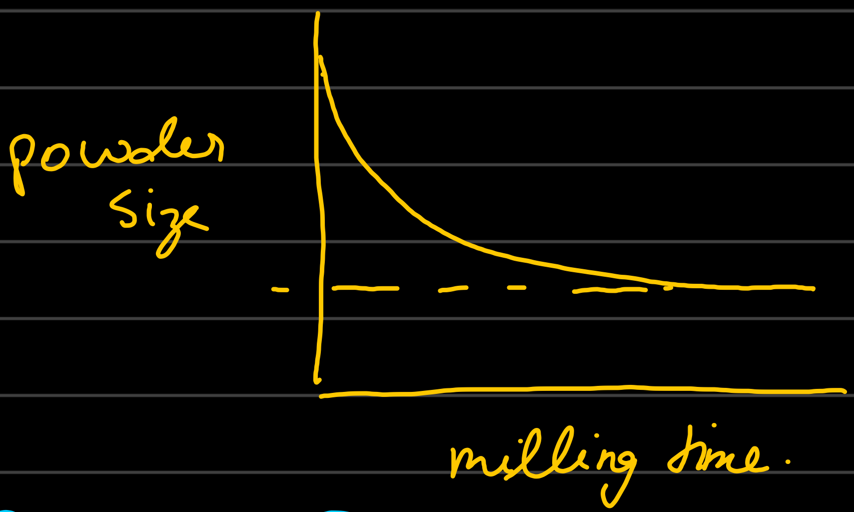
Lecture

Powder Processing

Ball Milling:

↳ material must be brittle;
upon impact must disintegrate.



$$\boxed{\sigma_{fracture} \propto \sqrt{\frac{E\gamma}{a}}}$$

{Griffith theory of fracture}

Crack size   Surface energy

(decrease in powder size increase surface energy hence fracture strength increase)

→ small crack size → high fracture stress.

→ $d \approx a$ {particle size nearly equal to crack size}

★ $\sigma_{fracture} \propto \dfrac{1}{d}$

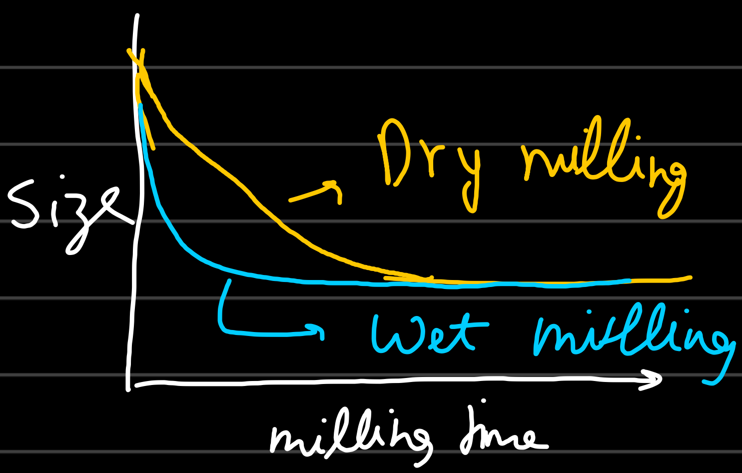
→ Above discussion for ball milling in dry condition.

→ **Wet milling:**

↳ some liquid media involved in milling.

→ much more efficient than dry milling.

→ particles stick to film over milling balls.



→ Ball milling is inefficient because most of the energy goes into noise and heat.

→ For optimal milling:

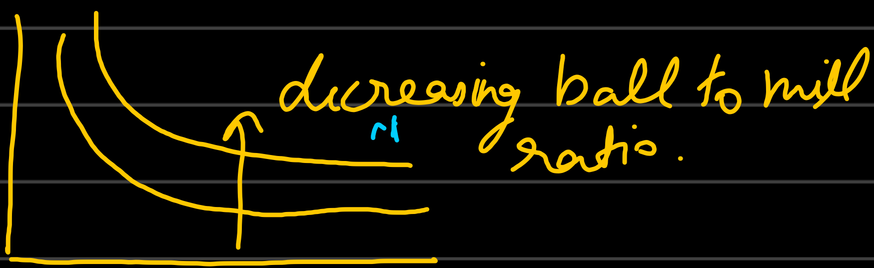
↳ ball diameter should be approximately

30 times the diameter of the powder.

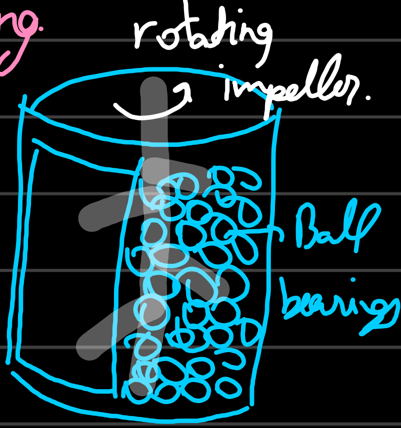
→ ball should fill half of jar volume.

→ fluids or protective atmosphere used to reduce oxidation and aid grinding

→ we cannot get extremely fine size powders.



Attrition and Mechanical Alloying

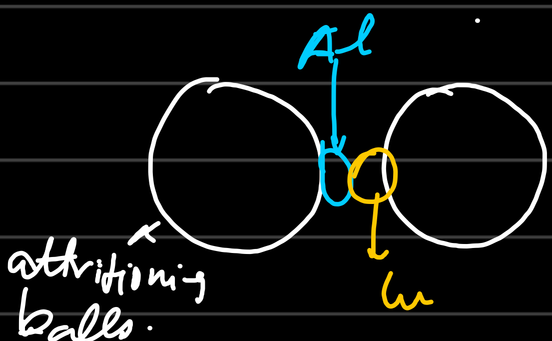


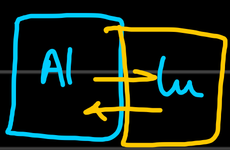
↳ alloying and reducing size

↳ cold welding and refinement

↳ lamellar structure.

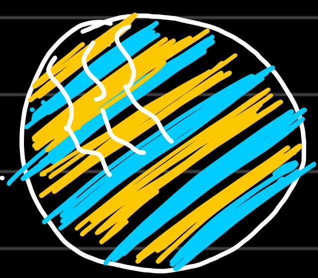
→ particles disintegrate due to shear action b/w mill ball bearings





Cold Welding of Al & Cu.

→ lamellar structure obtained.



→ shearing of particles.

→ novel microstructures can be obtained.

→ alloyed composite particle created.

→ mechanical alloys provides a homogenous distribution of all phases.

Drawbacks of Mechanical Methods:

↳ Not energy efficient

↳ contamination from milling media.
eg. Alumina powder with iron balls.

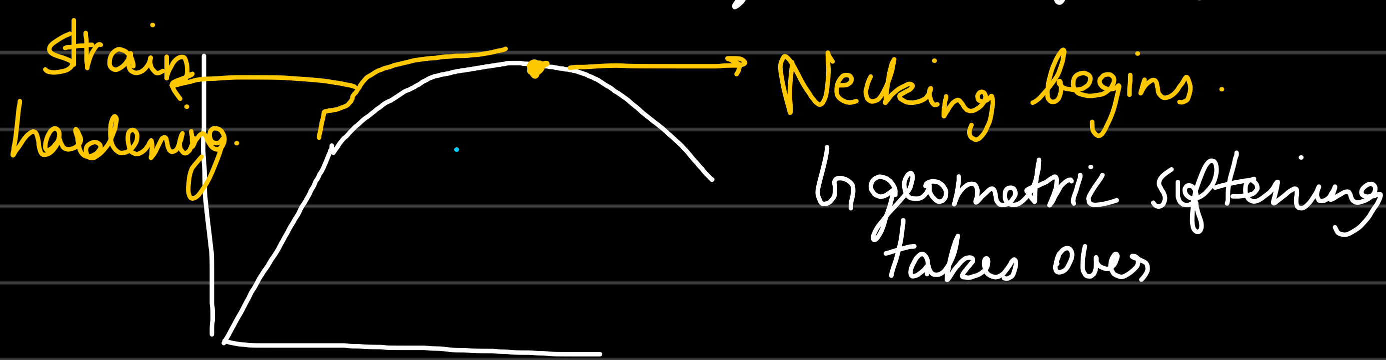
→ The smaller the particle size required, longer is the time taken.

→

Geometric softening: → cross-section reduces

Strain hardening: dislocation hardening.

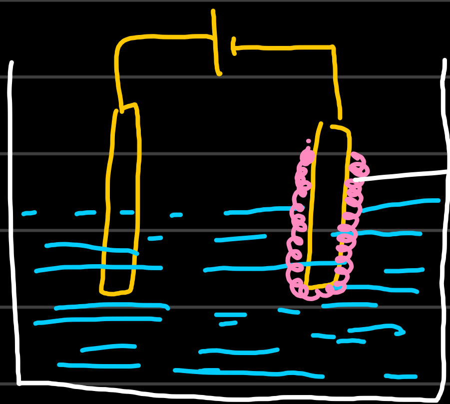
$$\frac{d\sigma}{d\varepsilon} = \text{combined effect of strain hardening and geometric softening.}$$



→ dislocation density ↑ses during dislocation hardening.

→ Work hardened powders are difficult to deform due to already high dislocation density.

Electrolytic Technique



→ elemental powders can be deposited on cathode.

→ very high purity particulates are obtained

→ morphology of particles is inhomogenous
↳ all spherical smooth particles cannot be obtained.

→ impure anode to get pure powders at cathode.

→ powder formed is often dendritic & sponge like in shape with poor packing characteristics.

→ particle size & shape can be adjusted by changing current & voltage.

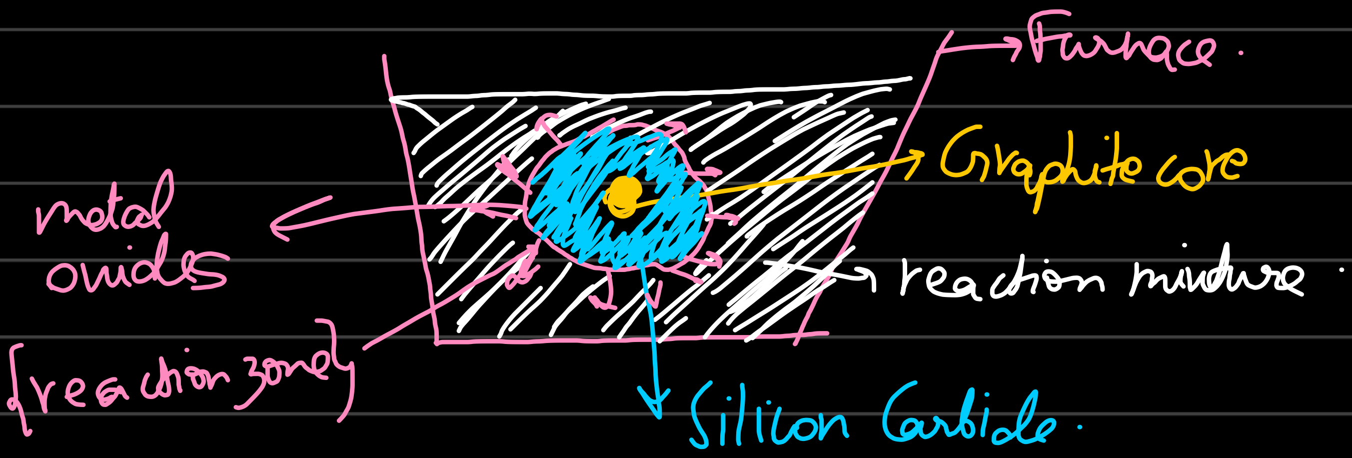
→ alloys can be generated but not the most practical.

Solid State Process:

1) Acheson Process:

↳ used for producing SiC → abrasive

$SiO_2 + C \longrightarrow SiC + CO_2$ after heating



Atomization:

- only technique that can yield spherical powders
- involves melting of material.
- Gas & Liquid Atomization.