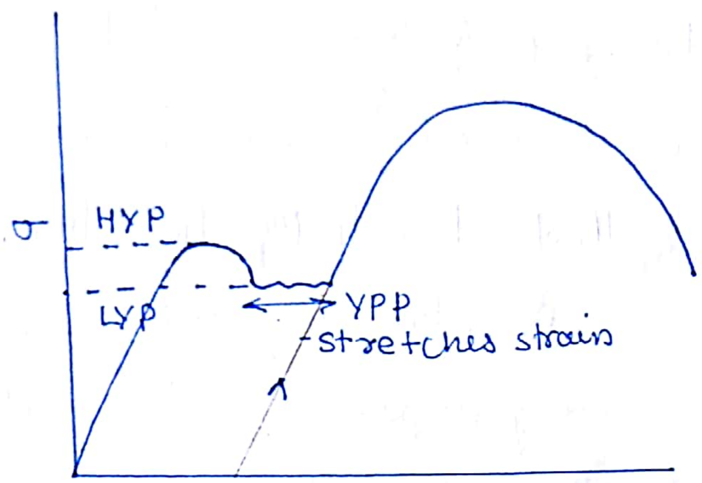
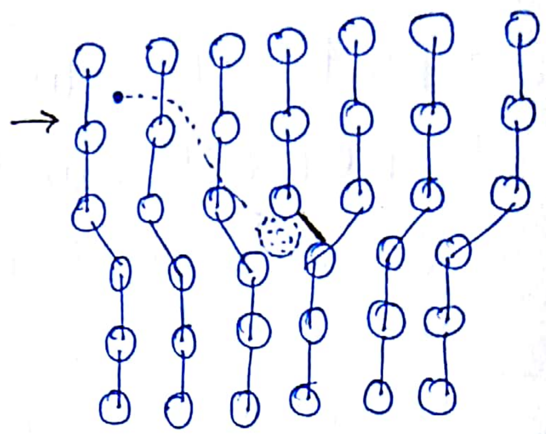
Yield Point Phinomina :-

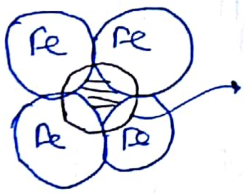
Low carbon steel





* YPP not appear any pure material.

In low c steel there is on some interstitial void so once high strain require dislocation to move and after that low stress require to move. So YPP occur



Size of carbon interstitial void is high than Grap.

Yield Point phinomina appears in those ductile materia in which major alloying element occupied interstitial site like low c steel, Ti, Zr. etc. Al doesn't show this phinomia.

Carbon in iron is an interstitial impurity but interstitial voids are much smaller than the size of carbon atom. This introduces atomic strains in the most iron atom, at the dislocation site due to presence of extra half plate interstitial voids are slightly larger in Size. So carbon diffuses to atomic structure and attracted towards dislocation site. Both carbon and nitrogen diffuses at the dislocation site and produces a carbon or nitrogen atmosphere called Cottrel atmosphere. This Cottrel atmosphere produces strain field in the host iron atom all around the dislocation.

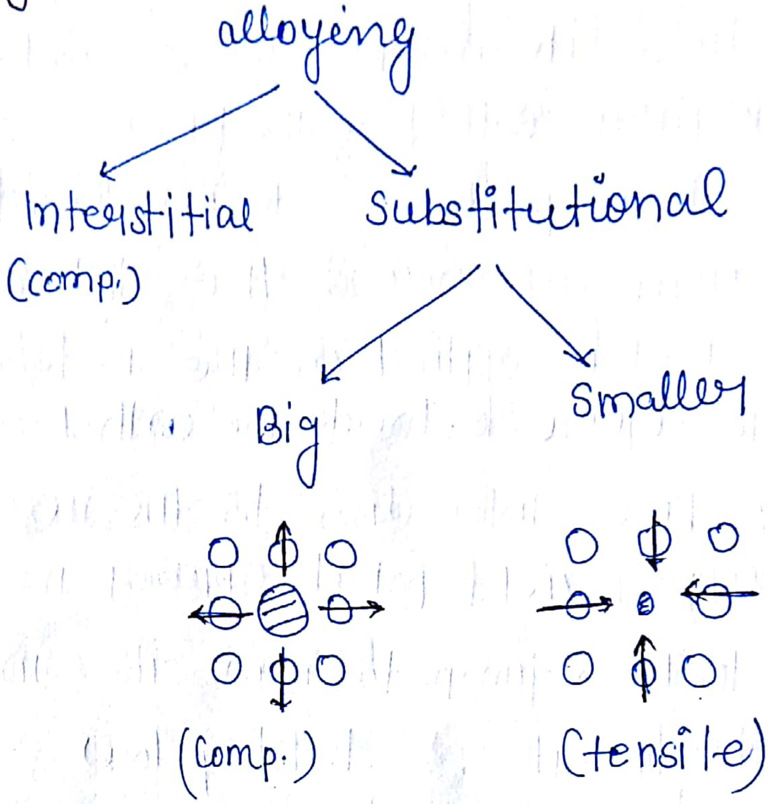
So when the load is applied on the material slightly larger stress are require to break the cottrel atmosphere and jumping the dislocation to the new site thats why upper yield point appear in material.

→ Once the dislocation jump to new site since there is no cottrel atmosphere slightly low stresses sufficient to keep the dislocation moving that why lower yield point and yield point phinomina appear in material.

→ Upon unloading the material from the region of workhardening and reloading again yield point phinomina will not appear again. but after ~~cet~~ certain time period (one & half to two year depand on C %) C & N again diffuse at new dislocation site ~~at~~ and the yield point phinomina will reappear in material. This time period after which YPP reappear in the material is called strain aging time. Skin rolling is perform on the material to ~~pr~~ print strain aging date

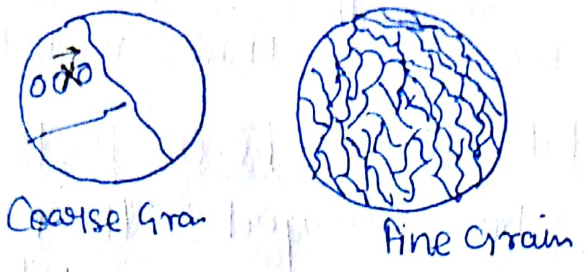
Strengthing Mechanisms

① Alloying



Interstitial impurities produces compressive strain field in host atom. smaller size substitutional impurity produces tensile strain field in host atom. & Big size substitutional impurity produces compressive strain field in host atom. These strain field creats an obstacle in the movement of dislocation this increase the strength of material. Larger is the strain field developed in the material more will be increase in strength. That is a reason alloy are always stronger than pure material.

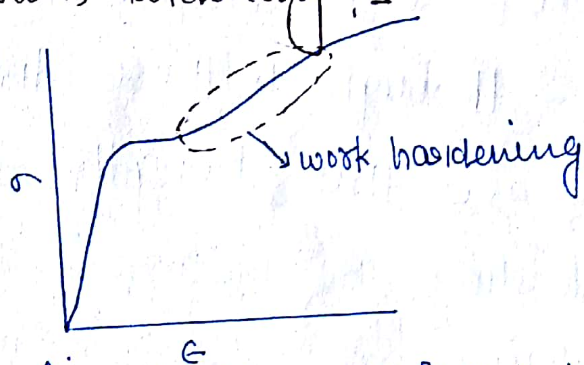
(2) Grain Refinement :-



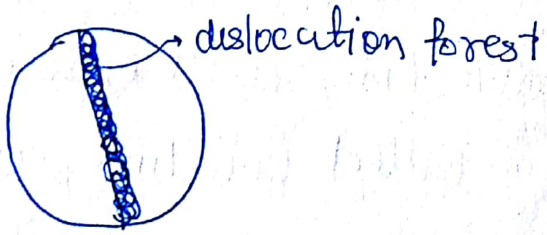
As soon as dislocation reaches the gain boundary, since atoms on the other side are oriented slightly differently so addition stess will be require by the dislocation to change it coarse so finer is the grain structure better will be the strength.

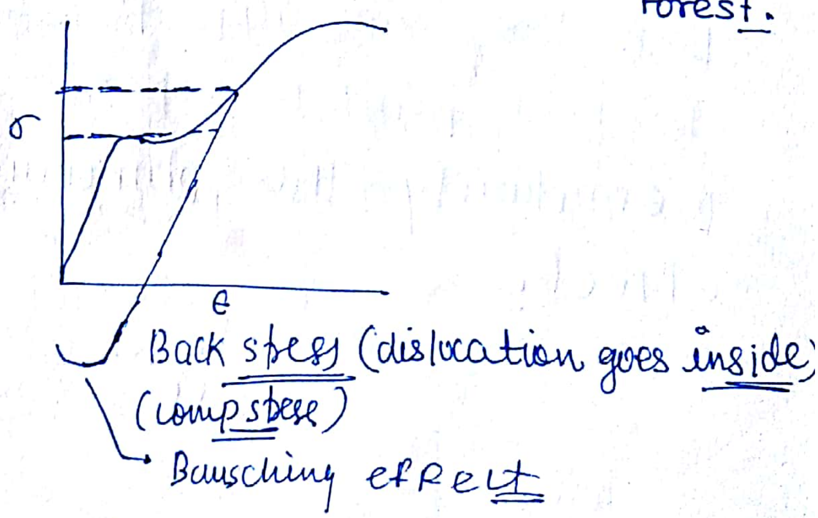
(3) Work hardening / strain hardening :-

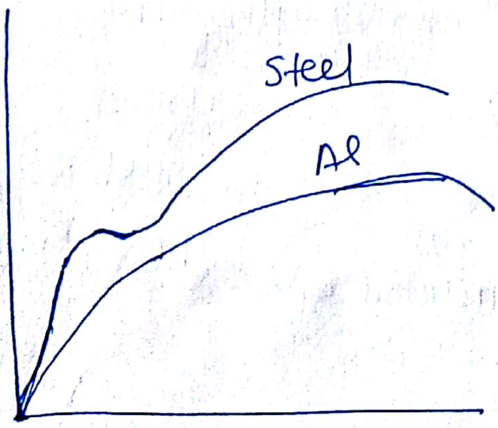
- shot blasting
- sand blasting
- shot peening



when stess applied dislocations comes on surface and creat dislocation forest.



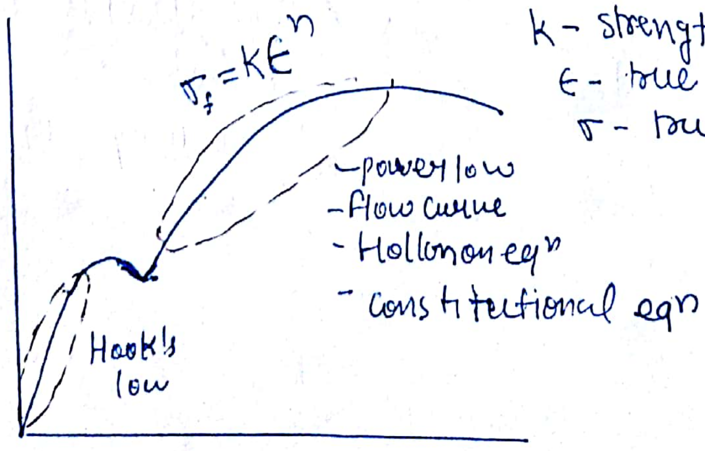




Work hardening :- upon cold working any material no. of dislocation increase in the material. How much dislocation multiflication take place its a property to material and can not be changed. This new dislocation that has been form they Pileup at grain boundries and create a dislocation forest. Interaction between two dislocation is repulsive in nature so this dislocation forest creates a back stress in the moment dislocation present within the grain. So larger stress will be require by dislocation withing grain to cross through these dislocation forest this increase the strength of material.

Upon unloading the material from the region of work hardening and reloading in opposite direction, back stress now support ~~moment~~ movement of dislocation so yield point in opposite direction will appear prematurely. This phinomina called Bauchinger effect.

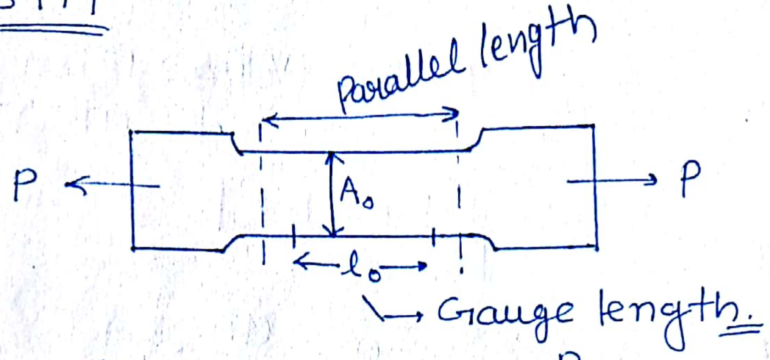
n - work hardening exponential
k - strength coeff.
ε - true strain
σ - true stress.



steel $n \simeq 0.3$

Al $n \simeq 0.05$

ASTM



Engg stress $\sigma_o = \frac{P}{A_o}$

Engg (nominal) stress $e = \frac{dl}{l_o} \rightarrow$ gauge length

Extonsometer – it use to measure instant area.

$\Rightarrow \sigma_t = \left(\frac{P}{A}\right) \times \frac{A_o}{A_o} = \sigma_o \cdot \frac{A_o}{A}$

$\Rightarrow V = A_o l_o = A l$

$\therefore \frac{A_o}{A} = \frac{l}{l_o}$

$e = \frac{dl}{l_o} = \frac{l}{l_o} - 1 = e$

$\frac{l}{l_o} = 1 + e$

$$\boxed{\sigma_t = \sigma_o (1+e)}$$

σ_t = true stress.
σ_o = engg. stress.

True strain

$$\int_0^{\epsilon} d\epsilon = \int_{l_o}^{l} \frac{dl}{l} = [\ln l]_{l_o}^{l}$$

$$\epsilon = \ln\left[\frac{l}{l_o}\right]$$

$$\boxed{\epsilon = \ln(e+1)}$$

ϵ = true strain
e = Engg. strain

$$P = \sigma_t A$$

$$V = Al \quad \text{(Volume is const. up to UTS)}$$

$$\frac{d}{d\epsilon}(P = \sigma_t A)$$

$$\frac{d}{d\epsilon}[V = Al]$$

$$\frac{dP}{d\epsilon} = \sigma_t \frac{dA}{d\epsilon} + A\frac{d\sigma_t}{d\epsilon} \quad -(1)$$

$$\frac{dV}{d\epsilon} = 0 = \frac{dA}{d\epsilon}\cdot l + A\frac{dl}{d\epsilon}$$

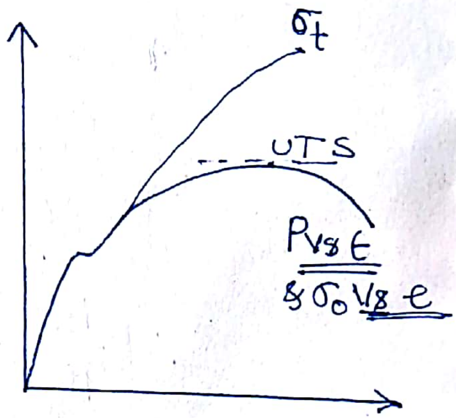
$$\frac{dA}{d\epsilon} = -A\left(\frac{dl}{l\,d\epsilon}\right) \quad \left(\frac{dl}{l\,d\epsilon} = 1\right)$$

$$\frac{dA}{d\epsilon} = -A \quad -(2)$$

From (1) & (2)

$$\frac{dP}{d\epsilon} = -\sigma_t A + A\frac{d\sigma_t}{d\epsilon}$$

$$\frac{dP}{d\epsilon} = A\left(\frac{d\sigma_t}{d\epsilon} - \sigma_t\right)$$



at UTS

From P vs E Curve

Slope is zero so $\frac{dP}{d\epsilon} = 0$

So
$$\frac{d\sigma_t}{d\epsilon} = \sigma_t \quad -(3)$$

we know $\sigma_t = k\epsilon^n$

So
$$\frac{d\sigma_t}{d\epsilon} = nk\epsilon^{n-1}$$

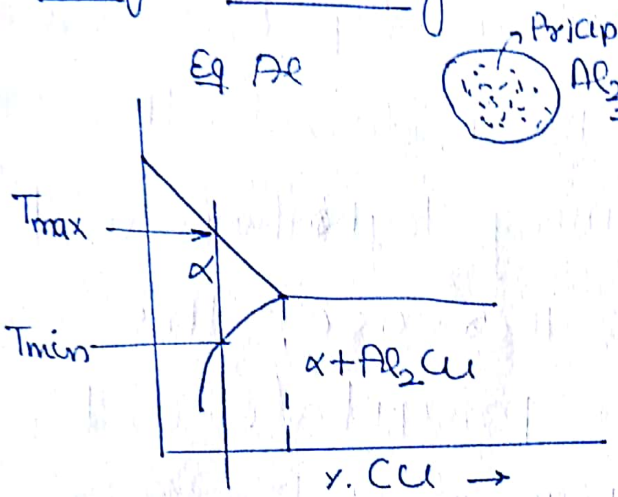
$$\frac{d\sigma_t}{d\epsilon} = \frac{n}{\epsilon}(k\epsilon^n) \quad -(4)$$

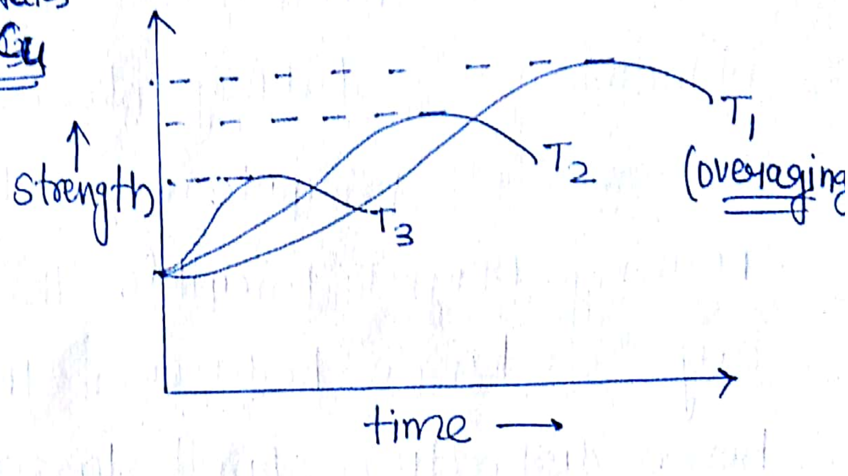
$$\frac{d\sigma_f}{d\epsilon} = \frac{n}{\epsilon}(K\epsilon^n)$$

$$\frac{d\sigma_f}{d\epsilon} = \frac{n}{\epsilon}(\sigma_f)$$

From ③ & ④ $\boxed{n = \epsilon}$

Age hardening :-





$T_3 > T_2 > T_1$

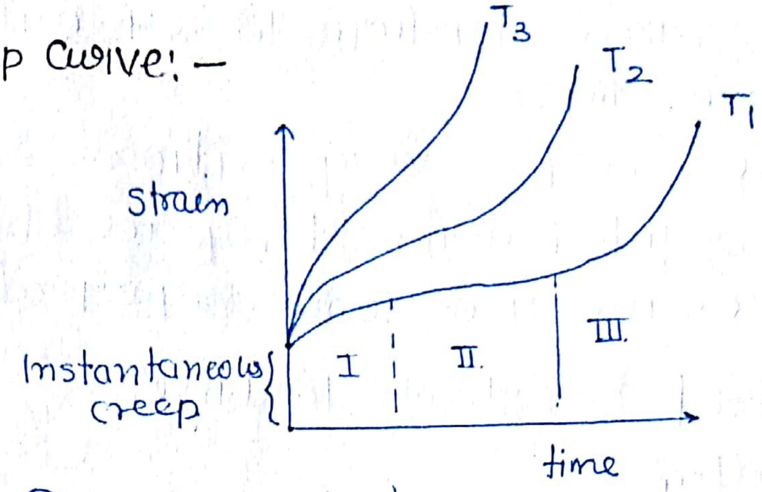
Any alloy of Al having the similar phase diagram as that of Al & Cu, can be age hardened. Alloy of Al & Cu with less 5.5% Cu in it is heated to a temp which uniform phase α appears in microstructure.

From this temp. sample quenched to room temp. Due to this quenching Cu get locked in the structure of Al, as the time passes Cu starts coming out the microstruct and form pricipitate Al_2Cu. these pricipitate create an obstakle in moment of dislocation and this cocept called age ~~or~~ pricipitation hardening.

As the time passes more and more precipitate nucleate and this will decrease the avgrage distance between the pricipitate and hence dislocation will find more no. of obstical in the path. Since cu is limited so after sometime nucleation start This corrosponds to the peak strength of material. Simantaneously one more phinomina is taking place in material that is smaller pricipitate combining toghethar and forming bigger pricipitate. This Increase the avg. distance between the pricipitate and hence dislocation find lasser no. of obsticale in has path this decreases it strength and the phinomina called over ageing.

When ageing is perform on a limited temp. it is called artificial ageing but this temp. less than Tmin. Higher is the temp. of artificial aging more will be the rate of nucleation so rate at which pricipitate are being fo will be high so material become stronger in lasser time period. High the temp. higher the diffusio so rate at which smaller pricipitate combining toghethar and forming a bigger pricipitate also increas this will decrease the peak strength.

Creep Curve: -



$T_3 > T_2 > T_1$

① work hardening
② Recrystallisation

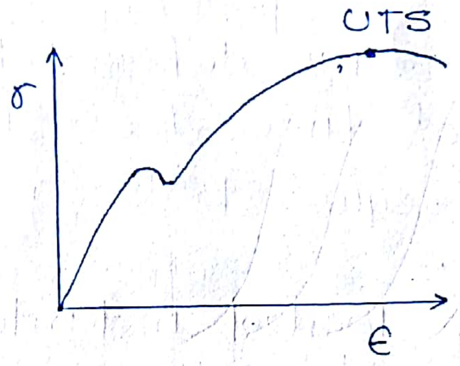
Creep is slow and progressive deformation of material over a period of time at constant load or stress and at a temp. equal to or greater than recrystallisation temp.
The moment material is loaded instantaneously creep will appear and it is similar to elastic strain. In primary creep region, strain rates are decrease because of work hardening. Due to this material becomes stronger.
In secondary creep region there will be a balane b/w work hardening and recrystallisation. So strain rate will be almost constant. but there will be a limit upto which work hardening can happen in any material and slowly recrystallisation phenomena take over hence strain rate suddenly increase and material fracture.
Higher is the temp. more predominent will be recrystallisation phenomena and hence creep curve will shift toward left. At high temp, grain boundary of material is having a tendency to

Flow so finer is grain structure lesser will be creep resistance.

Application:- where creep is very critical like ICBM, fighter aircraft, space shuttles, turbine rotors etc., we use some super alloys.

In Conel-600 → Used in steam turbine
(Ni based super alloy

Nack:-



When applied stress on UTM sample goes beyond yield strength, X-S/c area in parallel length will decrease and this will increase effective stresses. But material is not failing because due to work-hardening material is becoming stronger. Every material is anisotropic so the extent of work hardening will be different at different points. AT UTS there will be a point of weakness and it can appear any where in parallel length where sufficient work hardening has not been done to counter the increase stresses. At that point a unique neck will appear in the material. This neck can appear anywhere in parallel length.

Mechanical properties :—

① **Hardness** :– Resistance to scratch or indentation

② **Brittleness** :– That characteristics of material due to which it fails without any warning

③ **Toughness** :– Resistance to shock and quantified by total area under strain-stress curve upto fracture
→ By work hardening, toughness decreases.

④ **Resilience** :– Resistance to deformation and quantified by total area under stress-strain curve upto elastic point

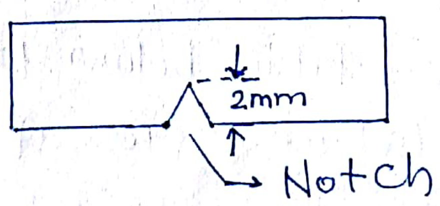
Hardness test (P.g. 39) theory Book Must see

① BHN $BHN = \frac{P}{\left(\frac{\pi D}{2}\right)\left(D-\sqrt{D^2-d^2}\right)}$

② VHN $H_V = \frac{P}{\left[\frac{d^2}{2\sin\frac{\alpha}{2}}\right]}$

③ RH $HRB = 130 - \frac{T}{0.002}$ (Medium), $HRC = 18 - \frac{t}{0.002}$ (Hard)

Impact test To measure toughness.



(i) Charpy test.
(ii) Izod test.
(iii) bend test.
(iv) Torsion test.