

Powder flow

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امام اد سبب الى بدرس عتادها (Flow)

اد سبب / compressibility / ما يغير عالمائة stickiness

Filling نهاد pipes 11 tanks بار Flow 11 -

tablets يكتظون بعده عن ملأ بزنة 11 dies دار powder

الجية 11 اجي يعني Volume متوازن ما يوزن مثل

يط powder لذا يعني حجم 11 dies ، فلارم يتحبب صح لفداد العزوة عتاد 11 Correct Dose تكون

ادا في متغير بار Flow يكون غير ملائمة بار Dose

Powder flow

Powders are generally considered to be composed of solid particles of the same or different chemical compositions having equivalent diameters less than 1000 μm .



نحوة بینیم particles
 اد cohes Adhesive
 دماتن formula
 دماتن diff components

Importance of (free)powder flow

لیت بعثت بار Flow
 Powder J, tablet corp
 Powder hopper container
 نهاد ciap
 ادا filling machine

no stickiness
 no stoppage
 entrapped air

لیل انصار tablet
 بعدي حسب الحجم
 حسب سوابع اعجمي، يتبع وزن حين في
 عده معيدي، تسلام يعني حسب حجمها
 تتحقق صح

- Reproducible and uniform filling of tablet dies and capsules, which is necessary for weight uniformity of these dosage forms, requires free flowing of the powder from the feeder.
- Uneven powder flow can result in excess entrapped air within powders, which may promote problems (capping and lamination).
- Many industrial processes that require powder movement from one location to another (such as mixing, feeding, transfer, and fluidization) are affected by powder flow properties.

لقد اخذنا في الاعتبار (1) Powder دعا ، يعني المهم ، حسب مكان particles (2) اذ تكتسب دار بعدهما ، الاتكبس الهوا دار بعدهما ، فراح يتصعد فراح يحصل جزء من tablet داري بالمحورة After removing at the compression force - air expansion

مراحل التفريغ لدرهم يكون (Flow مناسب)

(2)

Particle properties

drug + excipient

drug / excipient

Adhesion and cohesion

- Cohesive and adhesive forces are composed mainly from:

- Short range non specific van der Waals forces:

- Increase as particle size decreases and is affected by relative humidity

- Surface tensional forces arising from adsorbed layer of liquid

- Electrostatic forces arising from contact or frictional charging

① Coh adh

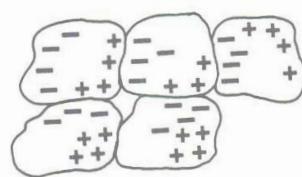
جذب معاين بجهة عدار اتفاقية
distance / distance
من اطراف ابتمان قوية لابكون في بين الجذب
molecules / molecules
surfaces / surfaces
particles / particles

atoms / particles / molecules: non specific
Short range forces: دفعات قوية في سطح معاين
attraction / جذب معاين / جذب معاين
attractive forces / جذب معاين / جذب معاين

net - انت اش موجو
charge / انت اش
polarizing / انت اش



PROCESSING AND/OR DRY PARTICLE MOVEMENT CAUSES POLARIZATION OF FINE PARTICLES (static electric forces)



POLARIZATION CAUSES AGGLOMERATION OF FINE PARTICLES (electrical charges induced by one particle on another van der Waals forces)

Figure 22 Effect of electrical forces on fine particles.

الجذب

irregular agglomerate

الجذب
friction
mixing
adhesion
attraction

induction
polarization
S.A
charge
high energy
small particles
energy (low energy)

الجذب
attraction
small particles
charge (large charge)

irregular agglomerate

Powder properties affecting bulk flow

Particle size

- Fine particles have high surface to mass ratios and are more cohesive (bad flowability). bad flowability » spherical

Particle shape

- Spherical particles have minimum interparticle contact and therefore optimal flow properties.

Particle density (True density)

- Dense particles are generally less cohesive than less dense particles of the same size and shape.

لوحن مادین نهناد سوزیواو Shape

Powder properties affecting bulk flow

Surface roughness of particles

- Rough surface of particles lead to bad flowability of powders.

Moisture content

- High moisture content causes increase surface-tensional cohesive forces and reduced flowability.

Electrostatic charge

flow will 'interfacial tension' \rightarrow Cohesive, جذب \rightarrow Chumbling

Small (neutral) $\xrightarrow{\text{polarizability}}$ high energy
Electrostatic
and reduced
agglomerate
bond flow
Arrangement

Solid, void مفهوم Mass-Volume relationship for powders

- A powder bed is composed of particles and voids. (1) (2) Solid
- Voids are:
 - Interparticulate voids: The air space between individual particles
 - Intraparticulate voids: Those within a single particle
 - Open to the external environment \rightarrow atmospheric: O_2 mainly
Solvent او ابخر سوائل environmental \downarrow mixing جاذب جذب \uparrow liquid
 - Closed to the external environment

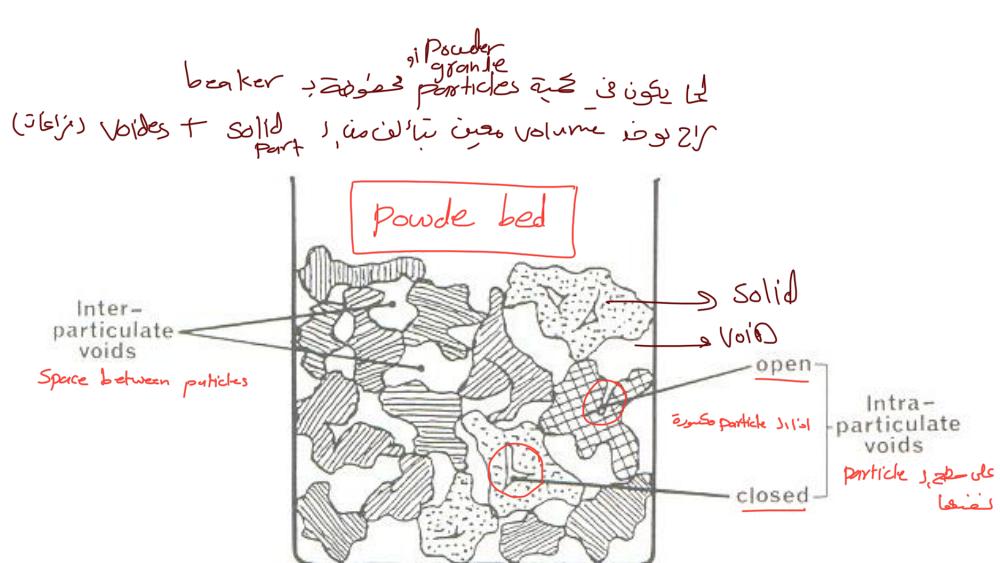


FIG. 4-4. Diagram of various intraparticulate and interparticulate air spaces in a bed of powder.

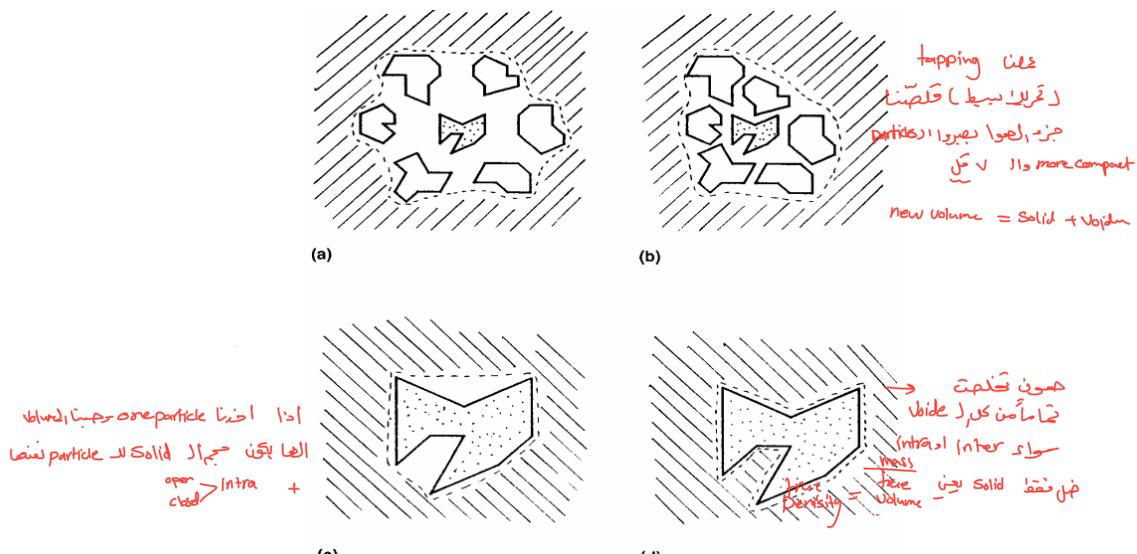
$$\text{Volume} = \text{Solid volume} + \text{intraparticulate} + \text{interparticulate}$$

Is density نسبت مasse Volume Mass-Volume relationship for powders

Three interpretation of powder volume may be proposed:

- The true volume (V_t): The total volume of the solid particles, which excludes all space greater than molecular dimension.
- The granular volume (particle volume) (V_g): The volume occupied by particles and all intraparticulate voids.
- The bulk volume (V_b): The total volume occupied by the entire powder mass (i.e. particles and intraparticulate and interparticulate voids)

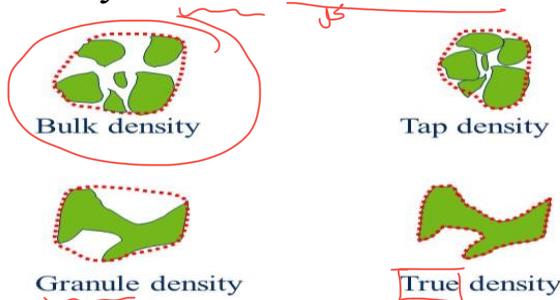
bulk \rightarrow solid \rightarrow beaker \rightarrow bulk \rightarrow volume
 (bulk \rightarrow mass \rightarrow volume)
 bulk density



The different types of densities a) bulk density b) tapped density c)
particle density d) true density Solid + Voids Solid + Bubbles

Mass-Volume relationship for powders

- True density = mass / true volume
- Granular density = mass / granular volume (particle)
- Bulk density = mass / bulk volume



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Packing geometry

الخطير مسح اد

Particle D
grain O

voids (ثقوب فارغة) (ثقوب فارغة)

Space

→

- The apparent volume (or density) of a powder can be changed by rearrangement of the packing geometry of particles (by vibration for example).
- Packing geometry can be characterized by: \rightarrow \rightarrow ١٢

Bulk density

- It is the mass of powder occupying a known volume.
- A powder can have many different bulk densities depending on the way in which the particles are packed.
- However, a high bulk density value does not necessarily imply a close-packed low-porosity bed, as bulk density is directly proportional to true density.

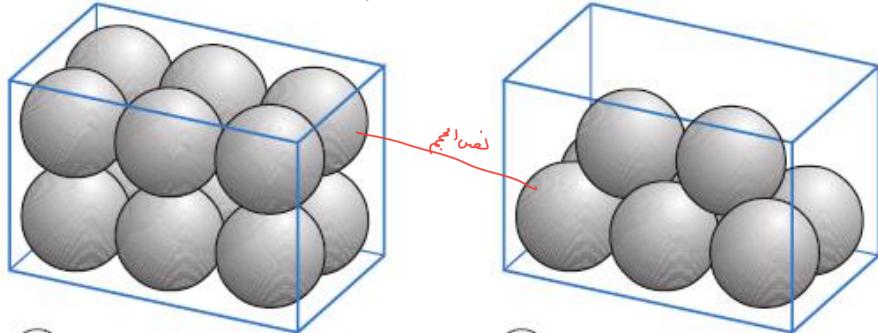
كثيف بحسب الاشكان ركينه اشكال
diff (متغير من حيث عدد بدل)

mass
packing
دichte
high bulk D: packing \rightarrow close \rightarrow no porosity \rightarrow close
* true packing
* ملحوظة عالي
* لا يمكن الحصول على true ملحوظة عالي من خلال
fine particles

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Geometry

لقص الـ V بـ A نحصل V_{sphere} مانع في الاصطدام 8 ملليلتر ml (Volume) Δ ml



الآن تجنبة 75% Particles
الآن تجنبة 25% voids / 100%

b (b) Rhombohedral packing.

64% particle
36% voidage

١- المجموع

Different geometric packings of spherical particles

۱۷۔ ملائیں

الصواب اعل منه؟

Packing geometry

11 Packing fraction = (Fractional solid content, k)

- It is the bulk density divided by true density of the solid.

$$K = \frac{\text{True volume}}{\text{Bulk volume}} = \frac{\text{Bulk density}}{\text{True density}}$$

Porosity (Fractional void content, e)

$$\text{Porosity (e)} = 1 - K \quad \text{ex } 1 - 75\% = 25\% \text{ porosity}$$

- Porosity represents the fractional void content of a powder bed.

عکس

Factors affecting packing geometry

size كأن بـ mixing packing voids Segregation voids air bubbles trapped air

1) Particle size and size distribution

- Void spaces between coarse particles may be filled with fine particles in a powder with a wide size range, resulting in closer packing. حجم فثمه Capping trapped air

2) Particle shape and textures

- Arches within the powder bed will be formed more readily through the interlocking of non-isometric, highly textured particles أغمون spherical

3) Surface properties

- The presence of electrostatic forces can promote closer particle packing الاتصال الجذب الجذب الجذب

4) Handling and processing conditions

- The way in which a powder has been handled prior to flow or packing affects the type of packing geometry

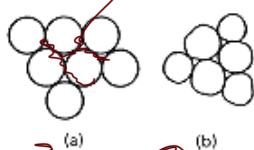
العائن في رأي يعكس في tablet mixing tableting flow

اد تبادل caps

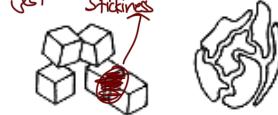
الflow قررت الجسيمات تدفق بينها mixing tableting

ار تبادل interaction

أعلى Cohesion الاتصال



Adhesion الاتصال



General particle shapes and their effect on powder flow.

(a) Spherical particles normally flows easily, mixing flow spherical لطفة لطفة لطفة.

(b) oblong shapes with smooth edges normally flows easily crystallized granules.

(c) equidimensionally shaped sharp edges such as cubes does not flow as readily as (a) or (b).

(d) Irregularly shaped interlocking particles normally shows poor flow and easily bridges.

(e) irregularly shaped two-dimensional particles such as flakes normally shows fair flow and may cause bridges.

(f) Fibrous particles very poor flow and bridges easily. Bridging refers to the stoppage of powder flow as a result of particles which have formed a semirigid or rigid structure within the powder bulk.

24 بريدج Bridging

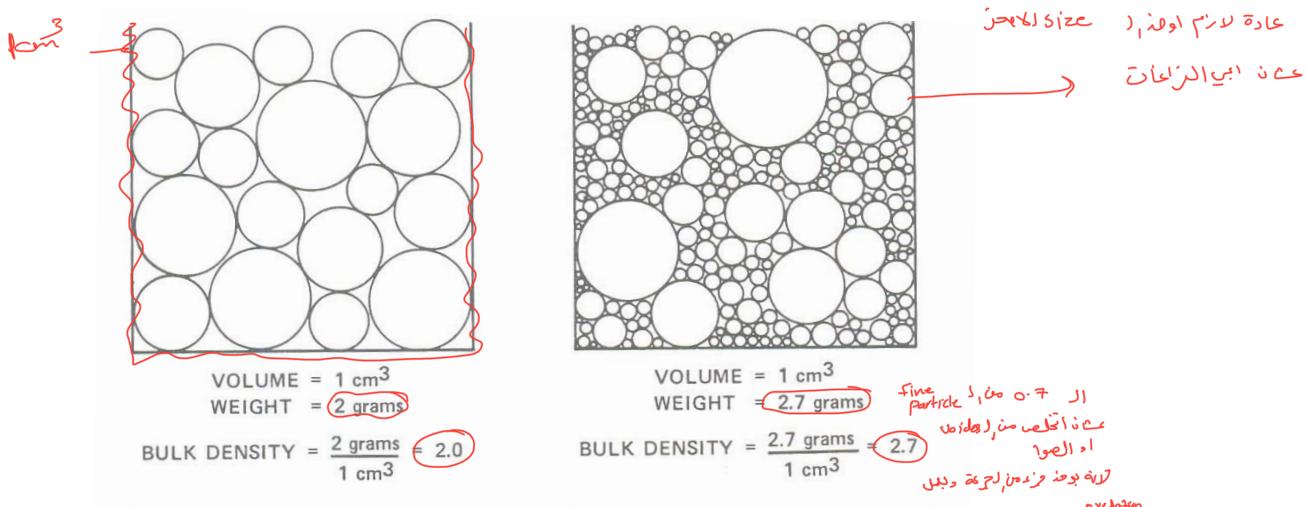


Figure 24 Effects of particle size distribution on the bulk density of a powder.

ارجوا سلام ١٢

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لصن عدو الرغبات

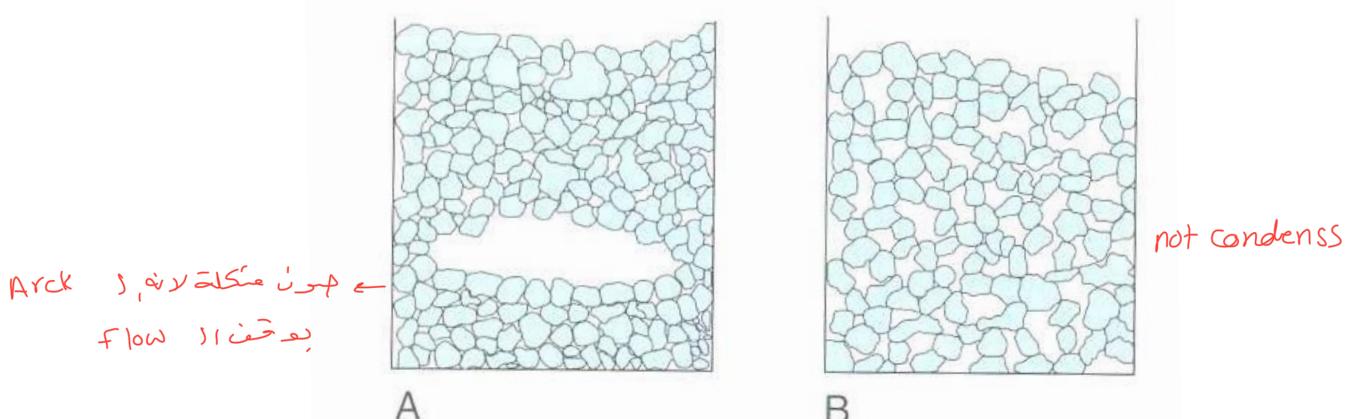


Fig. 13.6 Two equidimensional powders having the same porosity but different packing geometries.

ارض المزبانات بـ = B \rightarrow A \rightarrow كل الرغبات بنفس المكان
Packing voids (ark)

الرغبات متوزعة

loss - fluffy powder

لصن ادار Shape دلمن الارض حجم بس ادار مختلف packing

ارجوا سلام ١٥

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Flow rate through an orifice

- There are many manufacturing processes of pharmaceutical solid dosage forms that require the powder flow through the opening in a **hopper** or **Container** bin used to feed powder to tabletting machine, capsule- filling machine, sachet-filling machines

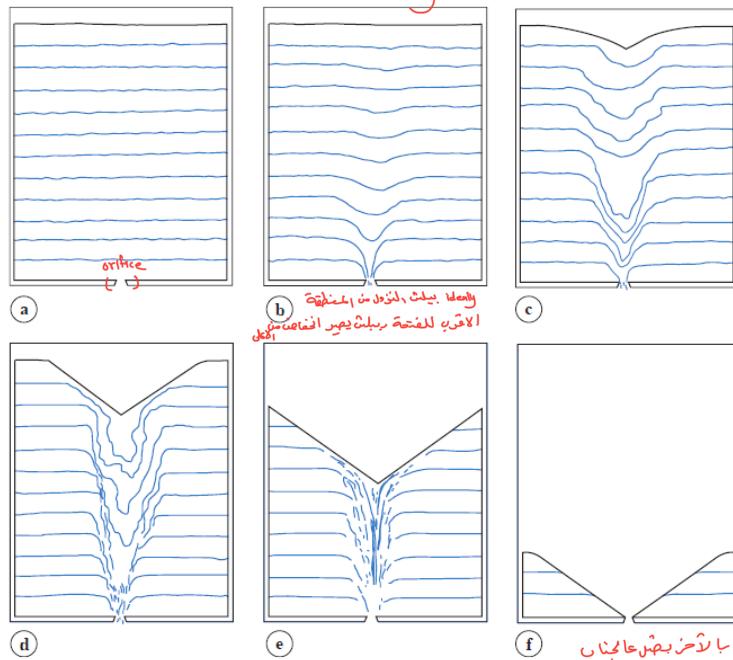
...

عمر وعمر من
هبا هبا من
capsule tabletting
اداری machine

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كتن لدرام تريلار powder

اديايا



Development of flow through an orifice

فتحة

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Flow rate through an orifice

- This flow through orifices is affected by:

1. Orifice diameter ↑ ↑ Flow لورسها

- Flow rate is proportional to orifice diameter

2. Hopper width العرض المدخل / فتحة المدخل

3. *Adhesion to the walls of hopper* → امتحن وسائل الـ *Stickiness* لـ *hopper* \rightarrow اضف *glidant* لـ *hopper* \rightarrow *adhesive*

4. Head size / height

- This is the height of powder bed above the orifice

5. Hopper wall angle also

- As the angle decreases, flow rate increases 

↳ Logic Flow

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الفراغ الى خوف
head
Space

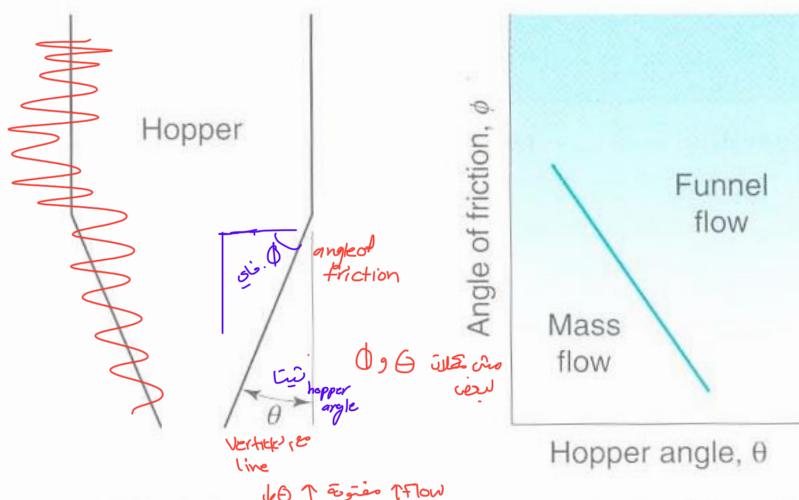


Fig. 13.11 Influence of hopper wall angle and particle-wall friction on powder flow.

٢٢ - ملائكة مجزأة \oplus مجزأة \ominus اعلى ما يكون \oplus Massflow \ominus اعلى ما يكون

Funnel flow

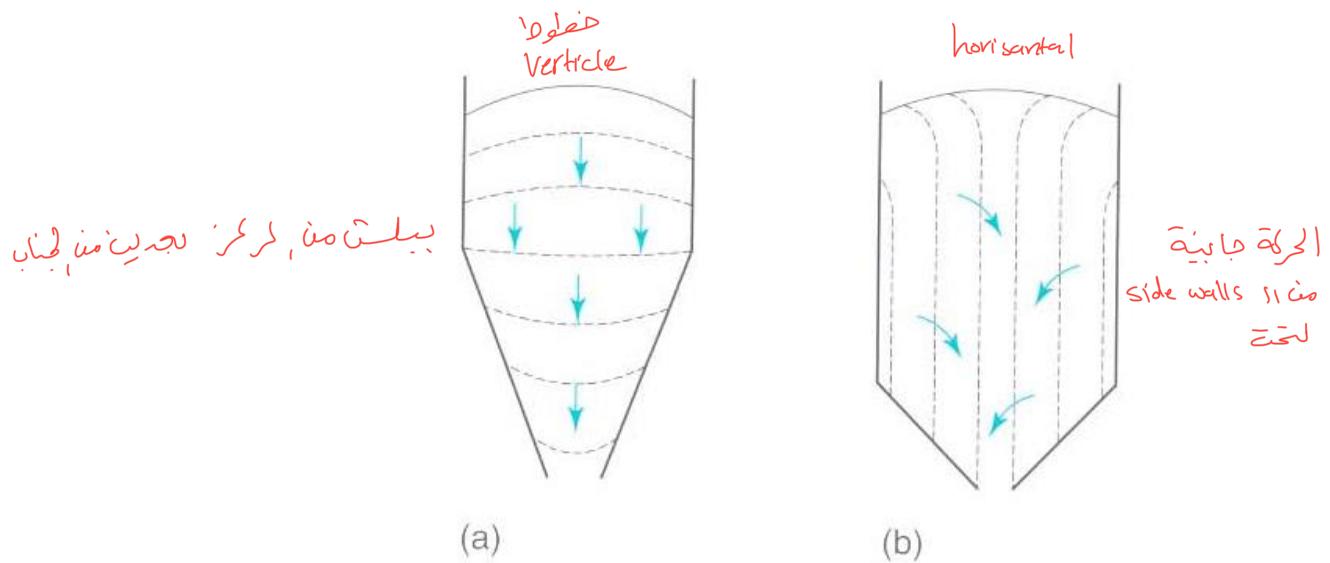
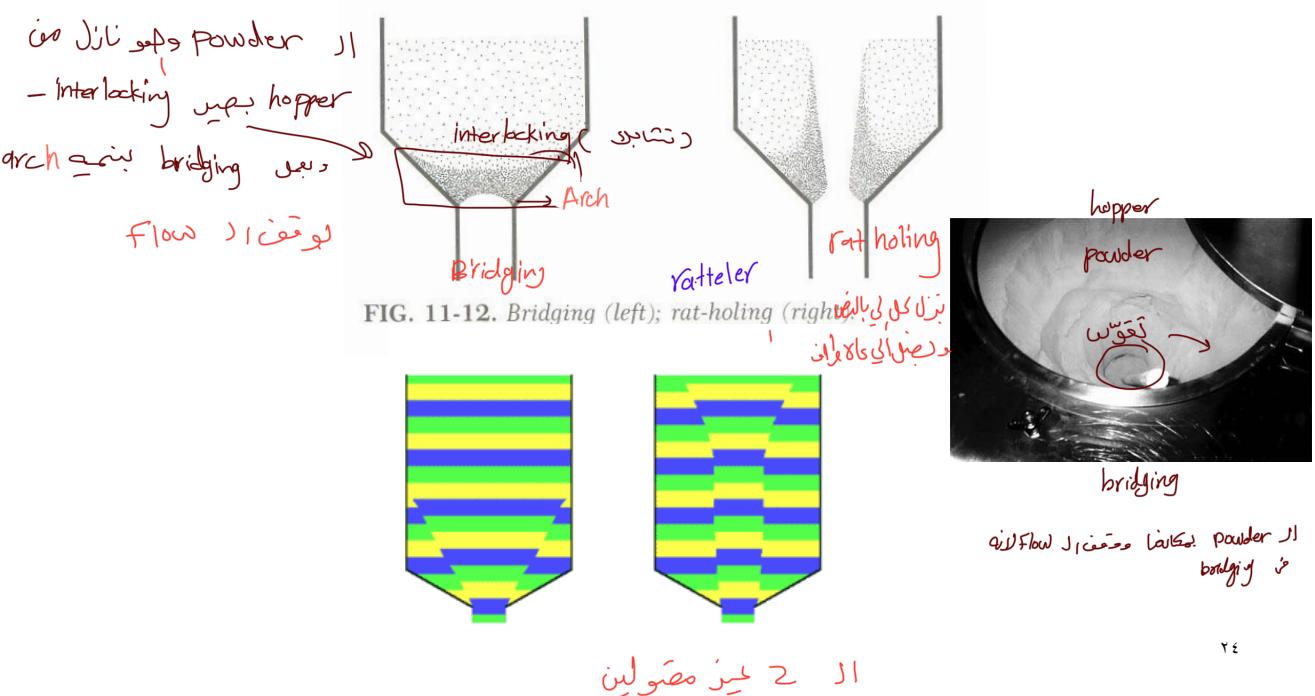


Fig. 13.12 (a) Mass flow hopper. (b) Funnel flow hopper.

فی ال نہ کریے
الصیحہ نہ نہیں دیجئیں
اصیان =



ووچن بیس ورن, (جھٹا من فوق ویوچن
shaker or vibrator or lubricant

Indirect methods (Measurement of adhesive/cohesive properties)

1) Angle of repose *indirect method*

- It represents the balance between frictional/cohesive forces and gravitational force
- Therefore, it describes interparticle cohesion and it is an indirect method for estimating powder flowability.
- There are different methods for determination of angle of repose which may produce different values.
- The high values indicate bad flow properties.

بـ حلـاـعـاـ لـمـعـادـلـاـتـ

استخدامها كـ Conical funnle

وفي ادفناح وحيث لا ينبع (بدر) Powder

حيث تزيد د. تكثيف angle

* ١١) Powder نزلة معرفة يعني المراوحة
كثيف قليلة = دار flow معاوحة، غالباً
not Cohesive

* ١٢) نزلة متوقفة تسمى ساقية
مصمومة بين بدها تحيط

* ١٣) امثل مزيجات توقفت معاوحة صافحة كبيرة
ليقطانات ينبع د. كلبيه
↓
المحكم

مرنة ساقية
غير قوية
زجاجية قليلة

\uparrow coh \downarrow flow \uparrow angle

گزروای
متهم بسته
لکل
flowable

MASS MOVEMENT DEPENDS ON THE NATURE OF MATERIAL, WATER CONTENT, AND SLOPE STEEPNESS

1

Angle of repose

2

3

Fine sand

Coarse sand

Angular pebbles

100%

0%

Percentage cohesive material

Determination of angle of repose for very cohesive powders

Cohesive powder poured in a heap

q_i

q_m

angle of repose

↳ Tech

Angle of repose

Draining method

Apparatus	Method	Angle defined	Apparatus	Method	Angle defined
Fixed height cone	Fixed height cone	Angle of repose static	a	Ledge	Drained angle of repose
Fixed base cone	Fixed base cone	Angle of repose static	b	Crater	Drained angle of repose
Tilting table	Tilting table	Angle of repose static	a	Platform	Drained angle of repose
Rotating cylinder	Rotating cylinder	Dynamic angle of repose	b	stand	

يتكون في beaker او رؤوس مستقيمة في الماء
فتحة انتزاع الماء اسفلها

التحريك من انتزاع الماء (الرطوبة تكون اقل)
ويتباين مع زوايا (الرطوبة تكون اقل)
مدى بالرغم من ارتفاع الماء

ارتفاع اعلى container ينبع من زوايا stand

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يساهم انتزاع الماء
على stand
مابعد قمة θ
نوعية الماء θ θ θ

Angle of repose (degrees)

Type of flow

25–30	Excellent
31–35	Good
36–40	Fair (flow aid not needed)
41–45	Passable (may hang up, flow aid might be needed)
46–55	Poor (agitation or vibration needed)
56–65	Very poor

↑ Flow Angle
↓ Powder

يساهم انتزاع الماء
على stand

مابعد قمة θ

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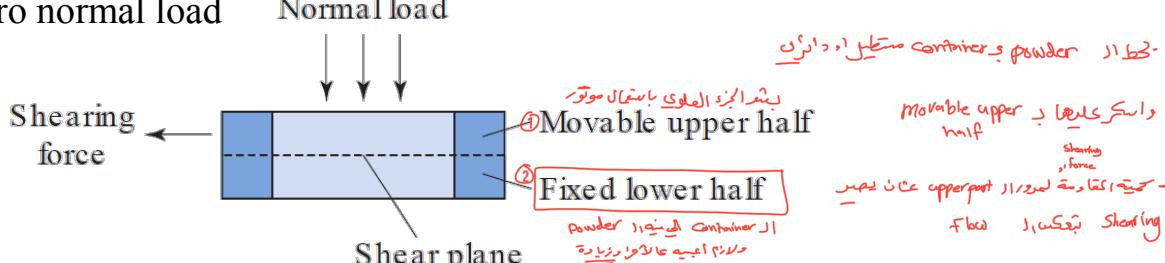
Characterization of powder flow

Indirect methods (Measurement of adhesive/cohesive properties)

Shear: two parallel surfaces
عِصْبَةِ جَانِبِيَّةٍ

2) Shear strength determination

- Cohesion can be defined as stress (force per unit area) necessary to shear the powder bed under conditions of zero normal load \rightarrow Normal load



Diagrammatic representation of Jenike shear cell.

Characterization of powder flow

Indirect methods (Measurement of adhesive/cohesive properties)

قطاع 3) Tensioning

3) Tensile strength determination

- The powder bed is caused to fail in tension by splitting.

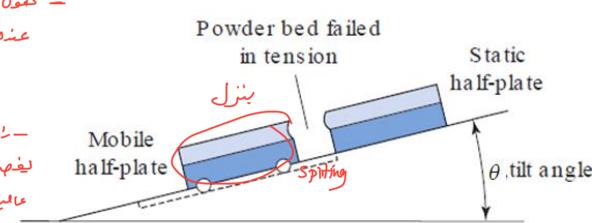
— حون لا) لمبوف (ل) ای بنسن
عندہ، ار لسین powder bed

کنے اسٹاکل (Stock Powder) نیز دا عدد 8

كينا سيليكول (Silica powder) داير

لکھنؤ (Lahore) لہوڑا بھارت

ـ جاذب Gravity یعنی جاذبیت
ـ جاذبیت نتیجه از جاذبیت ماده است
ـ جاذبیت نتیجه از جاذبیت ماده است



Diagrammatic representation of tilting table method

$$\sigma_t = \frac{Mg \sin \theta}{A} \quad \text{Angle of repose}$$

Equation for calculation of tensile strength

Characterization of powder flow

Indirect methods

4) Bulk density measurement (% compressibility and Hausner's ratio)

$$\% \text{ compressibility} = \frac{D_f - D_0}{D_f} \times 100 = \frac{V_0 - V_f}{V_0} \times 100$$

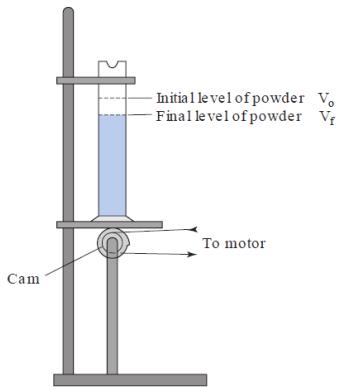
$$\text{Hausner's ratio} = \frac{D_f}{D_0} = \frac{V_0}{V_f}$$

D_f = Final bulk density (tapped density)

D_0 = initial bulk density

V_f = Final bulk volume (tapped volume)

V_0 = initial bulk volume



Mechanical tapping device

البلل (bulking) powder ازها تتمحظ دارتمان ممکن است بعن مارنج تتفتنج

فی لسیب ازها تتمحظ دارتمان متساکت و ادعا مانع

مقدمة الخطوط او الكبس

coh ②

نیادیت سیجی دارتمان

compressibility

↑coh ↑Compr ↓ flow

↑ Compressibility index (%) (Carr's index)	Type of flow	Hausner ratio
1–10	Excellent	1.00–1.11
11–15	Good	1.12–1.18
16–20	Fair	1.19–1.25
21–25	Passable	1.26–1.34
26–31	Poor	1.35–1.45
32–37	Very poor	1.46–1.59
>38	Very, very poor	>1.60

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حدرات - حمین خفظ

حداد نیه اویل آخروا

Characterization of powder flow

Indirect methods

5) Critical orifice diameter

- Critical orifice diameter is a measure of powder cohesion and arch strength.
- The smallest orifice diameter through which powder can flow

flow دفعه
Diameter ابعاد
 Powder اسمنت
 orifice اوریفیس
 امداد اسمنت
 دایری اسمنت

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Characterization of powder flow

Direct methods

1) Hopper flow rate

- Simple and direct
- The mass of a powder discharged from a hopper is divided by the time taken for the powder to discharge.

نیز اصطلاح داریم معنی اینکه وقت لیزد

$$\text{rate} = (60 \text{ g/min}) \text{ min} / 30 \text{ g} = 2 \text{ min} : \text{ex}$$

container (نیز) powder

علی صیزان) نیز اورن

log time

ایجاد چون عدی کی وزن

linear flow curve

نمودار خطی

- که ما در این لزنت این این اینی لی نیز این

کنول powder و سبکی داده ای داده

flow rate

(سرعت انتقالی-نیوفت)

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2) Recording flowmeter

- The powder is allowed to discharge onto a balance and the increase of powder mass with time is recorded.

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flow |deep|

Approaches for improvement of powder flow

Alteration of particle size and size distribution

- Coarse particles are less cohesive and therefore are flowing better than fine particles. اعجمان کرامہ میں

نکر بواختان (Powder) نعنعا
قبل ما وصفنا صادقاً صافية
① size ② shape ③ static charge
بأذن الله تعالى

Alteration of particle shape or texture

- Spherical particles have better flowability than irregular particles.
- Particles with smooth surface have better flowability than particles with rough surface.
- Particles with suitable shape can be obtained by spray drying or by controlling crystallization process.

٢٥ - $\Delta H_{\text{fus}} = \text{Heat of fusion}$ (Heat required to melt 1 mol of solid at constant pressure) $\Delta H_{\text{vap}} = \text{Heat of vaporization}$ (Heat required to vaporize 1 mol of liquid at constant pressure) $\Delta H_{\text{sub}} = \text{Heat of sublimation}$ (Heat required to sublime 1 mol of solid at constant pressure)

دیسیلولاریک
فری فلیپ اسپری
Free flowing/spherical
morphs
عنه تصفیه فعالی لامب بخنزه رای افرازی

Approaches for improvement of powder flow

Alteration of surface forces

- Electrostatic charges and high moisture content decrease the flowability. aggregates, lumpy, سکونتگاهی، water / ازادرنهای سکونتگاهی، static charge

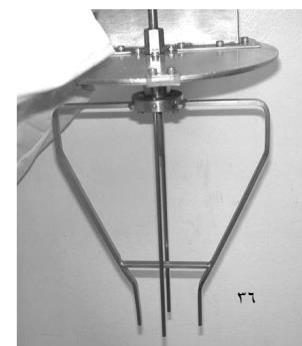
Formulation additives (flow promoters)

- Glidants decrease cohesive and adhesive forces.

۱۴) تغییر شرایط فرایند

- Use of vibration-assisted or agitated hoppers
- Use of force feeders

رَبِّ الْمَصْبِرَاتِ
لِبَلْ مَحْطَأَ عَنْ بَرْلَكْلَ (Pawder) دَمَاسِيَّ حَفَنْ



Internal agitator

Flow activators

- Flow activators (enhancers, promoters) improve the flowability of powders by reducing adhesion and cohesion

- They are referred to as glidants.
- Some of them have anti-adherent and lubricant properties.

- Commonly used glidants include talc, maize starch, colloidal silicon dioxide and magnesium stearate.



pourde از دارج مولعه است $\xrightarrow{\text{Talk}}$ participle $\xrightarrow{\text{sheat}}$ $\xrightarrow{\text{sheat}}$ $\xrightarrow{\text{جع}} \xrightarrow{\text{جع}} \xrightarrow{\text{جع}}$
 $\xrightarrow{\text{stearate}}$ Adh $\xrightarrow{\text{stearate}}$ $\xrightarrow{\text{stearate}}$ $\xrightarrow{\text{جع}} \xrightarrow{\text{جع}} \xrightarrow{\text{جع}}$

c, maize
magnesium →
fatty acid (Unhydrophobic)
stearate ١١٤٢
ستيرات سفید ۱۱۴۲

لادهيل لأنها سهل مخالطة اذا حضيت سهلة كثيرة عليه

Insoluble سارچر $\text{Ca}_3(\text{PO}_4)_2$ جلا mixing time \rightarrow
mixing time Lubricant \rightarrow $\text{Ca}_3(\text{PO}_4)_2$

Mechanisms of action of flow activators

Glidants improve flowability by one or more of the following mechanisms:

العلاقة تتأثر بمتغيرات مثل الرطوبة ونسبة الدهن