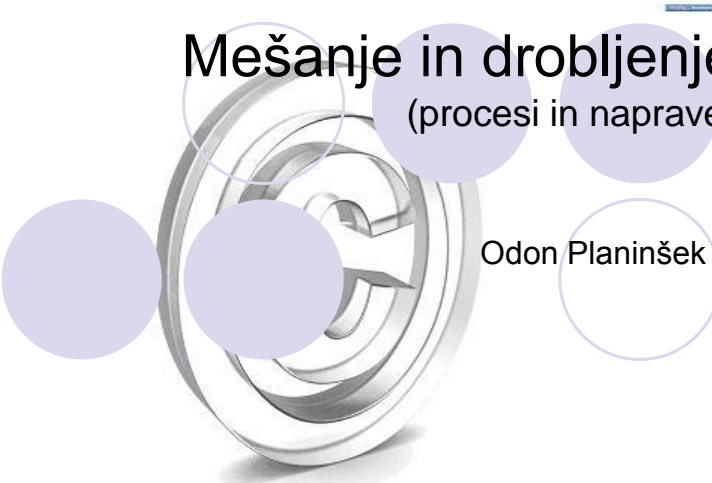


Mešanje in drobljenje (procesi in naprave)

Odon Planinšek



1

Mešanje

Pozitivno mešanje

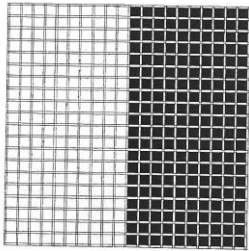
Negativno mešanje

Neutralna zmes

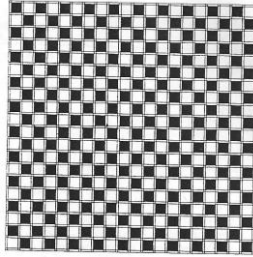


2

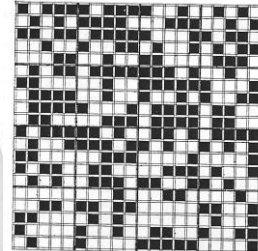
Mešanje praškov



Segregirani delci



Idealno porazdeljeni delci



Naključno porazdeljeni delci

3

Mešanje praškov

- Verjetnost, da 200 delcev tvori idealno zmes je $1:10^{60}$



4

Stopnja mešanja

$$M = \frac{S_r}{S_{act}}$$

M-stopnja pomešanja

S_r -standardna deviacija homogene naključne zmesi

S_{act} -standardna deviacija zmesi, ki še ni popolnoma homogeno pomešana



5

Stopnja mešanja

-Nižja kot je vsebnost aktivne komponente v zmesi, težje je doseči dovolj nizko deviacijo vsebnosti

-Več kot je delcev v zmesi, manjšo deviacijo lahko pričakujemo



6

Mešanje praškov

Mešanje praškov je potrebno spremljati iz naslednjih razlogov:

- da ugotovimo stopnjo zmešanja
- spremljamo proces (potek) mešanja
- ugotovimo končno točko mešanja
- ugotovimo učinkovitost mešalnika
- določimo čas mešanja določene zmesi



7

Mehanizmi mešanja

-Konvekcija

-Strig

-Difuzija

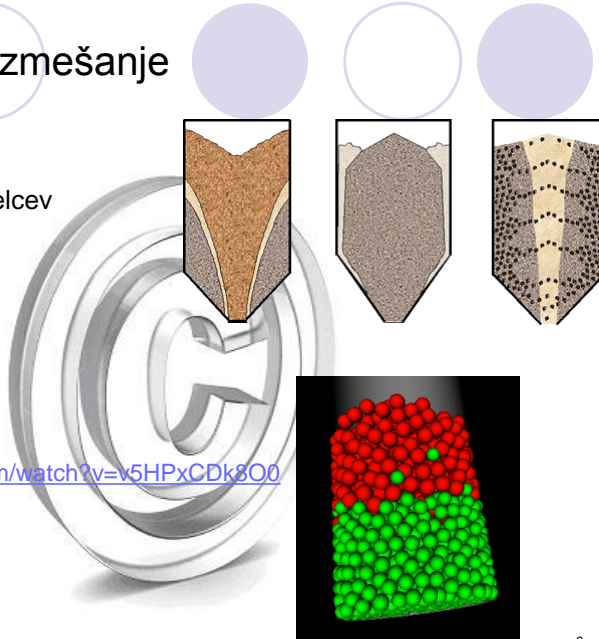


8

Segregacija-razmešanje

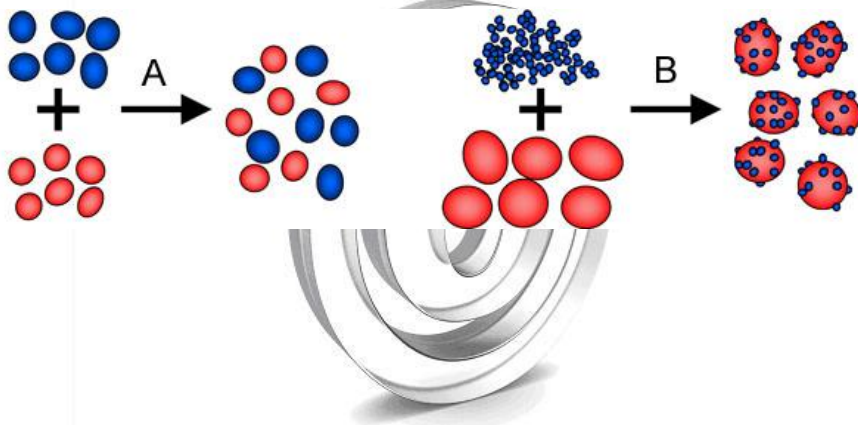
Posledica

- Razlike v gostoti delcev
- Velikosti delcev
- Obliki delcev



9

Urejene zmesi



10

Vrste mešalnikov

- Mešalniki s prevračanjem (angl. tumbling)



<http://www.youtube.com/watch?v=IGGWuzcc784>

11

Vrste mešalnikov

- Mešalniki s pretresanjem (agitator)

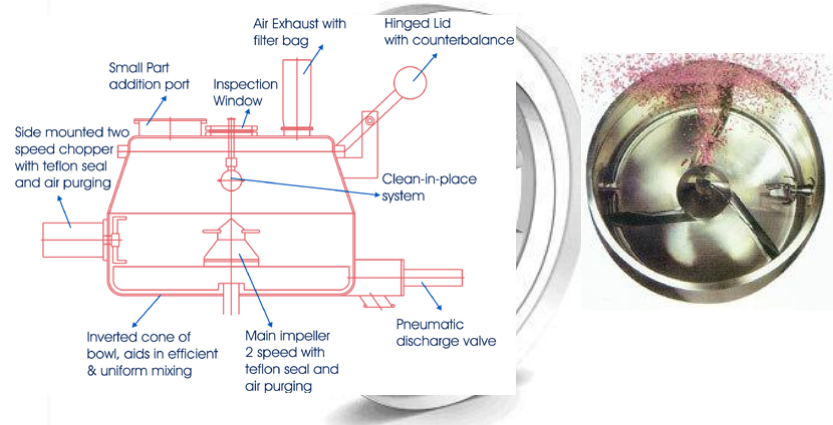


<http://www.youtube.com/watch?v=PzdP8fhYSTc&feature=related>

12

Vrste mešalnikov

- Hitrovrteči mešalnik/granulator

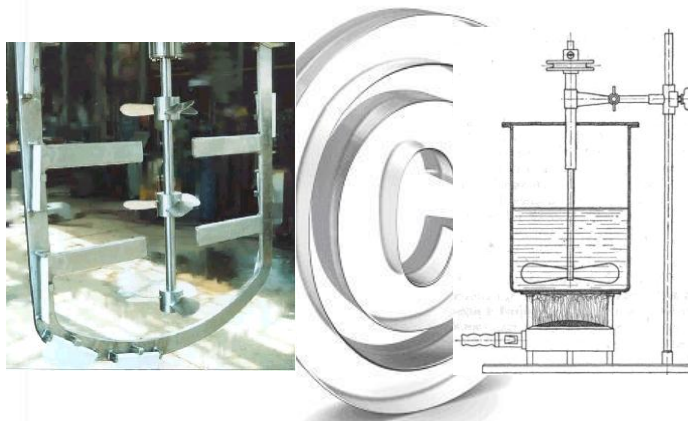


<http://www.youtube.com/watch?v=IR4mdtZlgDM&feature=related>

13

Mešanje tekočin in suspenzij

- Propellerski mešalnik



<http://www.youtube.com/watch?v=UoZB0P2vyUM>

14

Mešanje tekočin in suspenzij

- Propellerski mešalnik

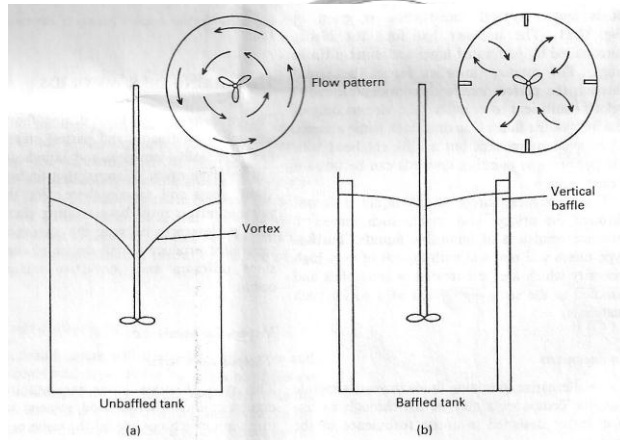


Fig. 32.10 Propeller mixer — formation of vortex (a) unbaffled tank (b) baffled tank

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Mešanje tekočin in suspenzij

- Turbinski mešalnik

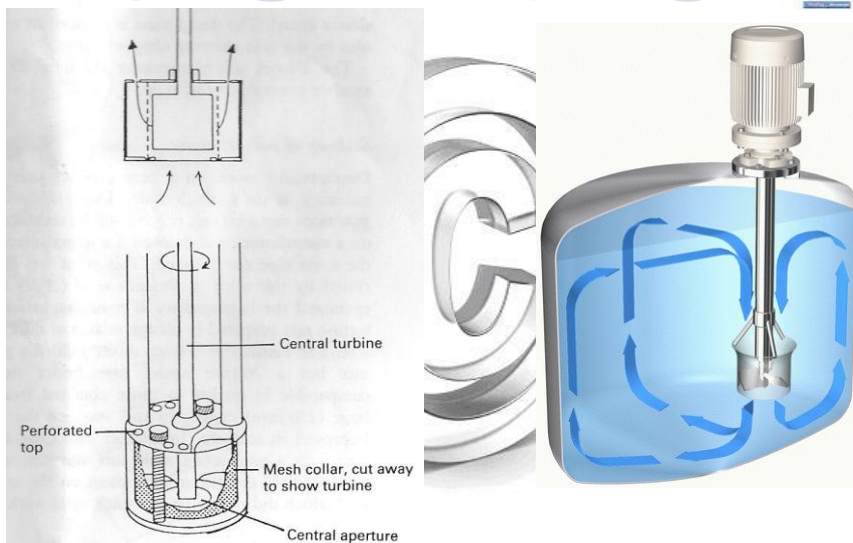
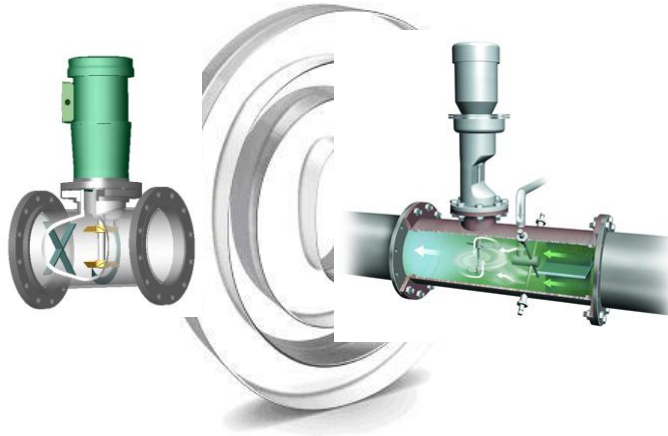


Fig. 32.11 Turbine mixer. (Courtesy of Silverson Mixers)

16

Mešanje tekočin in suspenzij

- "in line mešalnik



17

Mešanje poltrdnih snovi

- Planetarni mešalnik

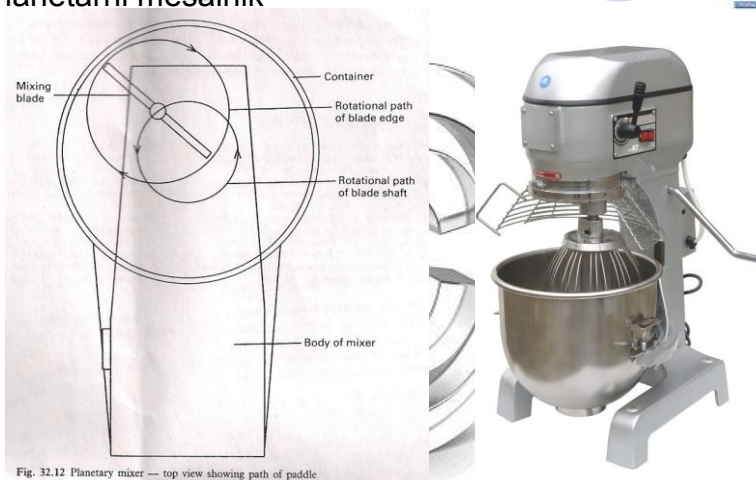


Fig. 32.12 Planetary mixer — top view showing path of paddle

<http://www.youtube.com/watch?v=R9GaAaY43Qc>

18

Mešanje poltrdnih snovi

- Mešalnik z mešalom v obliki črke S

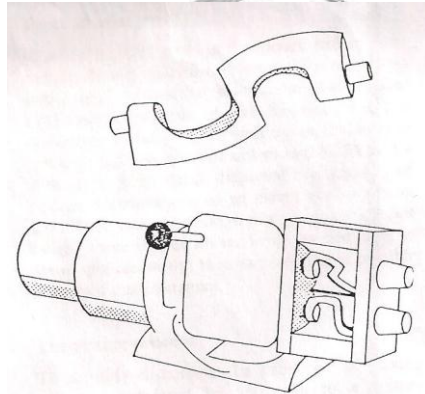
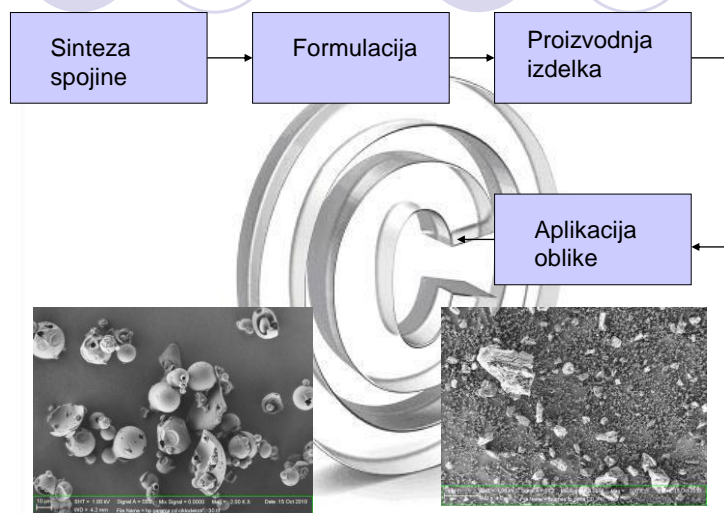


Fig. 32.13 Sigma-arm mixer

19

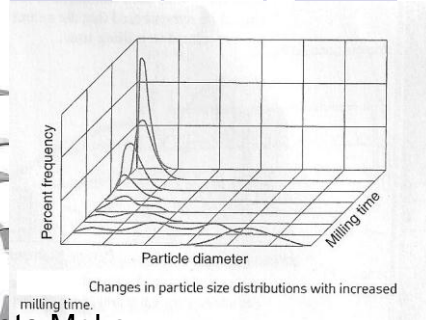
Mletje delcev



20

Mletje in zmanjševanje velikosti delcev

- Mehanizem drobljenja
- Krhki materiali
- Žilavi materiali
- Trdnost snovi (izražamo z enoto Mohs 3 (smukec)-7(diamant))

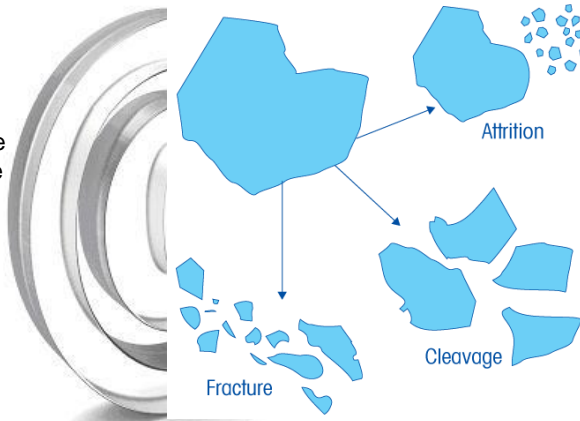


21

Mletje in zmanjševanje velikosti delcev

- Mehanizem drobljenja

Attrition-obraba
Cleavage-ceplenje
Fracture-drgnjenje



22

Energija potrebna za zmanjšanje velikosti delcev.

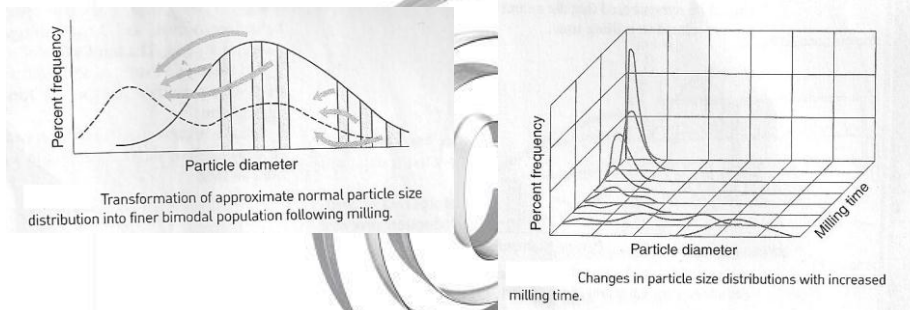
Pri mletju se energija porablja tudi za:

- elastično deformacija delcev,
- plastično deformacijo delcev brez loma,
- deformacijo delcev, ki povzroči nastanek razpok,
- deformacijo delov mlina,
- trenje med delci,
- trenje med delci in stenami posode,
- toploto,
- zvok,
- vibracije



23

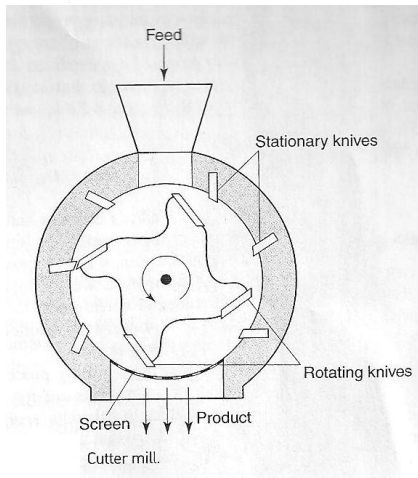
Mletje in zmanjševanje velikosti delcev



24

Metode manjšanja velikosti delcev

- Mlin rezalnik



25

Metode manjšanja velikosti delcev

- Mlini na principu stiskanja



“end runner” mlin

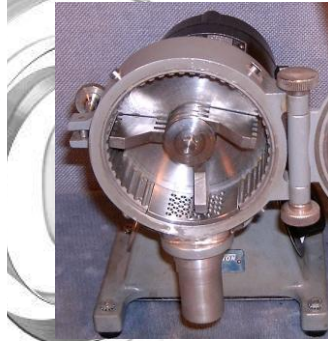
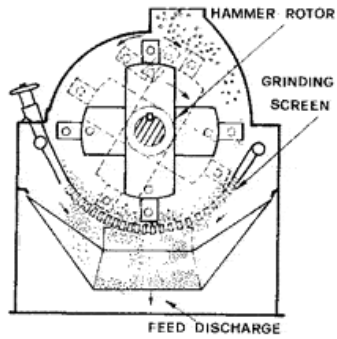


“edge runner” mlin

26

Metode manjšanja velikosti delcev

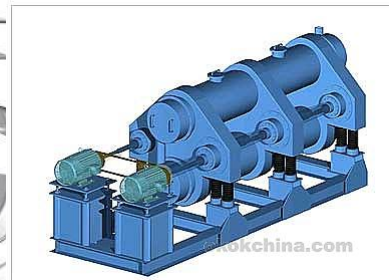
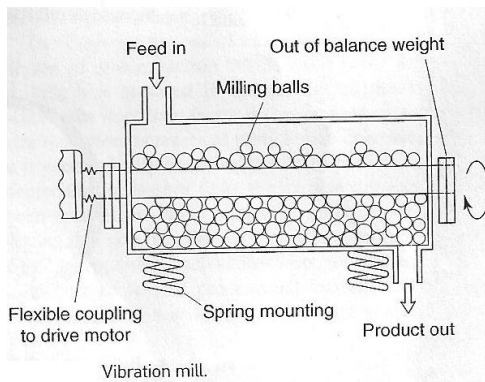
- Mlini na udarec



27

Metode manjšanja velikosti delcev

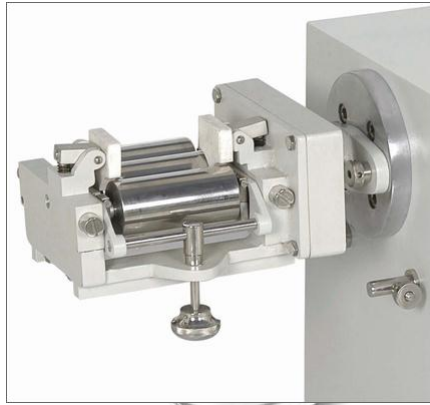
- Vibracijski mlin



28

Metode manjšanja velikosti delcev

- Mlin z valji

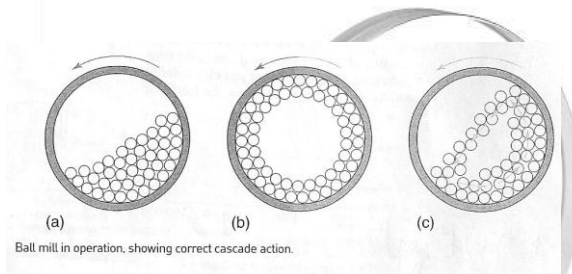


Mletje z obrabo

29

Metode manjšanja velikosti delcev

- Kroglični mlin



Ball mill in operation, showing correct cascade action.

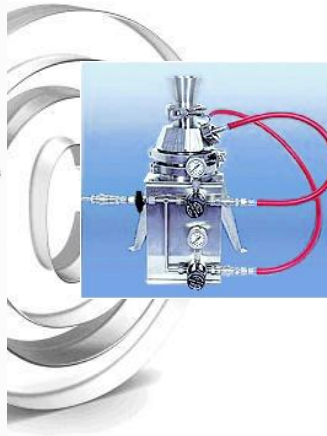
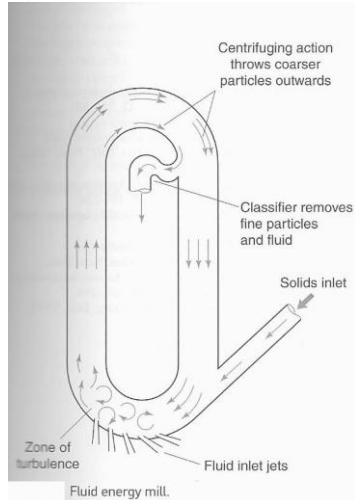
Mletje z obrabo in udarjanjem

<http://www.youtube.com/watch?v=MYesDY8TD6E&feature=related>

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Metode manjšanja velikosti delcev

- Mlin na zračni tok

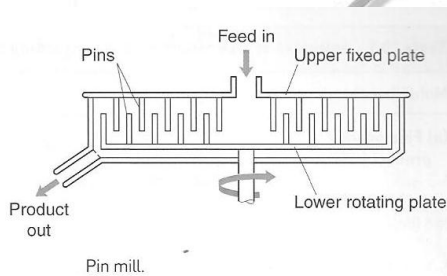


Metje z obrabo in udarjanjem

31

Metode manjšanja velikosti delcev

- Mlin z iglami



Mletje z obrabo in udarjanjem

32

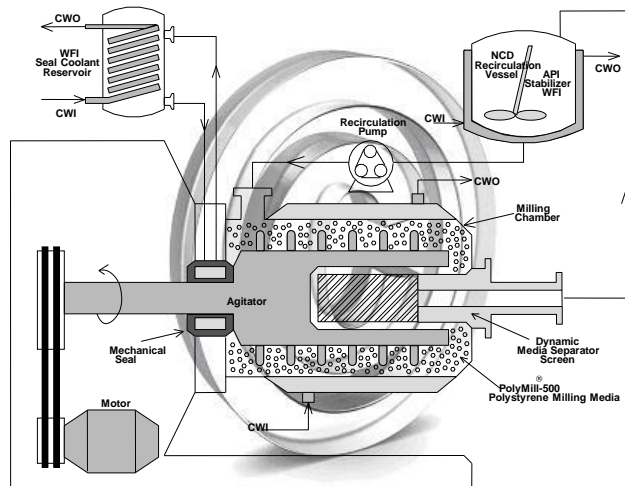
Metode manjšanja velikosti delcev

Selection of size reduction mills according to particle properties and product size required

| Mohs' 'hardness' | Tough | Sticky | Abrasive | Friable |
|---|--|-----------------------------|-------------------------------|--------------------------------------|
| (a) Fine powder product (< 50 μm) | | | | |
| 1-3 (soft) | Ball, vibration (under liquid nitrogen) | Ball, vibration | | Ball, vibration, pin, fluid energy |
| 3-5 (intermediate) | Ball, vibration | | | Ball, vibration, fluid energy |
| 5-10 (hard) | Ball, vibration, fluid energy | | Ball, vibration, fluid energy | |
| (b) Coarse powder product (50-1000 μm) | | | | |
| 1-3 (soft) | Ball, vibration, roller, pin, hammer, cutter (all under liquid nitrogen) | Ball, pin | | Ball, roller, pin, hammer, vibration |
| 3-5 (intermediate) | Ball, roller, pin, hammer, vibration, cutter | | | Ball, roller, pin, vibration, hammer |
| 5-10 (hard) | Ball, vibration | | Ball vibration, roller | |
| (c) Very coarse product (> 1000 μm) | | | | |
| 1-3 (soft) | Cutter, edge runner | Roller, edge runner, hammer | | Roller, edge runner, hammer |
| 3-5 (intermediate) | Edge runner, roller, hammer | | Roller | Roller, hammer |
| 5-10 (hard) | Roller | | | |

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Preparation of Engineered Nanoparticles by Wet Milling



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NanoMill[®]-2 Manufacturing Platform



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