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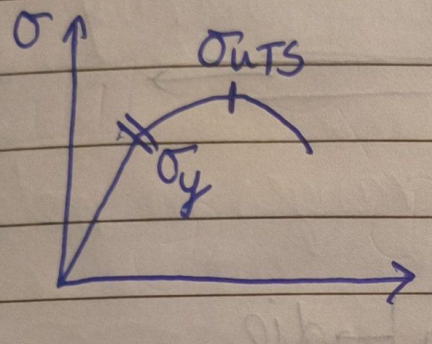
Materials Processing:

Metal Working

→ Large group of manufacturing process in which plastic deformation is used to change the shape of metal work pieces.



$\sigma >> \sigma_y \Rightarrow$ plastic deformation,

$\sigma << \sigma_{UTS} \Rightarrow$ avoid necking.

→ permanent shape change:

* movement of dislocations [5]
  ↳ move on slip planes & slip directions.

Tool called "die" → applies stresses that exceed yield strength.

→ metal takes shape based on geometry of die.

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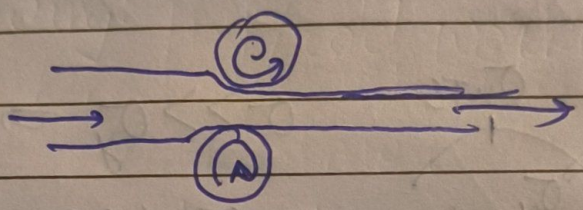
Classification of metal working

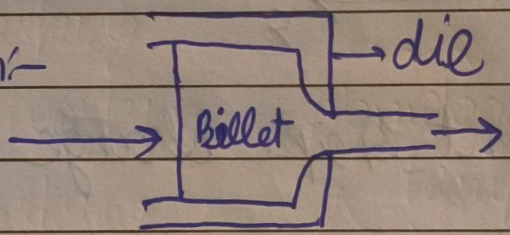
i) Bulk deformation → entire solid undergoes

ii) Local deformation → only a portion undergoes plastic deformation

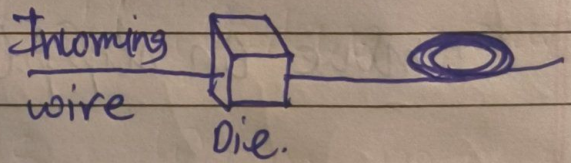
1) Rolling:



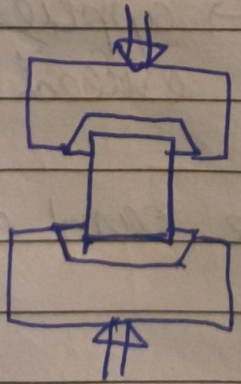
2) Extrusion:-



3) Wire Drawing:



4) Forging:



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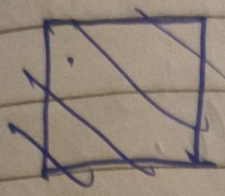
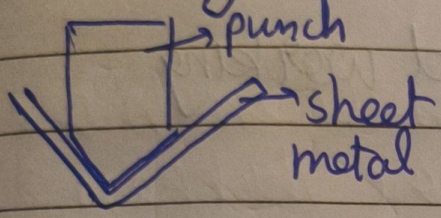
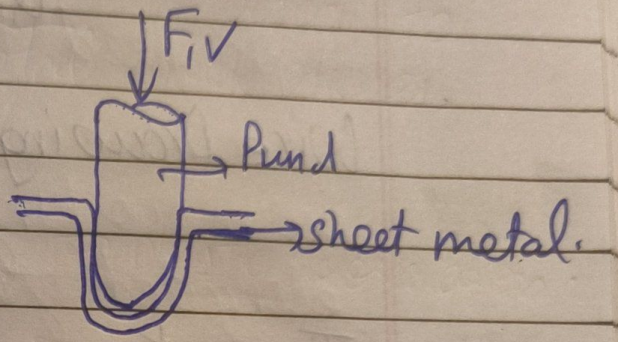


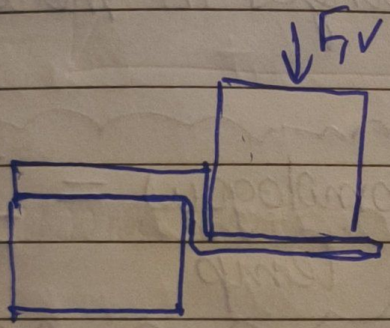
Local deformation process:

Bending





Cup-Drawing



Shearing

→ Nature of stresses involved:
↳ complex minture of compression/tension/shear.

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→ increase in strength & hardness of material post cold working.

→ large thickness reduction difficult in cold working.

↳ need to look into hot & warm working

Warm working can result in more elongated grains & more thickness reduction

↳ ρ dislocation ↑ but less than cold working.

↳ annihilation of dislocations start working at these temperatures.

** Also called as Recovery of material

↳ less hard, less strong than cold worked.

Hot rolling: ρ dislocation remains more or less same post working.

→ material undergoes recovery + recrystallization during hot working.

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- Old crystals replaced by new crystals.
- equiaxed microstructure but finer grain size.
- material has strengthened.
- Temp. needs to taken care of as grain growth will decrease strength.
- Scale formation (Oxidation of material) at high temperature.

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MLL371
Materials Processing

Metal Working

Equal channel Angular Pressing (ECAP)

↳ no change in cross-section.

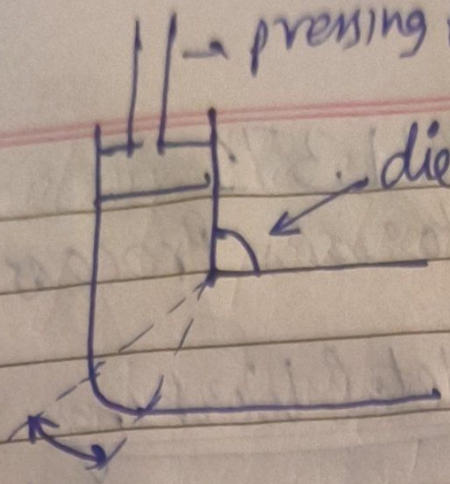
→ enormous shear strain imparted on material.

→ Eplastic is huge compared to other conventional processes.

→ largely used for grain refinement.

→ deformation & recrystallization occurs simultaneously.

→ Die angle (ϕ) → determines magnitude of strain imparted.



→ large strain can lead to higher grain size reduction.

→ Crystallographic texture of the material can be modified. (grain orientation).

$$\varepsilon = 2\cot\left(\frac{\psi}{2} + \frac{\phi}{2}\right) + \psi \operatorname{cosec}\left(\frac{\psi}{2} + \frac{\phi}{2}\right)$$

Shear strain

Equivalent strain:

$$\varepsilon = \frac{1}{\sqrt{3}}\left[2\cot\left(\frac{\psi}{2} + \frac{\phi}{2}\right) + \psi \operatorname{cosec}\left(\frac{\psi}{2} + \frac{\phi}{2}\right)\right]$$

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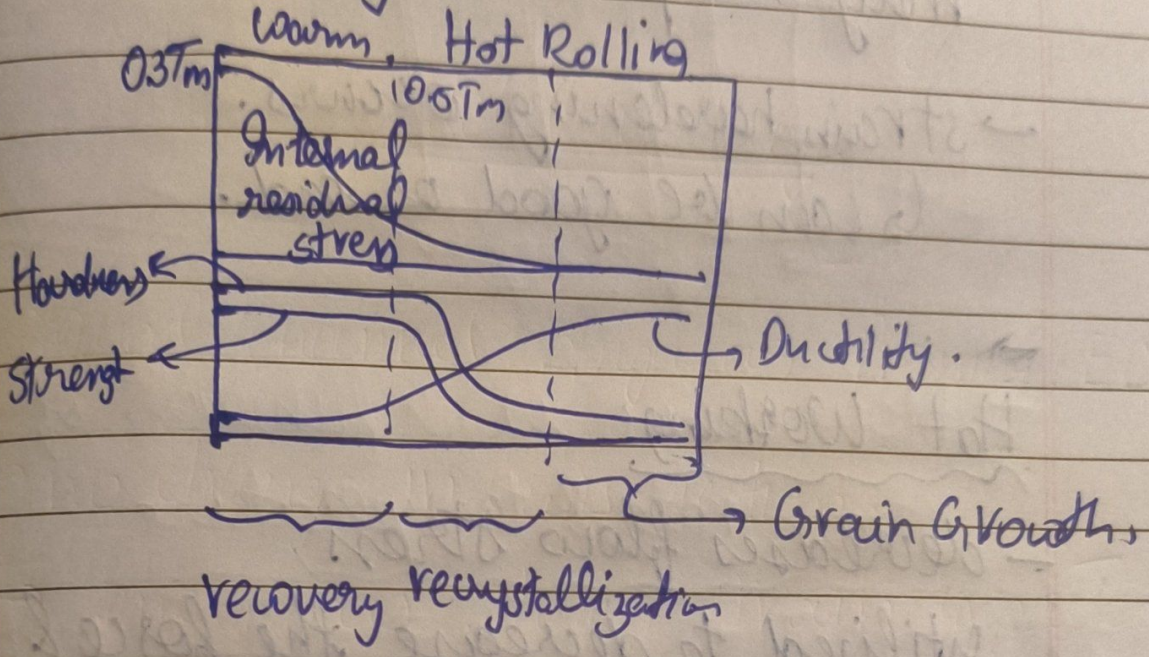
Effect of Temperature on Strength & Ductility:-



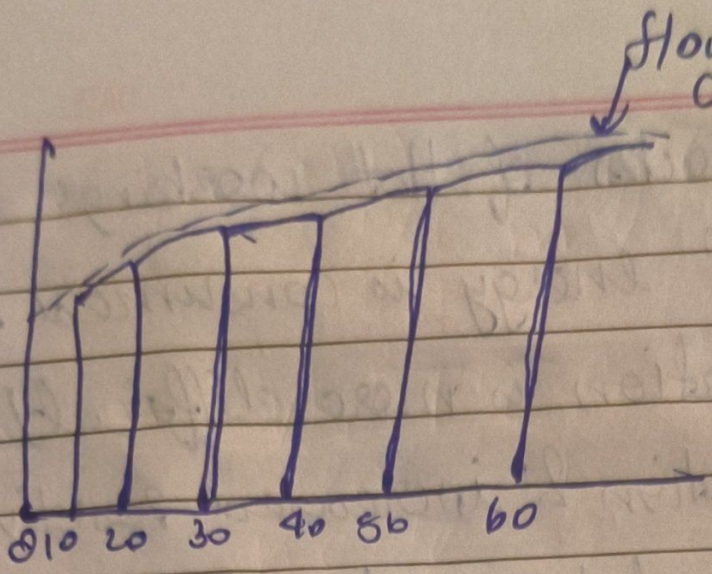
Cold working:-

(Advantages.

- better surface finish:
- better dimensional control
- better strength, fatigue, wear properties.
  strength & hardness ~~&~~ fatigue
- directional properties

Disadvantages: higher forces required.

- more powerful equipment.



- Flow curve is a function of strain rate & temperature

Strain rate: $\dot{\varepsilon} = \frac{d\varepsilon}{dt}$

	Rolling	Tensile
$\dot{\varepsilon} \Rightarrow$	$10^2 - 10^3/s$	$10^{-3}/s$

$|\dot{\varepsilon}| \Rightarrow$ less ~~&~~ sensitive to $\dot{\varepsilon}$ change at low temp.

→ enteremely sensitive to high temp.

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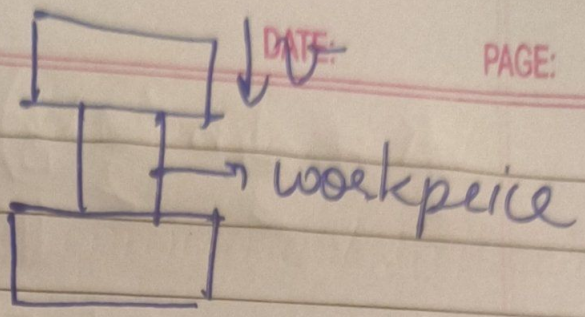
$\dot{\varepsilon} = \frac{v}{h}$



$= \frac{\text{velocity}}{\text{height (instantaneous) of workpeice}}$

Q) $\sigma_{Y/S}$ same or different.

* How stress increases with strain rate.