

Particle Size Reduction

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Particle Size Reduction

- Other terms used to describe the operation: milling, grinding, crushing, chopping, comminution, micronizing.
Handwritten notes: بر فيه طحت طحت, سحق, تقطيع, نفس 1+2, تغيير حجم الـ Particle, Micro

- Most materials used in pharmaceuticals must be milled at some stage during the production of raw material or dosage form



Handwritten notes: الهياكل بجيبوا المادة الخام و بعد ذل تقطع حجم الـ Particle و يستعمل صوها

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Particle Size Reduction

Objectives of particle size reduction:

1. Facilitating drug release (dissolution rate) → لما تكون الـ Particle حجمها صغير
2. Exposing cells prior to extraction → لما بدى اعيل extraction لما زدت من فوات او حيوان فلما يحتاج حكيته عنه بالفايز السابق
3. Reducing the bulk volume of material → يكون حجمها كبر - اطحنها عفاها قدر استخلص المادة
4. Facilitating drying → تسهيل عليه التجفيف لانه اذا كانت حجم الـ Particle صغيرة رح تنشف بسرعة من الكبيرة
5. Helping good mixing → لتسهيل الخلط
6. Increasing adsorption capacity → adsorption هو الالتصاق بل السطح كلما كانت الـ Particle صغيرة زاد الـ adsorption
7. Some excipients need to be in very fine powder to do well their function (lubricants, colors) → الحيوب اكي بنسوفها ملونه تكون اللون

صفات الهاتى شكل Powder لكن يكون ناعم ومطحون وبنحافة Powder لونه ابيض
يس يا انه الـ Particle حجمها صغير الصيت مارج تميز وتفكر لون واحد

Theory of Size Reduction

Fracture mechanics

- Reduction of the particle size requires application of mechanical stress to the material.

المواد تستجيب للإجهاد (القوة المؤثرة عليها) عن طريق الانفعال أو التشوه (yielding) وينتج عن ذلك تكون انفعال أو تغير في الشكل (strain).

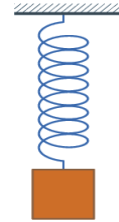
- Materials respond to stress by **yielding**, with consequent generation of **strain**.

- Hooke's law** → يعني كل ما زدت القوة التغير بالشكل رح يزيد

- Stress**: force
- Strain**: deformation or elongation of a solid body due to applying a str/stress/force

- Elastic**: reversible → زعي المطاطية قد ما شدتها رح ترجع ربيع ما كانت

- Plastic**: permanent, irreversible → بعد حد معين الـ Particle مارج ترجع لوضعها الطبيعي (irreversible) والعلاقة رح تغير Non-linear



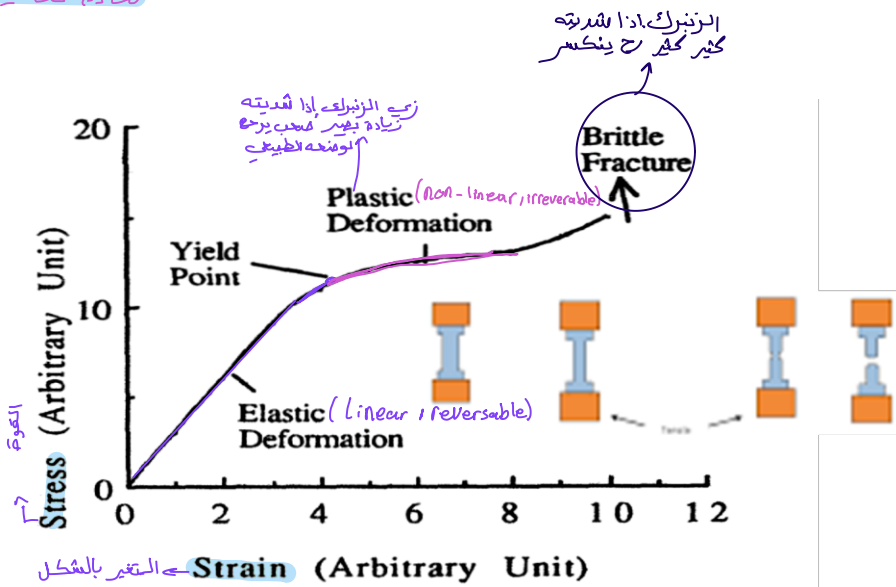


Fig. 19.1 Stress-strain diagram for a solid.

the **yield point** is the point on a stress-strain curve that indicates the limit of elastic behavior and the beginning of plastic behavior

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Theory of Size Reduction

Fracture mechanics

- The initial portion of the stress-strain diagram is linear and is defined by Hooke's law.
- In this portion the deformation is reversible (elastic deformation), i.e. the particle retains its shape if the stress is removed.
- After a certain point (yield point) the relation becomes nonlinear and the deformation becomes irreversible (plastic deformation). →

مرحلة
الاعود

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Theory of Size Reduction

Fracture mechanics

بحسب انظر الى هذا يظهر بسبب شغل باد Particle
او نقطة ضعف كانت موجودة قبل ما الحيف
ad stress



Crack propagation

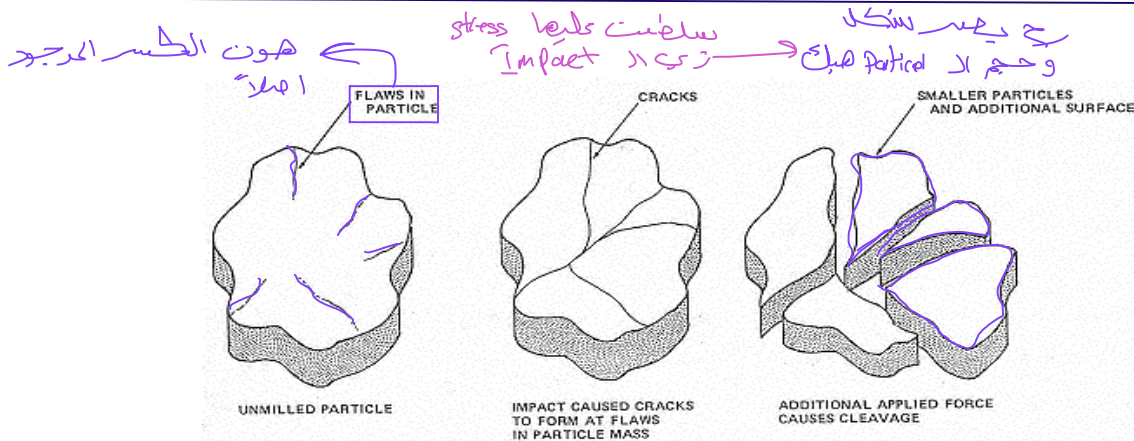
- Size reduction begins with the opening of any small cracks that were initially present.

- Flaws (defect)** → نقطة الضعف الموجودة بال Particle
- Larger particles fracture more readily than small particles as they contain more cracks.

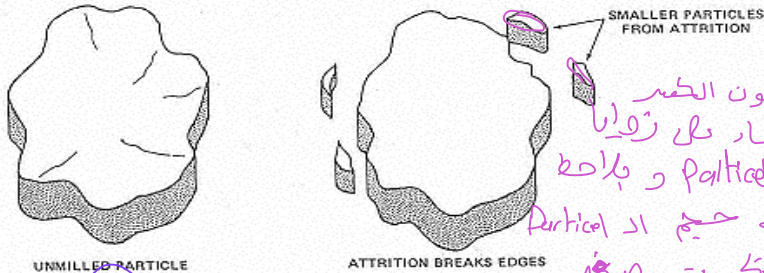
كل ما كانت ال Particle اكبر، رح
يكون فيها cracks اكثر

اما المخرقة ممكن ما يكون
فما اصلا cracks وانا
رحان فيه يتكون قليل

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طبيعت لو حاسه
Attrition ← stress
احتكاك
زي الجرد



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اد امانت ال stress
hopping (تقطيع)
شور رح يكون شكل
ال Particle اكي رح يتبع

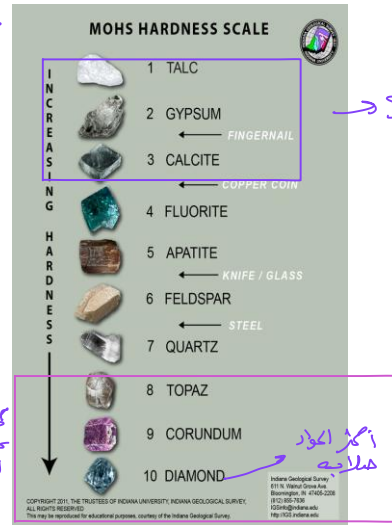


حسب ال stress الى طبيقة
رح يكون شكل ال Particle بعد
تطبيق ال stress

Influence of material properties on size reduction

Surface hardness (Mohs' scale) بصفتك المواد حسب هولاند

- The hardness of material can be described qualitatively by its position in Mohs' scale.
 - Materials from 1-3 are described as soft
 - Materials from 8-10 are described as hard
- Hardness is related to **abrasiveness**. قدرة المادة على التآكل كلما كانت أعلى
- Hard materials may cause **abrasion** to the mill. تآكلت قدرتها على التآكل



حسب نوع المادة
أي مدى استخدامها
بجهاز اد ملل لانه
ممكن كسرها
Mill

Influence of material properties on size reduction

Material structure

- Crystalline materials** fracture along crystal cleavage planes; **noncrystalline materials** fracture at random.

مرتبين بشكل
منتظم وصافي يسمى
نراعات



صاحب الخطوط هي
الاشعة (Crystal) هي
Cleavage plan
وهي التي مع شكل

- Fibrous materials** (e.g. crude drugs) need cutting or chopping action and can not be milled effectively by compression or impact.

نوع الزجاج
سكالم تيم
منتظم

المتكسر راح يكون عشوائي



Influence of material properties on size reduction

Moisture content →

نسبة الرطوبة ز تآثر على
عملية الطحن

- The presence of more than 5% water hinders comminution and often produces a sticky mass upon milling.

5% < مئوح

20% < يحطها بالoven لتوحد الـ 5%

30% < يحطها بالـ Wet mill

Stickiness →

زئى العلطة

- Sticky materials may adhere to the surface of milling machine or the screen
- This is a problem of gummy and resinous materials.

إذا كانت المادة زئى العلطة ز طزق على
المطينة وعلى الـ Screen

Particle بعد الطحن

Toxicity and harm

Potential of explosion (fine)

إذا كانت fine particle مطروقة بالآلة
مغطيت تغير مشحونه وتسبب
الانفجار

صمكت اعل Cutting او Chopping

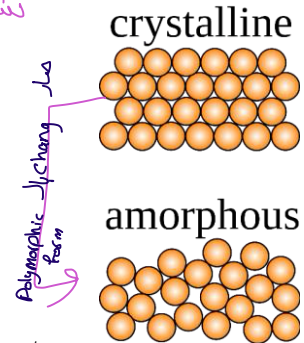
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Effect of size reduction on material properties

نشو زح زغير بعد الـ Milling

Milling of material may lead to:

1. Change of the polymorphic form
2. Dehydration of hydrates
3. Development of amorphous structure
4. Damage of thermolabile drugs due to heat involved.
5. Development of free static charge →



زئى 1

↑

ممكن تتلوث كهرباء
سالكه

2- المادة لما تنطحن ز تتولد حراره فإذا كان في H₂O بالمادة (تكون فيها نسبة رطوبة الماء) ز تبخر
وهذا بغير dehydration

1- برفقه اذا الحاده كانت حساسه للحراره ز تخرب بسبب الحراره الناجمه من الطحن

طاقة كهرمائية - طاقة حركية

الآلة تستخدم 2% للطحن طيب ومن
الـ 98% من 1 - 6

Energy requirements

The most efficient mills utilize as little as 2% of the energy input to fracture particles.

- The rest of energy is lost in:

1. elastic deformation of unfractured particles → الآلة ضغطت على الـ Particle بين ما وملت الـ paint لانت عسات ههنا
2. transport of materials within the milling chamber → الـ Particle رح ترجع لوقوعها الطبيعي
3. friction between particles
4. friction between particles and mill → الاحتكاك بين الـ Particle والـ الآلة والاحتكاك
5. heat → جزء من الطاقة رح تحول لطاقة حرارية نتيجة الاحتكاك
6. vibration and noise → الاهتزاز والارتفاع رح يكون بسبب طاقة خائفة (زمن الخلط)

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Energy requirements

ترتبط بين الطاقة
وبين الـ surface area
الـ Particle

Rittinger's theory

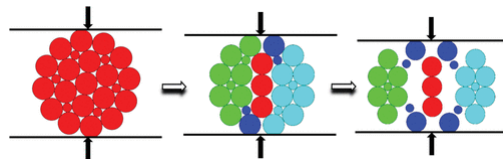
$$E = K_R(S_n - S_i)$$

S_i : the initial surface area,

S_n : new surface area → بعد الطحن

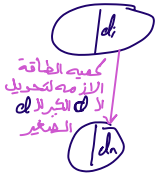
K_R = Rittinger's constant of energy per unit area

يعبر عن الطاقة المسطحة
كل المسطح



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دiameter و الطاقة يرتبط بين



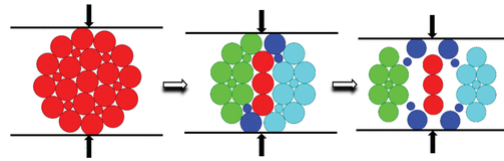
Kick's theory

$$E = K_K \log \frac{d_i}{d_n}$$

d_i : the initial **particle diameter**,

d_n : new particle diameter

K_K = Kick's constant of energy per unit mass → **يعبر عن الطاقة المسطحة لكل وحدة**



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Energy requirements

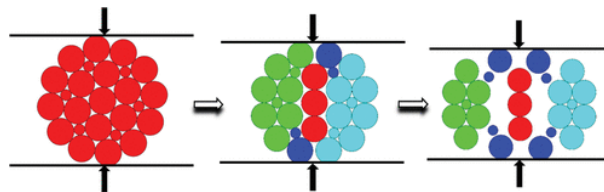
الطاقة مع مقلوب diameter

Bond's theory

$$E = 2k_B \left[\frac{1}{d_n} - \frac{1}{d_i} \right]$$

K_B : Bond's work index, **كمية الطاقة اللازمة لتحويل الحجم إلى**
 d_i : the initial particle diameter, **منها أكبر**
 d_n : new particle diameter **أصغر**

أكبر من $\frac{1}{d_i}$ لأنه **السرعة يطلع قيمة أكبر (أو أكبر من $\frac{1}{d_i}$)**



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Influence of milling on size distribution

- As milling progresses, the mean particle size decreases, and a material with initially a monomodal size distribution develops a bimodal size distribution.
- The primary component gradually decreases in weight and the secondary component increases in weight.
- Continued milling tends to eliminate the primary component to give a positively skewed (log normal) distribution with narrow size range.
- Milling rate follows first order kinetics

normal (log normal) size distribution



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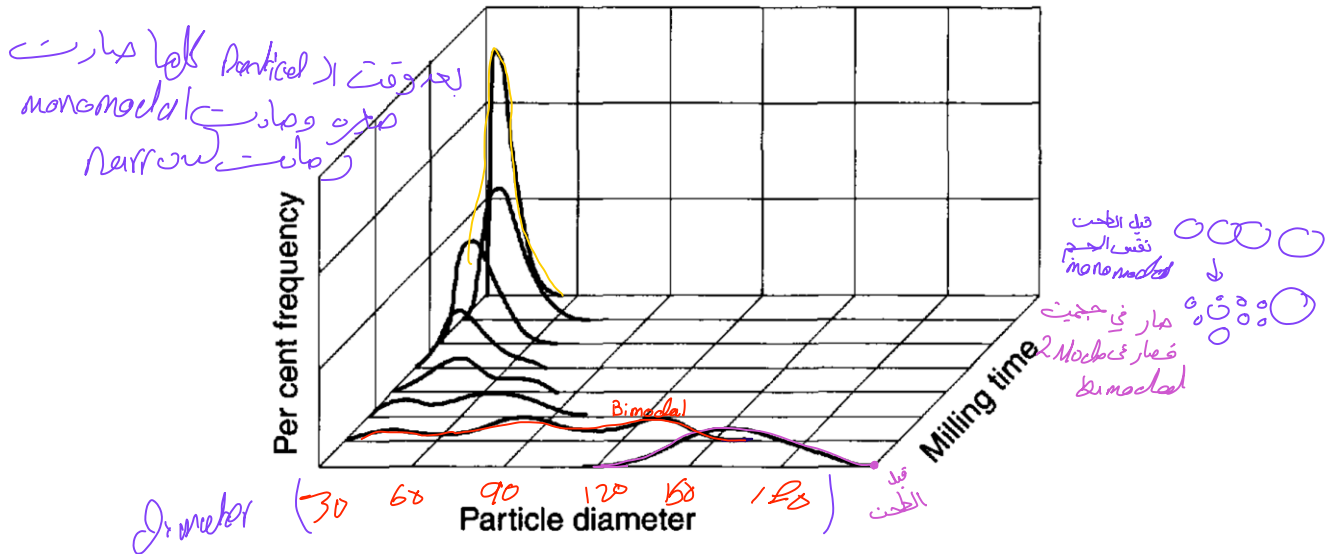


Fig. 11.2 Changes in particle size distributions with increased milling time.

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الانحناء سطح ثابت و سطح متحرك او السطحين متحركين بين كل واحد يتحرك بحسب الثاني

Mechanisms of size reduction

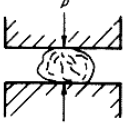
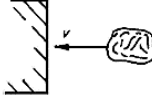
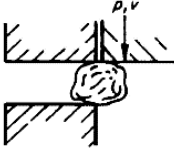
ضغط كاحودية
Compressive

المطرق
Impact

الاحتكاك
Attrition

Cut

بعضها كهيئة لوزم يكون فيها blade و knife و sharp
انحناء حاد

Force	Schematic diagram	Principle	Example of equipment
Compressive		Nutcracker	Crushing rolls
Impact		Hammer	Hammer mill
Attrition		File	Disc attrition mill
Cut		Scissors	Rotary knife cutter

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Mechanisms of size reduction

- There are four different mechanisms of size reduction:

a) Cutting

The material (particle) is cut by means of sharp blades or knives.

b) Compression

The particle is crushed by application of pressure.

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Mechanisms of size reduction

السطح ثابت ويضرب الـ Particle
أو الـ Particle ثابت ويضرب
على السطح ذي الحركة

c) Impact

The particle is hit by an object moving at high speed, or a moving object strikes a stationary surface.

D) Attrition

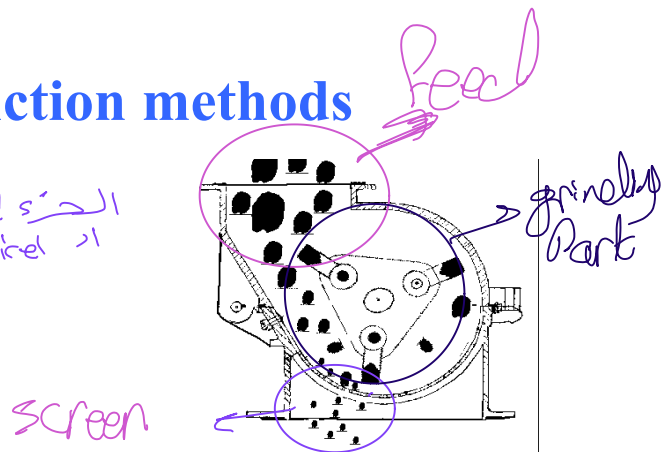
This involves breaking down of the material by rubbing between two surfaces that are moving relative (parallel) to each other.

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Size reduction methods

A mill consists of three basic parts:

- 1) Feed chute → الجزء الذي يدخل فيه Particle
- 2) Grinding part → الجزء الذي يطحن Particle
- 3) Discharge chute → Screen



- The manner (way and rate) in which an operator feeds a mill affects the product.
- In most cases the grinding effect is a combination of different mechanisms.

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Size reduction methods

- There are two ways of feeding: **choke feeding** and **free feeding**.
 ← بزرگ (Large) ← Feed مرة ← بزرگ (Large)
- In **open-circuit milling**, the operation is carried out so that the material is reduced to a certain size by passing it once through the mill.
- In **closed-circuit milling**, the discharge from the milling is passed through a classifier and the over-size particles are returned to the grinding chamber. ← سبب (Cause) ← سبب (Cause)
- closed-circuit milling is most valuable in reduction to fine and ultrafine size. ← بزرگ (Large) ← بزرگ (Large)

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Cutting methods

- Cutter mill (closed)
 - Principle of operation: It consists of a feed, a series of knives attached to a rotor which act against a series of knives attached to the mill casing, and a screen fitted in the base which control the particle size.
 - Uses:
 - Coarse degree of size reduction of dried granulations
 - Grinding of crude drugs such as roots and barks before extraction



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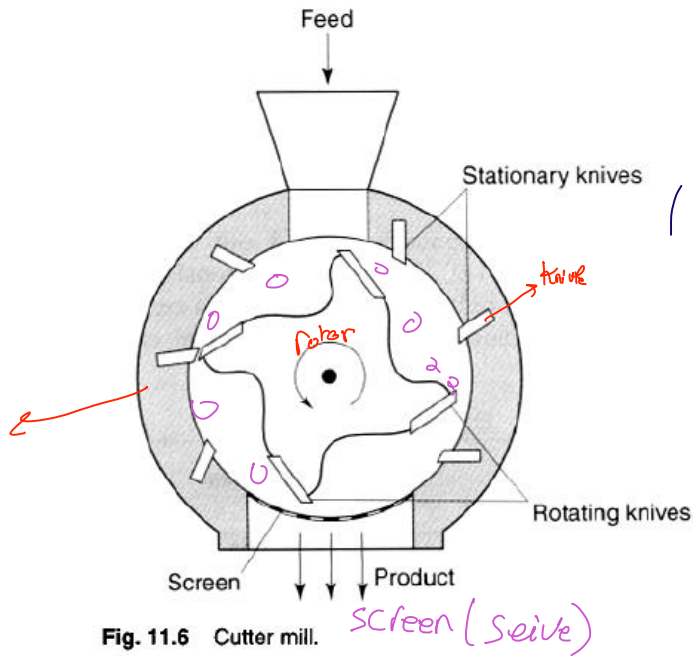


Fig. 11.6 Cutter mill.

Screen (seive)

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Compression methods

لطحنت
كس فلتة

- Size reduction by compression can be carried out on a small scale by pestle and mortar.
- End runner and edge runner mills are mechanized forms of mortar and pestle-type compression.

حجوم سالا
مالية

mortar and
pestle



edge runner
في "2" في
2 mortar



end runner
طوايه تات في
جبار الحط

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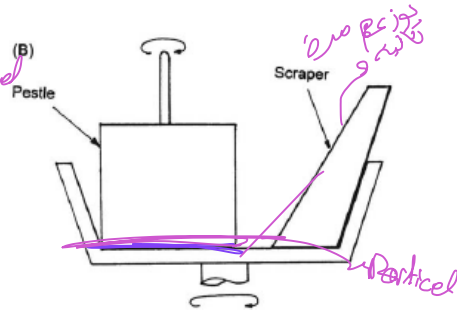
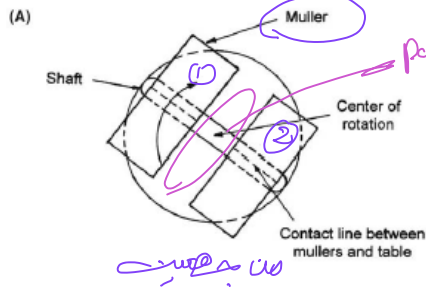


FIGURE 12.3 (A) Edge runner mill and (B) end runner mill.

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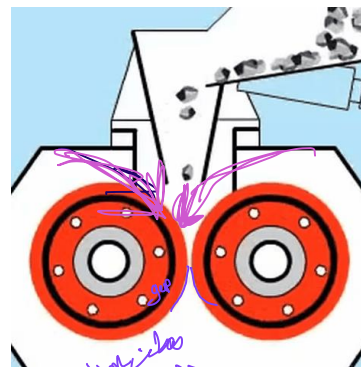
Compression methods

Roller mills

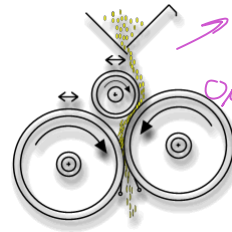
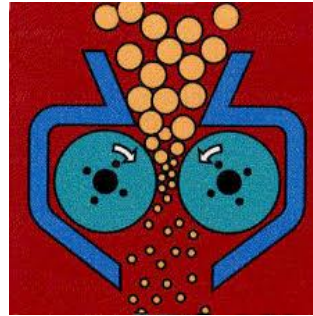
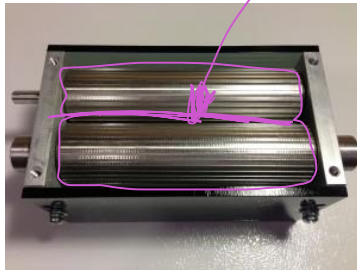
- Roller mills use two cylindrical rolls, mounted horizontally, and rotating about their longitudinal axis

One of the rolls is driven directly while the second is rotated by friction as material is drawn through the gap between the rolls.

Compression and attrition



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يمكن
الضغط
بما فيه

Roller mill (compression method)

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gap ↑

Particle size ↓
أو سطح

Compression methods

Roller mills

- The gap between the rolls can be adjusted to control the degree of size reduction.

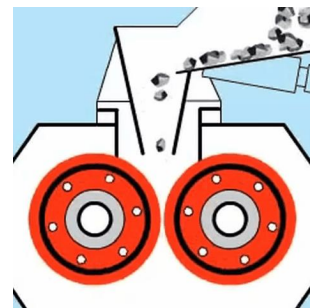
بقدر التحكم بـ gap

used

- Roller mills are used for crushing such as cracking seeds prior to extraction.

لكن قصور البنات

- This form should not be confused with the type used for milling ointments and pastes where **both** rolls are driven but at different speeds, so that size reduction occurs by attrition.



هذا الجهاز الـ roller

مستعمل في سحق البنية ويكون فيه بس

attrition بدون compression

إذا نريد simple crushing بخلاف الـ speed تكون بطيئة

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