF MILLS

Mill Type	Variant
<b>Cutter Mill</b>	Double Runner Disc Mill
<b>Roller Mill</b>	Multiple Smooth Roller Mill
<b>Hammer mill</b>	Fitzpatrick (FITZ Mill), Stokes Tornado Mill
<b>Ball Mill</b>	Hardinge Mill
<b>Fluid Energy Mill</b>	Central Impact Pulverize



### EXAM PUNCH

- Factors influencing size reduction include stickiness, hardness, softening temperature, but sublimation is not a factor
- **Fick's Law** is not related to size reduction.