Poisson's ratio physically signifies that the amount of lateral strain for lateral stress (or) tensile load on tensile stress.

Shear force is the main part to have deformation in the metal on specimen due to tensile load on tensile stress.

Sliding of atoms take place due to the action of shear force. we can't say in which way the deformation can take place unless we know that what is the "orientation of planes and applied load (or) stress line". F.C.C metals deform more than the b.c.c metal due to max^m no. of dense planes as compare to b.c.c dense planes and direction of deformation.
F.C.C metals have four closed packed planes and each contains three closed pack directions

INTERNAL STRESS RELIEF :

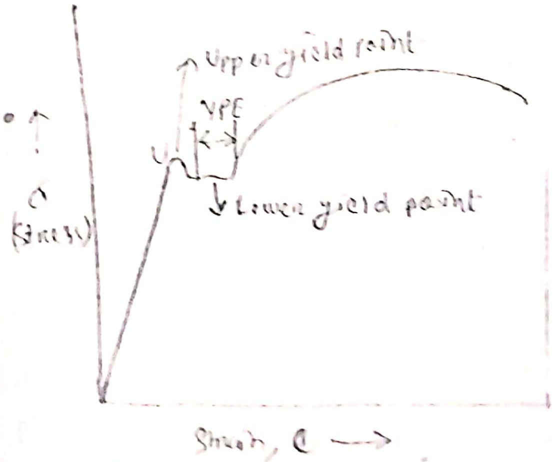
The strain hardening leads to massive decreasing in many properties of the material. The original state of material can be brought back to the properties by relieving the internal stresses due to heavy plastic deformation. This can be achieved by very simple heat treatment process, known as annealing. When the internal stresses are relieved, the material can be further plastically deformed at a lower load which is the basic principle of metal working

When the metals or alloys are worked in a cold condition, the internal stresses ~~are~~ developing for each percentage of straining or strain hardening is very high. while for the same amount of deformation under hot condition the internal stress developing in the material is almost nil.

YIELD POINT PHENOMENON.

INTRODUCTION :

This is the diagram of stress strain curve for (annealed) low carbon steel. The yield point phenomenon was originally found in this material. Here,

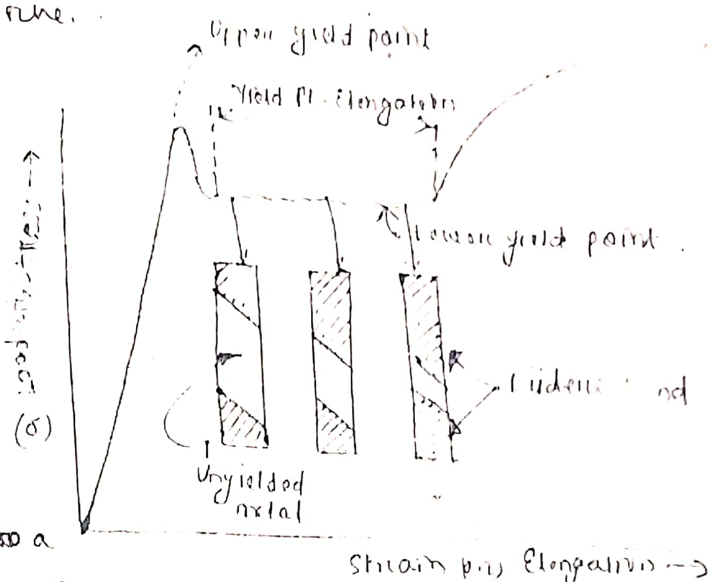


Stress strain diagram for (annealed) low carbon steel.

upper and lower yield points can be seen in the diagram.

Most metals, particularly low-carbon steel, show a localized, heterogeneous type of transition from elastic to plastic deformation which produces a yield point in the stress-strain curve.

Rather than having a flow curve with a gradual transition (σ/ϵ) from elastic to plastic behaviour, metals with a yield point have a flow curve or, what is equivalent, ~~to~~ a load-elongation diagram.



(Typical yield-point behaviour)

The load increases steadily with elastic strain, drops then suddenly, fluctuates about some approximately constant value of load, and then rises with further strain. The load at which the sudden drop occurs is called the upper yield point. The constant load is called the lower yield point, and the elongation which occurs at constant load is called the yield point elongation (YPE). The deformation occurring throughout the yield-point elongation (YPE) is heterogeneous. At the upper yield point a discrete band of deformed metal, often readily visible with the eye, appears at a stress concentration such as fillet, and coincident with the formation of the band, the load drops to the lower yield point. The band then propagates along the length of the specimen, causing the yield point elongation. In the usual case several bands will form at several points of stress concentration. These bands are generally at approximately 45° to the tensile axis. They are usually called Lüder's bands. When several Lüders bands [illegible] mechanism [illegible]

are formed, the fluctuations during the YPE will be irregular, each jog corresponding to the formation of a new Lüders band. After the Lüders bands have propagated to cover the entire length of the specimen test section, the flow will increase with strain in the usual manner. This marks the end of the yield point elongation (YPE).

The yield-point phenomenon was found originally in low carbon steels. A pronounced upper and lower yield point can be obtained and a yield point elongation of over 10 percent with steel material under proper conditions. Yield point phenomena has been accepted as a general phenomenon, since it has been observed in a no. of other metals and alloys. In addn to iron & steel, yield points have observed in polycrystalline Mo, Ti & aluminium alloys and in single crystals of iron, cadmium, zinc, α & β brass, and aluminium. Usually small amounts of interstitial or substitutional impurities can be associated with the yield point. For e.g., it has been observed that almost complete removal of carbon and nitrogen from low carbon steel by wet-hydrogen treatment will remove the yield point. However, only about 0.001% of either C or N is required for a reappearance of the yield point.

A number of experimental factors affect the attainment of a sharp upper yield point. A sharp upper yield point is promoted by the use of an elastically rigid (hard) testing m/c, very careful axial alignment of the specimen, the use of specimens free from stress concentrations, high rate of loading, and frequently, testing at subambient temperature. If, through careful avoidance of stress concentrations, the first Lüders band can be made to form at the middle of the test specimen, the UYP can be roughly twice the lower yield point (LYP). However, it is more useful to obtain an UYP 10 to 20% greater than the LYP.

The onset of general yielding occurs at a stress where the avg. dislocation sources can create slip bands through a good volume of the material. Then, the general yield stress (σ_0) can be expressed as

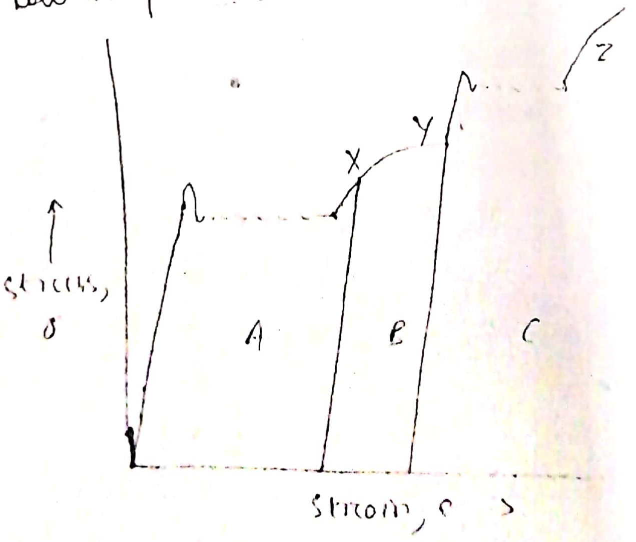
$$\sigma_0 = \sigma_s + \sigma_i$$

where σ_s is the stress to operate the dislocation sources and σ_i is the friction stress representing the combining effect of all the obstacles to the motion of dislocations arising from the sources.

If the stress to operate the dislocation sources is high, then the initial yield stress is high. The explanation of the yield-point phenomenon in terms of dislocation behaviour arose from the idea that the dislocation sources were locked or pinned by solute atom interactions.

Yield drop :- The continuous fall in stress value once the yielding operation begins, is called yield drop.

Strain-aging :- This is a type of behaviour, usually associated with the yield-point phenomenon, in which the strength of a metal is increased and the ductility is decreased on heating at a relatively low temperature after cold-working.

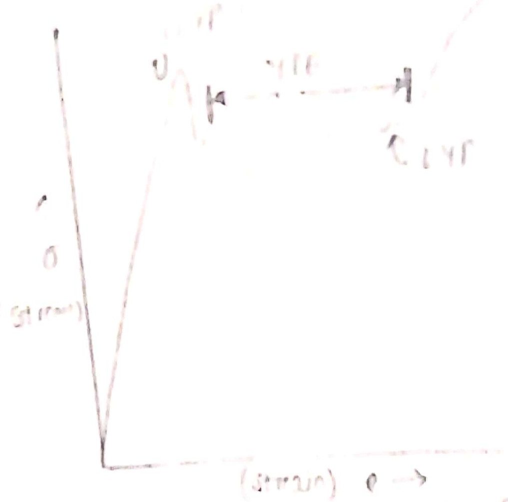


Stress-strain curves for low-carbon steel showing strain-aging. Region A: Original material ~~strain~~ strained through yield point. Region B: Immediately retested after reaching point 'X'. Region C: Reappearance and increase in yield point after aging at 400°K (~130°C).

roughening

(35

Yield Point Phenomenon



[Stress-strain diagram for (annealed) low 'c' steel]

This is the σ-e diagram for (annealed) low carbon steel. The pronounced yield pt phenomenon was found originally in this material. Upper and lower yield points can be seen in the diagram.

The diagram shows that the load (or stress) increases steadily with elastic strain to the point, U, the upper critical point (or UYP). At this point, the metal begins to yield, with a simultaneous drop in the stress required to continue deformation. The stress fluctuates about some approximately constant value, L known as lower critical point (or) LYP and then rises with further strain.

The elongation that occurs at constant stress is called the yield point elongation (YPE).

Importance

In addition to iron and steel, yield point phenomena have been observed in polycrystalline Mo, Ti and Al alloys.

Sharp yield point is very important for a manufacturer who stamps or draws thin sheets of these materials in forming such as automobile bodies & other objects.

Yield point has significance, because once the metal yields and the plastic deformation starts in a given area, the metal at that point is effectively softened and suffers a relatively large plastic deformation.

The deformation then spreads over the material adjoining the region which has yielded because of the stress concentration at the boundary between the deformed and undeformed areas.

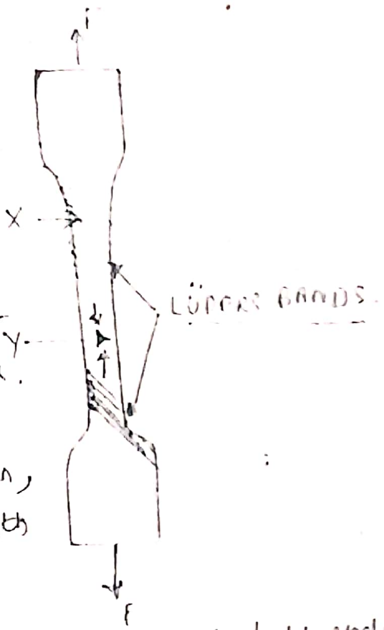
In general, deformation starts at positions of ~~fo~~ stress concentration as discrete bands of deformed metal, called Lüders Bands

Lüders Band formation.

(1) In a tensile test specimen, the fillets are stress raisers and first of all at these points Lüders bands may form.

(2) These bands are generally at approximately 45°-50° to the tensile load axis.

(3) Once a Luder band has formed at one fillet of the tensile test specimen, it can move through the gage length of the specimen.



(4) The Luders band can form simultaneously at both ends of a specimen under certain conditions or at a number of positions throughout the specimen gage length.

(5) Luders bands distinguish those portions of the specimen (X) that have yielded from those which have not (Y).

(6) Arrival at the upper yield point (UYP) is indicated by the formation of luder bands.

(7) Actually, the lower yield stress is perhaps the stress required to propagate the Luder bands.

(8) As the specimen passes through the stage of the yield point elongation (YPE), these bands spread along the specimen and cover the entire gage length, thereby showing that the entire gage length has been overstrained.

(9) Luders bands generally (or) frequently occur in drawing and stamping operations when the surface markings or reliefs are called stretcher strains.

Furrowed - narrow trench made by plough, rut, wrinkle

Stretcher strains are furrowed roughening of the surface of metal sheet, due to uneven yielding in the first stages of cold work and deformation after an aging on, in a lesser degree, normalising or after hot rolling.

In order to avoid stretcher strains on finished parts, the sheet is overstrained prior to pressing operation by means of a temper roll pass to eliminate yield phenomenon.

Yielding Criterion (for Ductile ~~materials~~ metals)

The condition of plastic yielding begins when a ~~material~~ metal is subjected to any possible combination of stresses in the field of plasticity. The prediction of plastic yielding of a material is an important consideration in the yielding criteria determination of a ductile material. In uniaxial loading, as in tension test, macroscopic plastic flow occurs on begins at the yield stress, σ_0, where plasticity goes on increasing. It is expected that yielding under a situation of combined stresses can be related to some particular combination of ~~stresses~~ principal stresses. Yielding criteria means it is always associated with ductile material because there is no yielding occurrence in case of brittle materials. There is at present no theoretical way of calculating the relationship between the stress component to correlate yielding for a three-dimensional state of stress with yielding in the uniaxial tension test.

The yielding criteria are essentially empirical relationships. However, a yield criterion must be consistent with a number of experimental observations, the chief of which is the pure hydrostatic pressure does not cause yielding in a continuous solid. As a result of this, the hydrostatic component of a complex state of stress does not influence the stress at which yielding occurs, so, a stress deviator is to be involved with yielding. Moreover, for an isotropic material, the yield criterion must be independent of the choice of axes, i.e., it must be an invariant function. This leads to a conclusion that yield criteria must be some function of the invariants of the stress deviator. At present there are two generally accepted criteria for predicting the onset of yielding in ductile metals:

(i) Von Mises' (or) Distortion Energy Criterion
(ii) Max^m shear-stress (or) Tresca Criterion

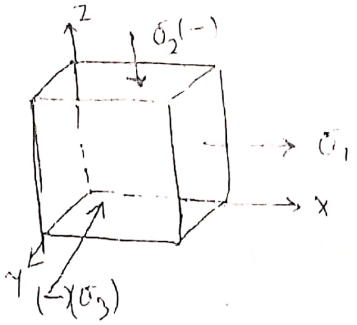
(i) Von Mises' (1913) proposed that yielding would occur when the second invariant of the stress deviator J_2 exceeded some critical value.

$$J_2 = K^2 \quad \text{- - - - ①}$$

~~where J_2~~ where K is a constant

where $J_2 = \frac{1}{6}\left[(\sigma_1-\sigma_2)^2+(\sigma_2-\sigma_3)^2+(\sigma_3-\sigma_1)^2\right]$

Here, there are three principal stresses, $\sigma_1, \sigma_2, \sigma_3$; shear stress, $\tau_{xy}, \tau_{yz}, \tau_{zx}$. σ_3 is the principal stress acting on the sideplane normal to it.



To evaluate the constant K and relate it to yielding in uniaxial tension test, we realize that at yielding in uniaxial tension, $\sigma_1 = \sigma_0$, $\sigma_2 = \sigma_3 = 0$. (yield stress in uniaxial tension, σ_0)

$$J_2 = \frac{1}{6}\left[\sigma_0^2 + (-\sigma_0)^2\right] = \frac{1}{6}\cdot 2\sigma_0^2 = \frac{1}{3}\sigma_0^2$$

$$J_2 = \frac{1}{3}\sigma_0^2 = K^2$$

$$\Rightarrow \boxed{K = \frac{1}{\sqrt{3}}\sigma_0} \rightarrow \boxed{\sigma_0 = \sqrt{3}K}$$

where σ_0 is the distortion energy yielding criterion or condition

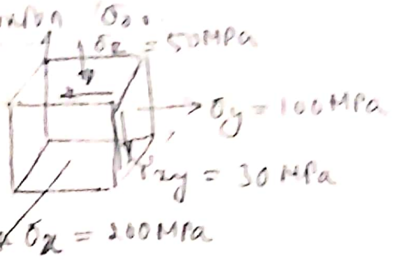
$$\sigma_0 = \sqrt{3}\times K \Rightarrow \sqrt{3}\times\frac{1}{\sqrt{6}}\left[(\sigma_1-\sigma_2)^2+(\sigma_2-\sigma_3)^2+(\sigma_3-\sigma_1)^2\right]^{1/2}$$

$$= \frac{1}{\sqrt{2}}\left[(\sigma_1-\sigma_2)^2+(\sigma_2-\sigma_3)^2+(\sigma_3-\sigma_1)^2\right]^{1/2}$$

$$\sigma_0 = \frac{1}{\sqrt{2}}\left[(\sigma_x - \sigma_y)^2 + (\sigma_y - \sigma_z)^2 + (\sigma_z - \sigma_x)^2 + 6(\tau_{xy}^2 + \tau_{yz}^2 + \tau_{zx}^2)\right]^{1/2} \quad \text{--- ⑪}$$

These two equations predict that yielding will occur when the differences of stresses on the right side of the equation exceed the yield stress in uniaxial tension σ_0.

$\sigma_0 = 500$ MPa



Ans. $\sigma_0 = \frac{1}{\sqrt{2}}\left[(200 - 100)^2 + (100 - (50))^2 + (-50 - 200)^2 + 6(30)^2\right]^{1/2}$

$\sigma_0 = \frac{1}{\sqrt{2}} \times (100{,}400)^{1/2} = \frac{316.859}{\sqrt{2}} = 224$ MPa

Since the value of σ_0 calculated from the yield criterion is less than the yield strength of the aluminium alloy, yielding will not occur. So, the safety factor is $\frac{500}{224} = 2.2$

To identify the constant K, consider the state of stress in pure shear, as is produced in a torsion test.

$\sigma_1 = -\sigma_3 = \tau \quad \sigma_2 = 0$

at yielding $\sigma_1^2 + \sigma_1^2 + 4\sigma_1^2 = 6K^2$

$\therefore |\sigma_1 = K|$

So that K represents the yield stress in pure shear (torsion).

Therefore, the Von Mises' criterion predicts that the yield stress in torsion will be less than in ~~[illegible]~~ uniaxial tension according to

$K = \frac{1}{\sqrt{3}}\sigma_0 = 0.577\,\sigma_0$

As a result, the von Mises' yield criterion represents

on implies that yielding is not dependent on any particular normal stresses, on shear stress, but instead, yielding depends on a function of all three values of principal shearing stress $(\sigma_1, \sigma_2 \,\&\, \sigma_3)$ since the yield criterion is based on differences of normal stresses, $\sigma_1 - \sigma_3$, etc, the

the criterion is independent of the component of hydrostatic stress. Since the von Mises' yield criterion involves squared terms, the result is independent of the sign of individual stresses. This is an imp. advantage since it is not necessary to know which are the largest and smallest principal stresses in order to use this yield criterion.

Von Mises' originally proposed this criterion because of its mathematical simplicity. Subsequently, other workers have attempted to give it physical meaning.

~~Henky~~ Henky show that, the equation

$$\sigma_0 = \frac{1}{\sqrt{2}} [(\sigma_1-\sigma_2)^2 + (\sigma_2-\sigma_3)^2 + (\sigma_3-\sigma_1)^2]^{1/2}$$

$$\sigma_0 = \frac{1}{\sqrt{2}} [(\sigma_1-\sigma_2)^2 + (\sigma_2-\sigma_3)^2 + (\sigma_3-\sigma_1)^2]^{1/2}$$ was equivalent to assuming that yielding occurs when the distortion energy reaches a critical value.

The distortion energy is that part of the total strain energy per unit volume that is involved in change of shape as opposed to a change in volume.

④ Maxm. shear stress or Tresca Criterion :

This yield criterion assumes that yielding occurs when the maxm shear stress reaches the value of the shear stress in the uniaxial-tension test.

we know that maxm shear stress is given by

$$\tau_{max} = \frac{\sigma_1 - \sigma_3}{2}$$

where σ_1 is the algebraically largest and σ_3 is the algebraically smallest principal stress.

For uniaxial tension, $\sigma_1 = \sigma_0$, $\sigma_2 = \sigma_3 = 0$, and the shearing yield stress τ_0 is equal to $\sigma_0/2$.

$$\tau_{max} = \frac{\sigma_1 - \sigma_3}{2} \Rightarrow \boxed{\tau_0 = \frac{\sigma_0}{2}}$$

when $\sigma_1 - \sigma_3 = \sigma_0$, yielding will just start

Therefore, the max^m shear stress criterion is given by

$$\sigma_1 - \sigma_3 = \sigma_0$$

For a state of pure shear, $\sigma_1 = -\sigma_3 = k$, $\sigma_2 = 0$, the max^m shear stress criterion predicts that yielding will occur when

$$\sigma_1 - \sigma_3 = 2k = \sigma_0$$

$\sigma_1 - \sigma_3 = \sigma_0$

$2k$; $k = \frac{\sigma_0}{2}$

or, $\boxed{k = \sigma_0/2}$

so that the max^m shear stress criterion may be written

$$\sigma_1 - \sigma_3 = \sigma_1' - \sigma_3' = 2k$$

We know that the max^m shear stress criterion is less complicated mathematically than the von Mises' criterion, and for this reason it is often used in engineering design. However, the max^m shear criterion does not take into account the intermediate principal stress. It suffers from the major difficulty that it is necessary to know in advance which are the max^m and min^m principal stresses. Moreover, the general form of the max^m shear stress criterion is far more complicated than the von Mises' criterion. and for this ~~reason the~~ reason the von Mises' criterion is preferred in most theoretical work.

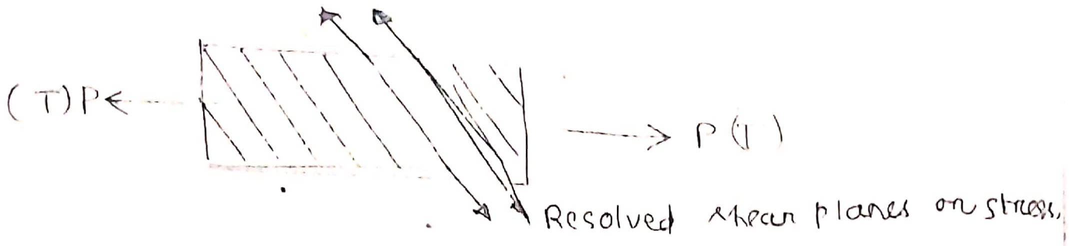
The general form of the max^m shear-stress criterion (or) Tresca criterion is

$$\boxed{4J_2^3 - 27J_3^2 - 36k^2 J_2^2 + 96k^4 J_2 - 64k^6 = 0}$$

Critical Resolved Shear Stress (for plastic deform^n):-

The plastic deformation of the material is due to slip of one atomic plane over the other plane. So, it indicates plastic deformation is a result of shear stress only. Whenever tensile force (or) compressive force arises on a metallic object, the plastic deform^n takes place on certain crystallographic planes and the stress associated with plastic deform^n is the resolved shear stress of the original tensile or compressive stress working on the object

T > Tensile



As per basic theory of plastic deformation, the plastic deformation in metals and alloys (or) slips in metals and alloys take place along

(a) Closed pack direction
(b) on closest pack plane } Orientation of slip plane w.r.t. the tensile forces applied

The extent of slip in a single crystal depends on magnitude of the shearing stress produced by the external load, orientation of the active slip planes w.r.t. shearing stress & the slip direction. slip begins when the shearing stress on the slip plane in the slip direction reaches a <u>threshold value</u> known as <u>critical resolved shear stress</u>. ~~for ordinary~~ this value For ordinary (or) for a single crystal For single crystal. For is the yield stress of the single crystal. this value is half the polycrystalline materials of the σ_0 (Shear stress).

Resolved shear stress $= \frac{1}{2}\sigma_0$.

Resolved (on) slip plane is relatively Plastic deform not only on the tensile related to the shear stress load or force

τ_{CRS} (Critical resolved shear stress) $\geq \frac{1}{2}\sigma_0$.

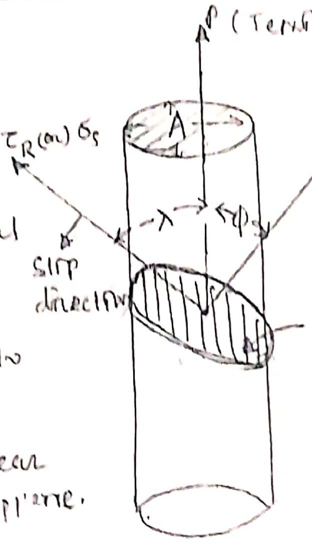
$$\tau_{CRS} \geq \frac{1}{2}\sigma_0 .$$

Critical resolved shear stress for slip is a property of material and does not depend upon the structure. The value of critical resolved shear stress depends on composition and temperature.

Besides being a function of critical stress, the force need to produce slip also depends upon the

(i) Angle between the slip plane and the direction of force (φ is the angle between the tensile axis on load and normal to the slip plane)

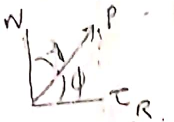
(ii) Angle between the slip direction and the direction of tensile load, is λ.



$\cos\phi = P$

Consider a cylindrical single crystal with cross-sectional area (A).

So, when a specimen is subjected to tensile or compressive stresses, the material fails due to the induced shear stresses along the shear plane or slip plane.



$\cos\phi = \frac{\tau_R}{...}$

$\tau_R = P\cos$

$\tau_R = P\cos$

The area of the slip plane inclined at the angle φ will be A/cos φ, and the component of the axial load acting in the slip plane in the slip direction is P.cos λ.

Therefore, the critical resolved shear stress is given by

$$\tau_R = \frac{P\cos\lambda}{A/\cos\phi} = \frac{P}{A}\cos\phi\cdot\cos\lambda$$

$$= \text{Tensile stress} \times \cos\phi\cdot\cos\lambda.$$

$$= \text{Tensile stress} \times \cos\phi\cdot\cos\lambda$$

$$= \sigma\cdot\cos\phi\cdot\cos\lambda$$

$$\tau_{CRS} = \sigma_0\,[\cos\phi\cdot\cos\lambda]$$

where σ_0 = Tensile stress value of a particular value of a standard metal

$$\tau_R = \frac{P}{A}\cdot\cos\phi\cdot\cos\lambda = \sigma\cdot\cos\phi\,\cos\lambda$$

↓

Since equation gives the shear stress resolved on the slip plane in the slip direction.

The shear stress is max^m when $\phi = \lambda = 45°$, so that

$\tau_R = \frac{1}{2} \frac{P}{A} = \frac{1}{2}\sigma_0$ when $\cos\phi \cos\lambda = \frac{1}{\sqrt{2}} \cdot \frac{1}{\sqrt{2}} = \frac{1}{2}$

$\boxed{\tau_R = \frac{1}{2}\sigma_0}$

If the tension axis is normal to the slip plane ($\lambda = 90$) or if it is parallel to the slip plane ($\phi = 90$), the resolved shear stress is zero. Slip will not occur for these extreme orientations, since there is no orientation shear stress on the slip plane. Crystals ~~the~~ close to these orientations tend to fracture rather than slip.

The ratio of the resolved shear stress to the axial stress is called the Schmid factor (τ_R/σ_0), m. For a single crystal loaded in tension or compression along its axis, $m = \cos\phi \cdot \cos\lambda$. [illegible] Schmid factor

$\tau_R = \sigma_0 \cdot \cos\phi \cdot \cos\lambda$ → Schmid's law.

It is observed experimentally that a single crystal will slip when the resolved shear stress on the slip plane reaches a critical value. This behaviour, ~~is~~ known as Schmid's law, is best demonstrated with hcp metals where the limited number of slip systems ~~because~~ allows large differences in orientation between the slip plane and the tensile axis. In fcc metals the high symmetry results in so many equivalent slip systems that it is possible to get a variation in the yield stress of only about a factor of 2 because of differences in the orientation of slip plane ~~and~~ with tensile axis.

The magnitude of the critical resolved shear stress τ of a crystal is determined by the interaction of its population of dislocations with each other and with defects such as vacancies, interstitials, and impurity atoms. This stress is, of course, greater than the stress required to move a single crystal dislocation but it is appreciably lower than the stress required to produce slip in a perfect lattice. On the basis of this reasoning, the critical resolved shear stress (τ_{CRSS}) should decrease as the density of ~~defe~~ defects decreases, provided

Deformation By twinning

Twinning results when a portion of the crystal takes up an orientation that is related to the orientation of the rest of the untwinned lattice in a definite, symmetrical way. The twinned portion of the crystal is a mirror image of the parent crystal. The plane of symmetry between two portion is called the twinning plane. If a shear stress is applied, the crystal will twin about the twinning plane. The region to the atoms have sheared in such a way as to make the lattice a mirror image across the twin plane, The region to the right of the twinning plane is undeformed. To left of twin plane, the planes of atoms have sheared in such a way as to make the lattice a mirror image across the twin- plane.

difference between twinning & slip

Slip	Twinning
1) the orientation of the crystal above and below the slip plane is the same after deformation as before	1) It results an orientation difference across the twin plane.
2) It occurs in discreate multiples of atomic spacing	2) atoms movements are much less than an atomic distance.
3) slipe occurs in milli seconds	3) Twin can forms in a time as short as few microseconds.

Twin produced by mech. deformation or as the result of annealing following plastic deformation. The first type are known as Mechanical twins, latter called annealing twins. mech. twinning produced in bcc and hcp metal under conditions of rapid rate of loading and decreased temp.

Strengthening Mechanism

Grain boundaries

The boundary between grains in a polycrystalline aggregate are a region of distruhed lattice only a few atomic diameters wide. The grain boundary structure contains grain-boundary dislocations. As the grain diameter is reduced more of the effects of grain boundaries will be felt at the grain center. Strain hardening of a fine grain size metal will be greater than in a corse-grain polycrystalline aggregate.

Hall - Petch Relation

A general relationship between yield stress and grain size was proposed by Hall and greatly extended by Petch.

$$\sigma_0 = \sigma_i + K D^{-1/2}$$

σ_0 = the yield stress.

σ_i = the friction stress, representing overall resistance of the crystal lattice to dislocation movement.

K = locking parameter, reaptive hardening contribution of the grain boundaries

D = grain diameter.

This is also applied grain boundaries and other type of grain boundaries such as ferrite and cementite boundaries in pearlite, mechanical twins and martensite plates.

Flow stress in terms of dislocation density by

$$\sigma_0 = \sigma_i + \alpha G b \rho^{1/2}$$

α = numerical constant = 0.3 to 0.6

ρ = dislocation density and $\rho = 1/D$

$$\sigma_0 = \alpha G b D^{-1/2} = \sigma_i + K' D^{-1/2}$$

Yield point elongation

Many metals, particularly low carbon steel, show a localized, hetrogenous type of transition from elastic to plastic deformation which produces a yield point in the stress-strain curve. Rather than having a flow curve with a gradual transition from elastic to plastic behaviour. The load increases steadily with elastic strain, drops suddenly, fluctuates about some constant value of load, and then rises with further strain. The load at which the sudden drop occurs is called the upper yield point. the constant load is called the lower yield point, the elongation which occurs at constant load is called the yield point elongation. The deformation occuring throughout the yield point elongation is hetrogenous. At the upper yield point a discreate band of deformed metal, readily visible with eye, appeares at stress conc. such as fillet and load drops to the lower yield point. These bands are generally called luder bands. It is approximaly 45° to tesile axis. They are found in low carbon steel.

Strain-aging

Strain aging is usually associated with the yield point phenomenon in which the strength of a metal is increased and the ductility is decreased on heating at a relatively low temp. after cold working. Nitrogen plays a more important role in the strain aging of iron than carbon. It has a higher solubility and diffusion co-efficient and produces less complete precipitation during slow cooling. The stress-strain curve for a low carbon steel strained plastically through the yield point elongation to a strain corresponding to point x. The specimen is then unloaded and ~~rested~~ retested without appreciable delay or any heat treatment (region B). Note that on reloading the yield point does not occur since the dislocations have been torn away from the atmosphere of carbon and nitrogen atoms. Consider now that the specimen is strained to point y and unloaded. If it is reloaded after aging several ~~hours~~ days at room temp. at an aging temp. 300°F, the yield point will reappear. The reappearance of the yield point is due to diffusion of carbon and nitrogen atoms to the dislocations during the aging period.

Solid solution strengthening

Forging equipment

1) It may be classified with respect to the principle of operation.

2) In forging hammers the force is supplied by a falling wt. of ram.

3) These are energy restricated machine and the deformation results from dissipating the K.E. of the ram.

④ Mechanical forging presses are stroke restricated machines since the length of the press stroke and the available load at various positions of the stroke represent their capability.

⑤ The two basic types of hammer are the board hammer and the power hammer. In board hammer the upper die and ram are raised by friction rolls gripping the board. When the board is released, the ram falls under the influence of gravity to produce blow energy,

⑥ the energy supplied by the blow is equal to P.E. due to wt. of ram and ht. of fall. Forging hammers are rated wt. of ram.

~~The two basic types of hammer are the board hammer~~
~~and the power hammer.~~ Hammer is an energy restricted machine in which the deformation proceeds until the total K.E. is dissapiated by plastic deformation of the work piece or elastic deformation of the dies and machine

In power hammer ram is accellrated on the down stroke by steam or air pressure in addition to gravity. Energy of the blow can be controlled, wheres the board hammer the mass and ht. of fall is fixed. It is used for closed die forgings. There is problems ground shock, noise and vibration, and can be over come by counter blow hammer.

Forging presses are either of mechanical or hydraulic design. Presses are rated on the basis of the forces developed at the end of the stroke. The production rate is high, initial cost is high.

Hydraulic presses are load restricted machine in which hydraulic pressure moves a piston in a cylinder. Full press load is available at any point during the full stroke of ram.

Screw press is used both hot and cold closed die forging. In a screw press the ram is connected by a rotary joint to a spindle, which is in effect a ~~loose~~ screw. The rotary motion of a fly wheel is transformed into linear motion by the multiple thread on the spindle and its nute.

Forging defect :- Incomplete forging penetration can readily be detected by Macroetching. If the deformation during forging is limi to the surface layers, when light rapid hammer blows are used, the dendritic structure will not be broken at the interior of the forging. internal cracks. to minimise Large section are usually made on forging press.

② Surface Carecking can occur as a result of excessive working of the surface at too low temp. or as a result of hot shortness. A high sulphur conc. in the furnace atomsphere can produce hot shortness in steel and nickel.

③ Cracking at the flash of closed die forging is another surface defect. Cracks penetrates into the body when the flash is trimmed off. It can be avoided by increasing flash thickness or hot trimming or stress releiving prior to cold trimming of flash.

④ Cold shut → Cold shut or fold is a discontinuity produced when two surfaces of metal fold against each other without welding completly.

⑤ Loose scale or lubricant residue accumulate in deep recess of the die forms scale pocket and causes underfill.

⑥ A secondary tensile stress can devlope during forging and cracking can thus be produced. internal cracks can develop during the upsetting of a cylinder. to avoid it use concave dies.

⑦ Flow lines or fiber structure → The deformation produced by forging results in a certain degree of directionality to the microstructure in which second phases and inclusions are oriented parallel to the direction of greatest deformation. when view at low magnification appears as flow lines or fiber structure, the fibre structure results in lower tensile ductility and fatigue properties in the direction normal to it.