LECTURE NOTES

On

MATERIAL TESTING

GOVT. POLYTECHNIC MAYUBHANJ, TIKARPADA

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Course code: Th5 Semester:3rd

Vision and Mission of the Department

VISION: To offer quality technical education In the field of Metallurgical Engineering with orientation towards industry, entrepreneurship, higher education and to strive for developing professionally competent technicians meeting the needs of the global economy.

MISSION:

M1: To develop students in the field of Metallurgical Engineering as highly motivated, skillful and qualified manpower for employment and higher learning

M2: To promote a conducive environment for all round development of students.

M3 : To promote linkages with external agencies to meet changing needs of industry and society.

M4: ToImproveLaboratories

Program Education Objectives (PEOs)

PEO1: Diploma professionals will be able to make a successful career in metallurgical industries or higher studies to meet the need s of future requirements.

PEO2: Diploma metallurgists will have technical and behavioral competencies through adequate exposure to industry.

PEO3: To impart technological knowledge and skills for so living real-time engineering problems.

PEO 4: To develop human resources with capabilities of effective communication, moral values and social responsibilities.

MATERIAL TESTING

Material testing is the measurement of the characteristics & behaviour of such substances as metals, ceramics or plastics under various condn.

→ But here we will study about the metals & non-metals.

Material Testing.

- Destructive Testing
  - → Hardness Test
  - → Tensile Test
  - → Impact Test
  - → Fatigue Test
  - → Creep Test
- Non-Destructive Testing
  - → Visual Testing
  - → Leakage Test
  - → Magnetic Particle Testing
  - → Dye penetrant Test
  - → Eddy current Testing
  - → X-ray Diffraction.

HARDNESS TEST

Hardness

→ Hardness usually implies resistance of the material to plastic deformation.

→ Deformation means the change in shape & size.

* Deformation is of two types
    1) Elastic
    ii) Plastic

(i) Elastic Deformation

→ It is the non-permanent deformation.

→ Hence the, after this change the material again return back to its initial size &shape.

→ Thus, no change in size & shape.

(ii) Plastic Deformation

→ It is the permanent Deformation.

→ Hence, after this change; the material not again return back to its initial size & shape.

→ Thus, a proper change in size & shape.

* Every material has a elastic limit. When the force on it crosses the elastic limit of it, the plastic deformation occurs. After heavy deformation the fracture occurs.

Need of Hardness Test

Hardness test is required to measure the effect of heat treatment.

Heat treatment is defined as the heating, coking & cooling operation.

It can the cooled upon 3 types
i) Annealing
ii) Normalizing
iii) Hardening

i) Annealing- Cooling inside the furnace
ii) Normalizing- Cooling over the normal air.
iii) Hardening- Cooling it by adding it inside the water.

TYPES OF HARDNESS

There are basically three types
(a) Elastic / Rebound / shore's hardness
(b) Scratch hardness
(c) Indentation hardness
- Brinell hardness
- Vicker hardness
- Rockwell hardness
- Knoop hardness

HARDNESS

- Elastic / Rebound / shore's hardness
  - Equipment → Shore's scleroscope
- Scratch hardness
  - → Moh's scale
- Indentation Hardness
  - Brinell hardness
  - Vicker hardness
  - Rockwell Hardness
  - Knoop hardness

(a) ELASTIC OR REBOUND HARDNESS

Defn

→ The resistance offered by the metal to impact & the resultant ~~ha~~rebound of the impact is known as elastic hardness.

→ OR, It is the property of the material which offers resistance to impact.

→ The device used to measure this hardness is called sceleroscope or shore's scletroscope.

Shore's Sceleroscope

→ The arrangement in this device is such that, it measures the height of rebound of a small diamond tipped hammer that is allowed to drop from a definite height onto the metal surface by its own weight.

→ The hammer, after hitting the surface rebound & the height of rebound is recorded.

→ The height of rebound is an indication of surface hardness.

→ Hence, the corresponding hardness is shore's hardness

Structure -

→ The surface is quench hardened high carbon steel surface

→ It contains the hammer with the diamond tip or indenter.

It's weight is only 2.6 gm.

→ The hammer strikes the test piece at the requisite area & momentarily exerts a stress of around 470 tons per squar. inch, which is enough to produce a permanent indentation.

→ Higher the hardness higher the rebound,
Lower the hardness lesser will be the rebound.

Explainatn

In softer material, the indentation will be more; Hence more energy will ~~from~~ use in forming the indentation.
So the hammer rebounds to a shorter height.
Similarly, alternate in case of harder material.

(b) SCRATCH HARDNESS & TEST

Defn
It is the property of the material which resist to scratch, wear & tear & abrasion.

→ This method is more used by Geologist & mineralogogist

→ This concept was given by the scientist Friedrich Mohs

→ The measurement is done by Mohs scale

Principle

→ whenever a soft material get ~~scratched~~ rubbed with a hard material, it get scratched. Hence, it proves its softeness.

→ The Mohs scale is formed as softer to harder in number of 10 materials. They are rubbed to any material & then in which it can't get scratched i.e its hardness no.

Mohs Scale :-

Mineral	Scratch Hardness no.
Talc →	1
Gypsum →	2
Calcite →	3
Fluorite →	4
Apatite →	5
Orthoclase →	6
Quartz →	7
Topaz →	8
Corundum →	9
Diamond. →	10

Soft ↕ hardest

Calculation

Let us a material 'A'.

Let A is scratchable at with Topaz. But A is not scratchable with corundum.

→ Hence, the Scratch hardness no. of A will between 8 & 9.

Advantages

→ Very simple & Low cost.

→ rapid & Quick

Disadvantages

→ very little use with metallurgist

→ hardness scale is highly limited to find the exact hardness.

(c) INDENTATION HARDNESS

It is defined as the property of material or resistance to indentation. (Plastic Deformation)

Indentation is the penetration by a indentor of known geometry.

Some major tests under indentation.

(i) Brinell Hardness Test

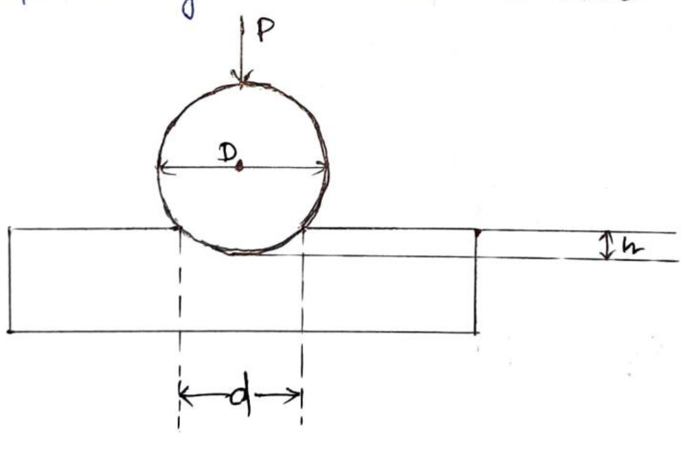
(ii) Vicker Hardness Test

(iii)

(iv)

(i) BRINELL HARDNESS TEST

Test was proposed by J. A. Brinell in 1900



where,

P = Load

D = Diameter of Indenter sample

d = Diameter of Indentation

h = Deapth of Indentation.

Types of Indenter -

i) Hardened steel ball of 1, 2, 5 mm, 5 mm & 10mm size

ii) For very hard material Tungsten Carbide (WC) ball may be used to minimize the distortion of indenter.

Principle

The load P is applied on the surface of the test piece by lever arrangement.

→ For harder material a load of 3000 kg is selected while for softer material a load of 500 kg is usually selected to avoid deep impressions.

→ For ferrous metals the load is applied for 10 seconds while for softer non-ferrous metals, the load is applied for 30 seconds.

→ When the steel ball indenter is impressed into the specimen surface, it produces an indentation of circular type/shape.

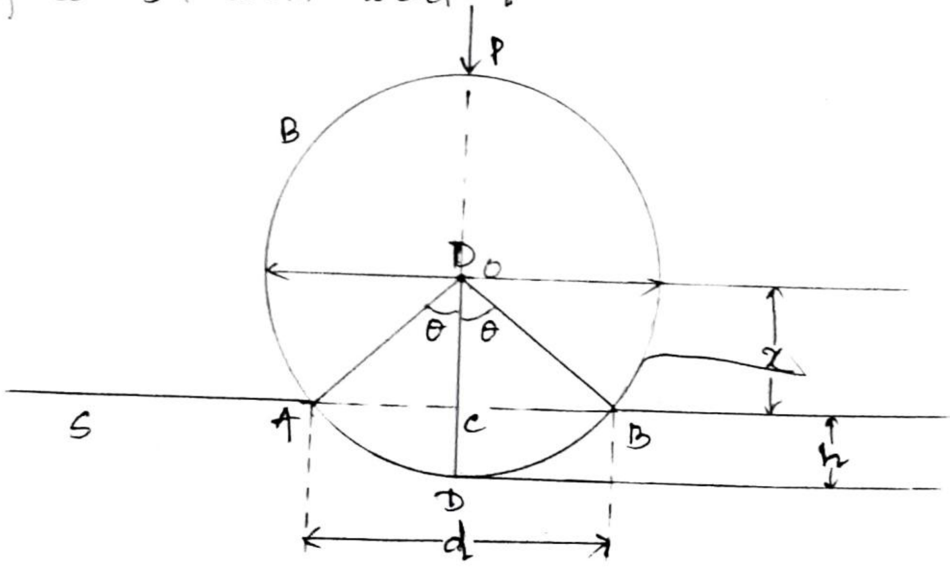
→ The Brinell Hardness Number (BHN) is expressed as the load (P) divided by the curved surface area of the indentation.

i.e $$BHN = \frac{P\,(\text{Load})}{\text{Curved Surface Area}} = \frac{P}{\pi D h}$$

$$= \frac{2P}{\pi D\left[D - \sqrt{D^2 - d^2}\right]}.$$

Derivation of B.H.N.

Let us consider the indenter B is impressed into the surface 'S', with load 'P'



here, D = Diameter of the indenter

d = Diameter of the indentation.

$\theta = \angle AOC = \angle BOC$

h = deapth of indentation

lets assume, $OC = x$

We know, $\cancel{B.H.N = \frac{2P}{\pi D [D - \sqrt{D^2 - d^2}]}}$

$$B.H.N. = \frac{2P}{\pi D h} \quad \text{——— (i)}$$

Thus, from diagram

$$OD = x + h$$

$$\Rightarrow D/2 = x + h$$

$$\Rightarrow h = D/2 - x \quad \text{——— (ii)}$$

In right Angled triangle AOC,

$$AO^2 = OC^2 + AC^2$$

$$\Rightarrow (D/2)^2 = x^2 + (d/2)^2$$

$$\Rightarrow x^2 = \frac{D^2}{4} - \frac{d^2}{4}$$

$$\Rightarrow x = \sqrt{\frac{D^2 - d^2}{4}}$$

$$\Rightarrow x = \frac{1}{2}\sqrt{D^2 - d^2} \quad \text{——— (iii)}$$

Putting the value of x in eqⁿ (ii)

$$\Rightarrow h = D/2 - 1/2\sqrt{D^2 - d^2}$$

$$\Rightarrow h = 1/2 [D - \sqrt{D^2 - d^2}] \quad \text{——— (iv)}$$

Now eqⁿ (i) will be,

$$BHN = \frac{2P}{\pi D \times 1/2 [D - \sqrt{D^2 - d^2}]}$$

$$\Rightarrow \boxed{B.H.N = \frac{2P}{\pi D [D - \sqrt{D^2 - d^2}]}} \quad \text{——— (v)}$$

Again in right angled Δ AOC

$$\sin\theta = \frac{AC}{AO} = \frac{d/2}{D/2}$$

$$\Rightarrow \sin\theta = d/D$$

$$\Rightarrow d = D\sin\theta \text{ ——————— (vi)}$$

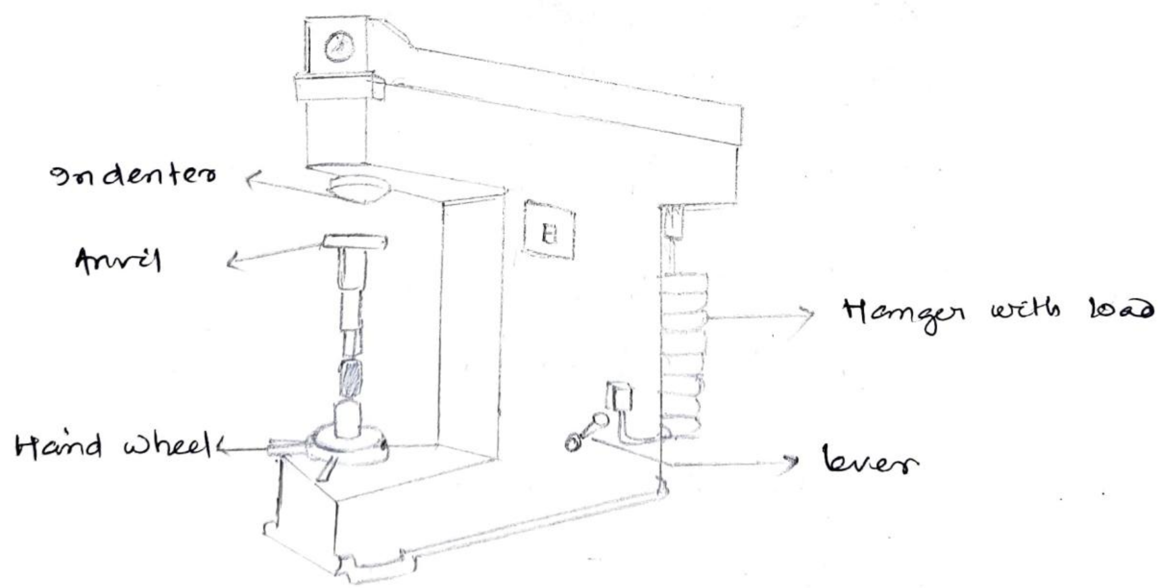
now putting the value in eqⁿ (v), we got,

$$BHN = \frac{2P}{\pi D\left[D - \sqrt{D^2 - D^2\sin^2\theta}\right]}$$

$$= \frac{2P}{\pi D\left[D - D\sqrt{1-\sin^2\theta}\right]}$$

$$\boxed{BHN = \frac{2P}{\pi D^2 (1-\cos\theta)}} \text{ ——— (vii)}$$

Brinell Hardness Testing Machine



Surface preparatn-

During the surface preparation it should be ensured that the surface hardness is not changed.

Rough surface should be ground flat before testing

Test Procedure

1. Selection of appropriate test force & indenter diameter.
2. Placing of the test piece on suitable anvil so that the test piece does not move at all during testing.
3. The indenter is brought into contact with the test surface by moving the anvil head.
4. The test load is then applied at a particular point perpendicular to the test surface for 10-15 sec. unless otherwise specified. It should be ensure that there is no vibration or shock during loading. After the loading time is over, load is removed & the diameter of the indentation is measured in to direct right angle to each other.
5. The mean diameter is found out. By the given formula Brinell hardness number is calculated.

Advantages -

1. Due to large size of the impressions in a Brinell hardness Test, the effect of local inhomogenity is averaged out
2. As Brinell test is less influenced by the surface conditions extensive surface preparation is not essential as compared to the other hardness test.

Disadvantages

(1) It is not possible to cover the entire range of commercial materials with a single load indenter diameter combination

(2) As the Brinell impression is large, the impression works as a potential site for failure for small & critically stressed machine component.

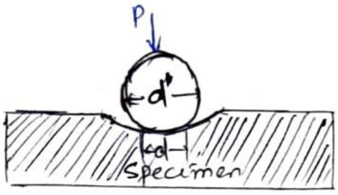
(3) High technical skill is required to evaluate BHN value

(4) This test is slower compared to other hardness tests

Two drawbacks –

(a) Sinking-in effect.

It occurs in manganese & austenitic steels.
This is primarily due to higher hardness of the material being tested compared to the ball hardness



d - Actual
d' - measured.

(b) Piling up effect.

It occurs in lead, tin & magnesium alloys. This is primarily due to much lower hardness of the material being tested compared to the indenter hardness

d = Actual
d' - Measured.

(ii) ROCKWELL HARDNESS TEST

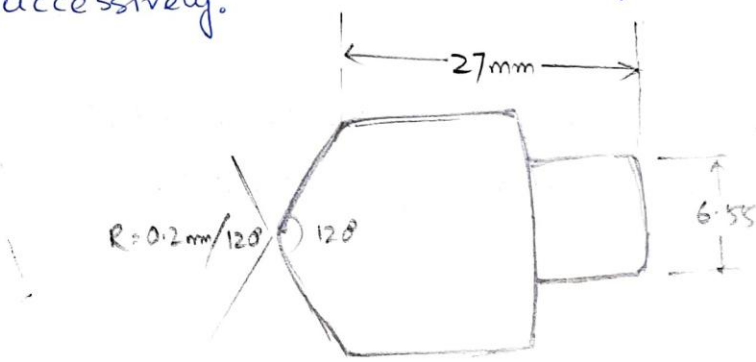
→ It is an indentation hardness test.

→ The Indenter –

Diamond cone indenter is used, having included angle 120 & 0.2mm radius of curvature at the tip.

or hardened steel ball of diameter 1.6mm or 3.2mm

→ The indenter is forced ~~to~~ into the surface of the test piece in 2 steps by applying a minor & a major load successively.



Rockwell Hardness No. (RHN) = $\frac{h}{0.002 \text{ mm}}$

where,

h = Depth of penetrat^n in mm or indentation.

Types of Indenters

1. The general Indenters are 1.6 & 3.2 mm hardened steel ball.
2. A 120° diameter cone with slightly rounded tip called Brale indenter is used for hard material.
3. The major loads of 60, 100 & 150 kg are applied

Scales used in Rockwell Hardness Testers

1. A - Scale.
   - → This scale is for soft materials (to extremely hard)
   - → It uses Brale indenter.
   - → 60 kg major load is applied.
   - → It is the most extended Rockwell hardness scale as it is used for extremely soft material brass to extremely hard cemented carbides (WC, TiC etc) materials
   - → The hardness value is represented as $HR_A 50$, $HR_A 60$.
2. B - Scale.
   - → This scale is for non-ferrous materials. (moderately hard)
   - → It uses steel ball indenter.
   - → 100 kg major load is applied.
   - → The hardness value is represented by $HR_B 50$ or $R_B 100$.
3. C - Scale.
   - → This scale is used for hardened steel components.
   - → It uses Brale indenter.
   - → 150 kg major load is applied.
   - → The hardness value is represented by $HR_C 20$ or $HR_C 50$.
   - → The most useful range of the scale is from $R_C 20$ to $R_C 70$.

- The total load applied on the test specemen in two stages, called.
  i) Minor load
  ii) Major load.

For B scale, generally 10 kg minor load is applied.

Minor load application is too important for the following reason.

1. It minimizes the amount of surface preparation.
2. It reduces the tendency for ridging or sinking of the test materials around the indenter.
3. As the indenter is imbedded to the sub surface by the minor load, the entire effect of surface finish is eliminated.

Surface preparation-

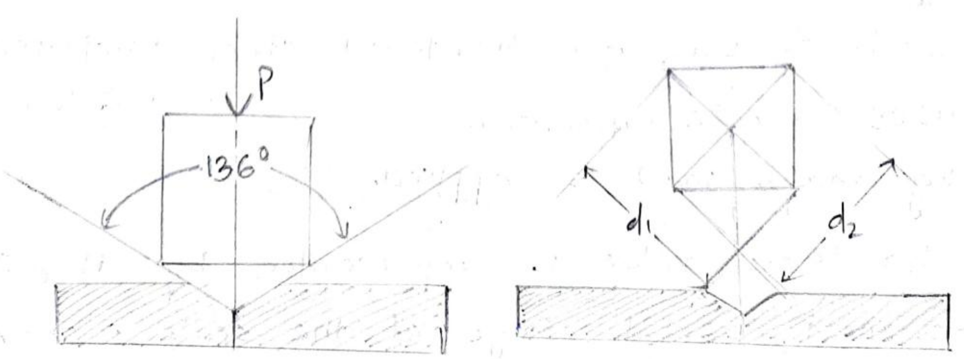
The surface should be flat and perpendicular to the indenter

(iii) VICKERS HARDNESS TEST :-

→ It is an indentation hardness test.

→ The indenter -

- Square based diamond Pyramid Indenter.
- It has an angle of 136° between the opposite faces at the vertex.



Mathematically,

The Vickers Hardness Number (VHN) or (DPH) $= \frac{2P\sin\theta/2}{L^2}$

here, P = Load in kg,

L = average lengths of Diagonal $= \frac{d_1+d_2}{2}$

$\theta = 136°$

$$\therefore \quad VHN = \frac{2P\sin\frac{136°}{2}}{L^2} = \frac{2P\sin 68°}{L^2}$$

$$= \frac{1.854\,P}{L^2}$$

Surface prepatication

In a macroscale it will be ground surfac.

For micro hardness test, the surface will be mechanically polished i.e electropolished.

Application

- In research work because it provides a continuos skale of hardness.

Procedure of Vicker Hardness Test

→ 120 kg load was applied on the sample for 15-20 sec.

→ After applicat of load, the load was removed & the length of diameters of indentation wase calculated.

→ Average length of the diameter was calculated.

→ Vicker hardness number was calculated by using the formula,

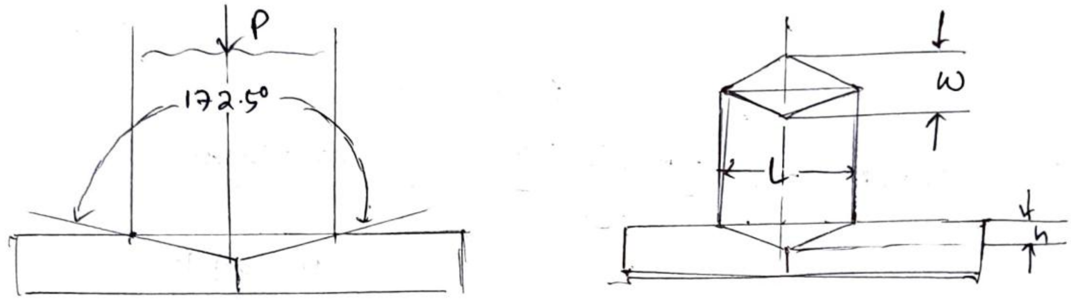
$$VHN = \frac{1.854\,P}{L^2}$$

(iv) Knoop Hardness Test

→ It is a indentation hardness Test. & It's a Micro hardness test.

→ Indenter

- Rhombic based diamond pyramid indenter
- Longitudinal angle 172.5° or 172°, 30' & included angle of 130° ~~is for~~



w = length of the short diagonal

L = length of the long diagonal of indentation in mm

P = Load in kg

h = Depth of Indentation

Knoop Hardness Number (HK) or (KHN)

$$HK = \frac{P}{L^2 C}$$

where,

P = Load in kg

L = length of long diagonal of Indentation in mm.

C = Indentation constant (0.07028), relating to the projected area of indentation to the square of the length of the long diagonal (L).

Surface preparation.

Top & bottom surfaces should be flat, smooth & parallel. The test surface should be fine polished to obtain a well defined indentation.

TENSILE TEST

Tension- Generally created by Pulling & streching

- Tensile strength & compressive strength is the body of knowledge which deals with the relationship between internal forces, deformation & external loads.

Equipment- Universal Testing Machine.

Strength-

It is the resistance of the material to permanent deformation when external force applied on it.

or

Resistance of the material to fracture.

Deformation-

Any change in original shape & size of the material due to action of external load is applied, is defined as deformation.

This is generally of two types-

- Elastic - non-permanent
- Plastic - Permanent

→ After plastic limit, the material get fractured.

→ But, the load upto which the material behaves elastically is known as elastic limit.

Elastic deformation-

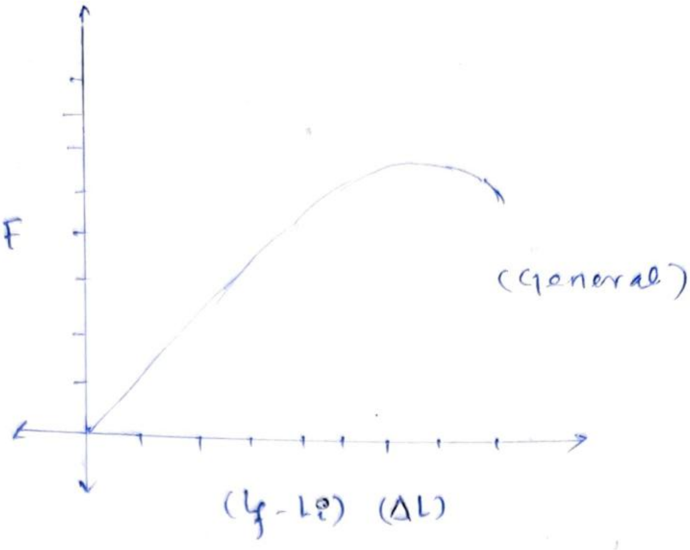
Many solid materials regain their original shape & size of the load working on them is taken off within certain limit of load. This character is known as elasticity.

Plastic deformation-

→ When the load working on the material exceeds the elastic limit, the material undergoes permanent deformation known as plastic deformation.

→ It is permanent, which will be not recovered even after the removal of the deforming load.

Load & Change in length relation.



Stress / Engineering stress (σ)

→ Stress is defined as the force acting on the unit cross-sectional area.

or

→ The internal resistance force to deformation per unit area of cross-section is known as stress.

Mathematically,

$$\sigma = \frac{F}{A}$$

where
F = External force
A = Cross-sectional Area of body.

Strain / Engineering strain (e) :-

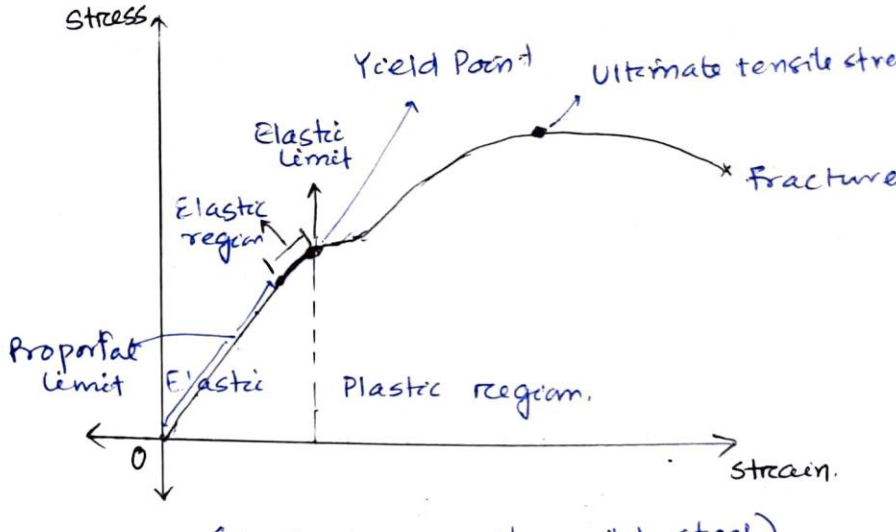
The change in dimensions with respect to the original dimensions associated with the stress is known as strain (e).

Hence average strain. (e)

$$e = \frac{L_f - L_0}{L_0} = \frac{\Delta L}{L_0}$$

It is the ratio of change in length to the original length.

Engineering stress - strain Diagram



(σ - e curve of mild steel)

Terms :-

Proportional limit :-

It is generally the initial straight line portion of the σ - e curve. & $\sigma \propto e$

Elastic limit :-

It is the limit upto the elastic deformation ie $\sigma \propto e$.

Yield point & Yield strength

The point at σ - e curve, after which material behaves plastically or deforms permanently is called as yield point.

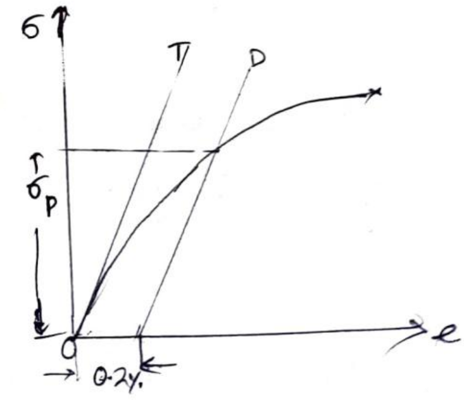
or,

A point at which material's permanent deformation starts.

- The corresponding strength is called yield strength.

Offset yield point & Proof stress

Some non-ferrous metals does n't have a well defined yield point.



→ A line is drawn from 0.2% (ϵ) strain, parallel to the tangent line drawn from the origin, & that point ~~touches~~ at which it touches the curve is known as offset yield point.

→ The corresponding stress at that point is known as Proof stress.

Ultimate Tensile Strength (UTS)

The maximum stress in stress-strain curve is known as ultimate tensile strength (UTS).

After this stress, the material progress rapidly to failure.

Note

→ For brittle material, the failure strength is same as its ultimate tensile strength.

→ For ductile material, the ultimate tensile strength is different from its failure strength.

Fracture stress & fracture point

→ The point at which the material fails is known as fracture point.

→ The corresponding stress at the fracture point is known as fracture stress.

HOOK'S LAW

Hook's law states that, within the proportional limit stress(σ) is directly proportional to strain (e).

Mathematically,

$$\sigma \propto e$$

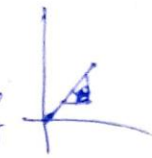
$$\Rightarrow \sigma = Ee$$

where,

E = Modulus of Elasticity or Young's modulus.

$E = \frac{\sigma}{e} = \frac{\text{Stress}}{\text{strain}}$

Note
Slope of straight line portion of σ-e curve give the modulus of elasticity

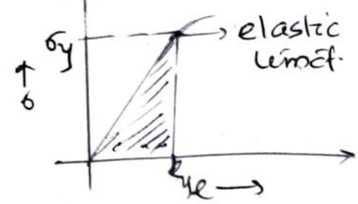


$\tan\theta = \frac{\sigma}{e} = E$

Unit of E = kg/mm^2

Resilience

The ability of the material to absorb energy during its elastic limit is known as resilience.



Mathematically,

$$U_R = \frac{1}{2} \sigma_y e_y$$

It denotes - Ductility property

Toughness

The ability of the material to absorb energy within its plastic range is called toughness of the material.

$$U_T \approx \frac{\sigma_0 + \sigma_u}{2} \cdot e_f \quad , \text{ for ductile.}$$

for Brittle,

$$U_T = \frac{2}{3} \sigma_f e_f$$

Ductility :-

It is the property of the material by virtue of which it can be converted to wire.

There are two methods to measure ductility

1) Elongation method.

In this method, ductility is expressed in the terms of percentage elongation of the specimen till the specimen fractures.

Let initial length = l_i

final length = l_f

$\therefore$ % Elongation $= \frac{L_f - l_i}{l_i} \times 100$

ii) Reduction in cross-sectional Area

In this method, ductility is expressed in the percentage reduction in area.

Let initial cross-sectional Area $= A_0$

final / Before fracture the cross-sectional Area $= A_f$

% reduction $= \frac{A_0 - A_f}{A_0} \times 100$

Malleability

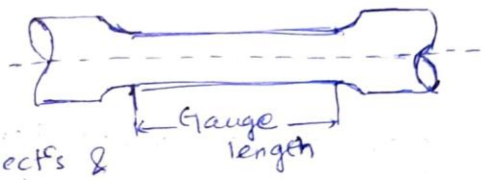
It is the property of the material by virtue of which it can be converted to plate or sheet.

→ It shows compressive property of the material.

Some measures in the laboratory Test

Gauge length (l_0)

most important parameter



&

$l_0 = 5.65\sqrt{A_0}$ for circular sect's &

$l_0 = 4\sqrt{A_0}$ for rectangular strips.

Generally, $l_0 = 5D$.

→ The test is performed in UTM. The Specimen is gripped firmly between the jaws of UTM, vertically. Then the machine adjusted to zero

→ Then the load is applied.

→ All things and changes are instrumentally observed.

→ Then the material fails.

→ The $\sigma - \epsilon$ curve is drawn.

COMPRESSION TEST

It is just opposite of tension test.
In this test the load is applied on the material & its deformations get observed.

compressive load – The maximum load in which the material get breaks.

$$\sigma_c = \frac{\text{Load}}{\text{Cross-sectional area}} = \frac{F}{A_i}$$

$$e = \frac{l_f - l_i}{l_i} = \frac{\Delta l}{l_i}$$

i.e compressive strength = $\frac{\text{Compressive load}}{\text{Cross-sectional Area of the specimen}}$

True stress & True strain

The instantaneous values of stress & strain based on the changed dimensions are known as true stress & true strain.

- The force per unit instantaneous cross-sectional area is known as true stress (σ_T)

$$\sigma_T = \frac{F}{A_{instantaneous}}$$

- The ~~strain~~ ratio of change in length to the instantaneous length is known as true strain (e_T)

$$e_T = \frac{\Delta l}{l_{instantaneous}}$$

i.e change in length to the instantaneous gauge length

Relation Between True Stress (σ_T) & Engineering stress (σ)

The True stress is, $\sigma_T = \frac{F}{A_{inst}}$ ——— (I)

& Engineering stress $\sigma = \frac{F}{A_0}$ ——— (II)

$$\therefore \sigma_T = \frac{F}{A_{inst}}$$

$$= \frac{F}{A_{inst}} \times \frac{A_0}{A_0}$$

$$= \frac{F}{A_0} \times \frac{A_0}{A_{inst}}$$

$$\Rightarrow \sigma_T = \sigma \times \frac{A_0}{A_{inst}} \quad \text{——— (III)}$$

As, the volume remain constant,

$$A_0 \times l_0 = A_{inst} \times l_{inst}.$$

$$\Rightarrow \frac{A_0}{A_{inst}} = \frac{l_{inst}}{l_0}$$

Now putting the value in eq^n (III)

$$\Rightarrow \sigma_T = \sigma \times \frac{l_{inst}}{l_0} \quad \text{——— (IV)}$$

we know,

$$\Delta l = l_{inst} - l_0$$

$$\Rightarrow l_{inst} = \Delta l + l_0$$

Putting it in eq^n (IV),

$$\Rightarrow \sigma_T = \sigma \times \left(\frac{\Delta l + l_0}{l_0} \right)$$

$$= \sigma \left(\frac{\Delta l}{l_0} + 1 \right)$$

$$\Rightarrow \boxed{\sigma_T = \sigma (e + 1)} \quad \left[\because e = \frac{\Delta l}{l_0} \right] \text{——— (V)}$$

$\therefore$ The eq^n (V) represents the relat^n between True stress (σ_T) & engineering stress (σ).

Relation Between True strain (ϵ_T) & Engineering strain (e)

True strain, $\varepsilon = \frac{\Delta l}{l_{inst}}$

& engineering strain = $\frac{\Delta l}{l_0}$

$\Rightarrow \varepsilon = \frac{\Delta l}{l_{inst}}$

$\varepsilon = \varepsilon_1 + \varepsilon_2 + \varepsilon_3 + \varepsilon_4 + \cdots + \varepsilon_n$

$\varepsilon = \sum_{n=1}^{\infty} \varepsilon$

As Integrating,

$$\int_0^{\varepsilon} d\varepsilon = \int_{l_0}^{l_{inst}} \frac{dl}{l}$$

$$\Rightarrow [\varepsilon]_0^{\varepsilon} = [\ln|l|]_{l_0}^{l_{inst}}$$

$$\Rightarrow \varepsilon = \ln(l_{inst}) - \ln|l_0|$$

$$\Rightarrow \varepsilon = \ln\left|\frac{l_{inst}}{l_0}\right| \quad \text{——— (I)}$$

we know, $l_{inst} = \Delta l + l_0$

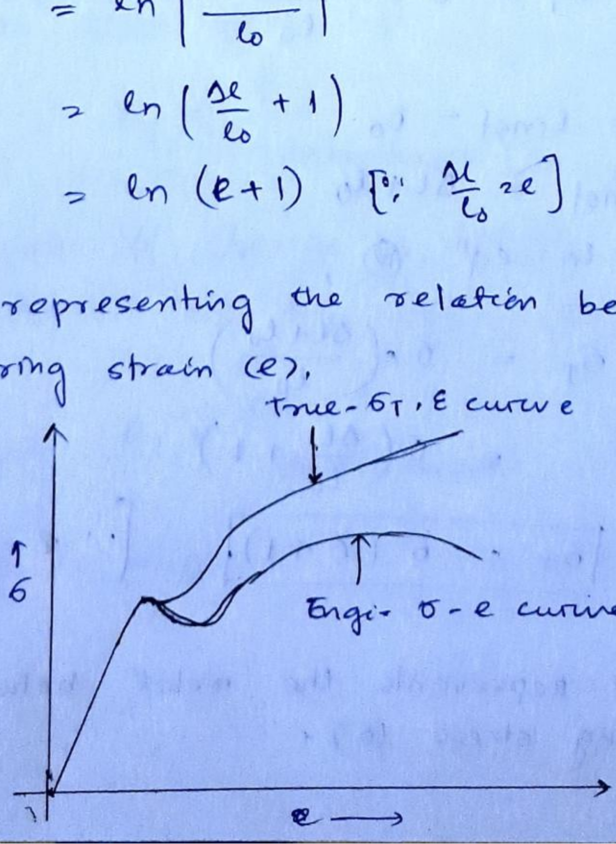
Thus,

$$\Rightarrow \varepsilon = \ln\left|\frac{\Delta l + l_0}{l_0}\right|$$

$$\Rightarrow \varepsilon = \ln\left(\frac{\Delta l}{l_0} + 1\right)$$

$$\Rightarrow \varepsilon = \ln(e+1) \quad \left[\because \frac{\Delta l}{l_0} = e\right] \quad \text{——— (II)}$$

Eq^n (II) is representing the relation between true strain (ε) & engineering strain (e).



IMPACT TEST

It is performed to know the impact of sudden load.

How much energy is absorbed by the material before fracture is its toughness.

→ Hence Impact test is required to measure the relative toughness of the material along with its resistance to sudden or impact load.

→ If a material have higher impact resistance is said to be a tougher material

- In mechanics, impact is a high force or shock applied over a short time period when a two or more bodies collide. Such a force or acceleration usually has a greater effect than a lower force applied over a proportionally longer period.

Classification of Impact Test

Impact test classified into two types :

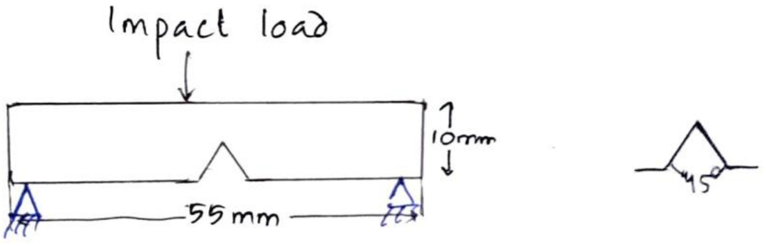
(I) Charpy Impact test

(II) Izod Impact test

(I) Charpy Impact Test :-

The charpy specimen is clamped in the vice so that it becomes a simple supported beam at both the ends

→ In charpy, specimens normally measure 55 × 10 × 10 mm with 2 mm V- notch at the middle of a specified surface.



- The notch is present at the opposite side of impact
- V notch also used of 5mm deep notch & 1mm radius. at the base

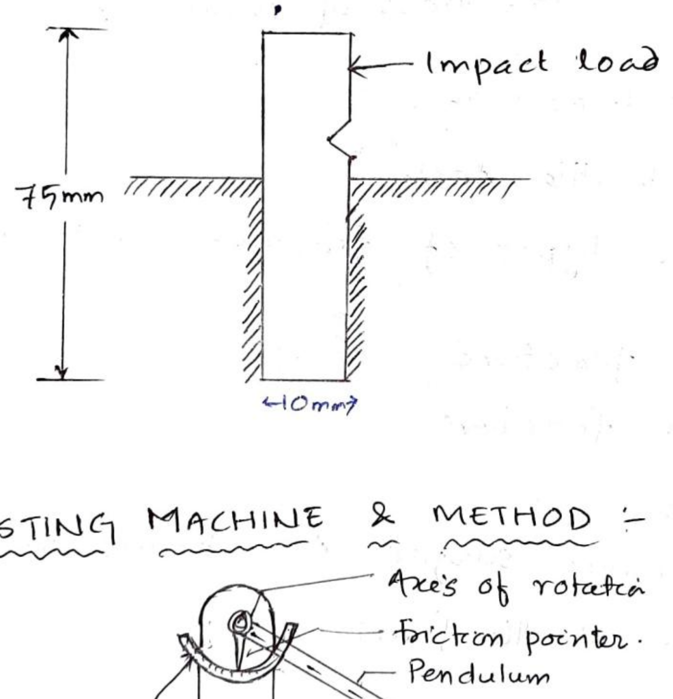
Note
Notch is created to ensure the point of fracture

(II) Izod Test :-

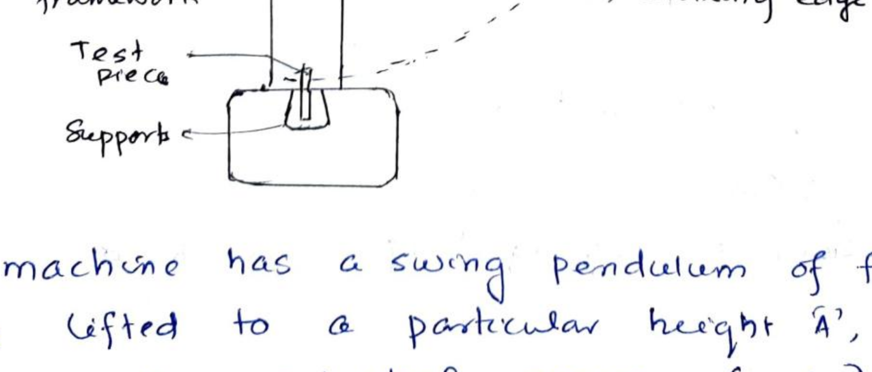
- The Izod test specimen is clamped in the vise, so that one of the ends of the specimen is free & it becomes a cantilever beam. (vertical)

→ The Ideal size of specimen is 75mm x 10mm x 10mm.

→ The V-notch is present at the 28th mm of the specimen. & in the same side of impact.



IMPACT TESTING MACHINE & METHOD :-



→ The machine has a swing pendulum of fixed weight

→ It is lifted to a particular height 'A', where it acquire the potential energy (mgh_1)

→ Then it swings down & hit the specimen & break it. with using some of kinetic energy.

→ And with the help of rest it again moves up to height h_2.

→ Some amount of energy delivered to the specimen in the impact machine.

→ That will be the loss in energy,

i.e $(mgh_1 - mgh_2)$

where,

h_1 = Initial height

h_2 = final height

g = Accelerat° due to gravity

m = mass of pendulum.

Application of the Impact Test

→ Ductility & Brittle test

There are two types of fracture will obtain in this test -

1- Brittle fracture

2. Ductile fracture

1. Brittle fracture

If the fracture surface is fibrous then it is ~~ductile fracture~~. Brittle fracture

2 Ductile fracture

If the fracture surface is granular then it is called ductile fracture.

Advantages of Charpy test

→ Relatively simple & cheap

→ carried over a range of temperature & on

Disadvantages of charpy test

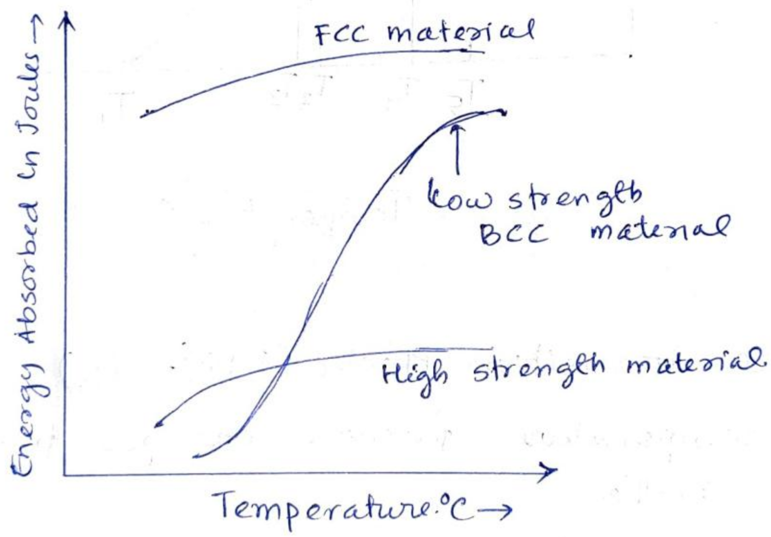
- It is difficult to use the test data for design purpose.
- The charpy test data is not co-related to the size of the flaw present in the material.

TRANSITION TEMPERATURE :-

The, temperature at which the material changes from ductile to brittle is called transition temperature.

- As the transition temperature is low, it results a good material to use in low temperature

Significance of Transition-temperature Curve:-



i) In FCC & HCP metals are very tough.
Energy absorb is very high so brittle fracture is not a problem

ii) High strength material where brittle fracture occurs at nominal stress around room temperature, Having low toughness..

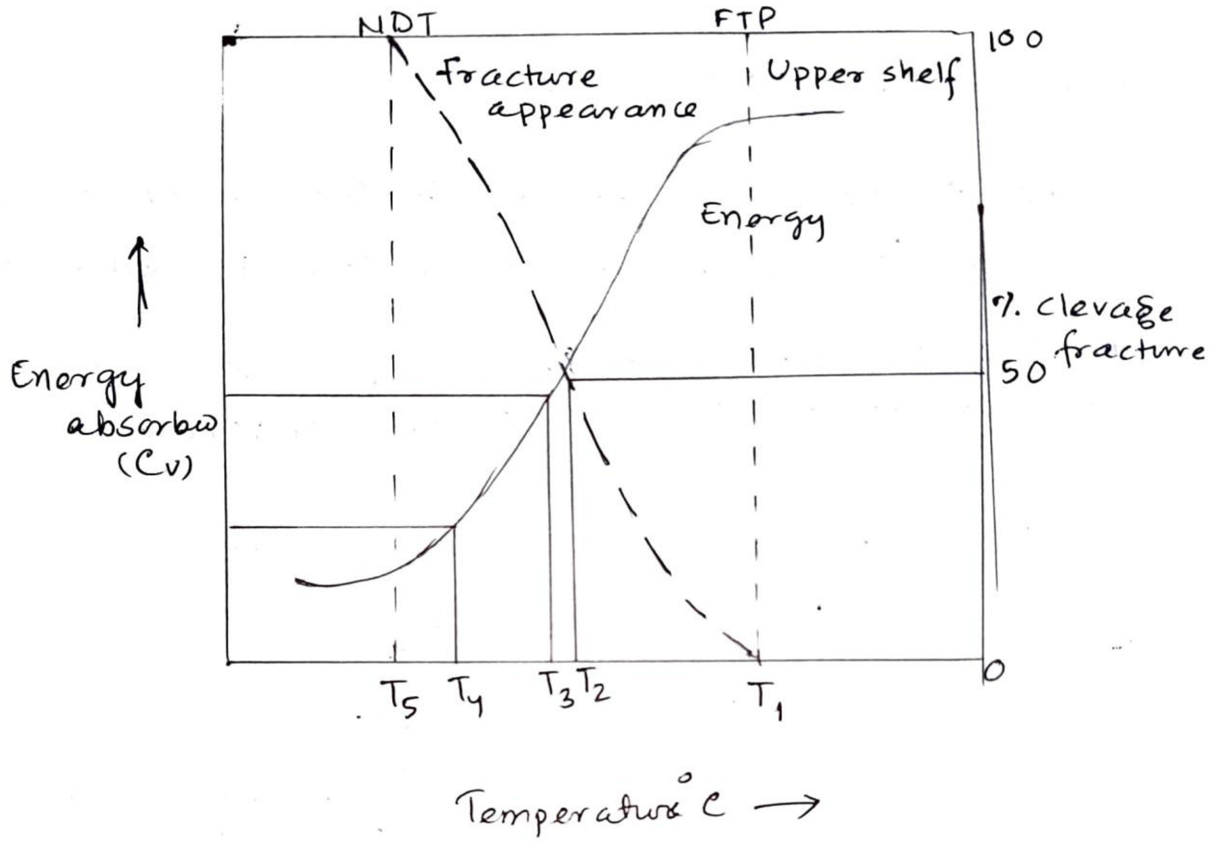
iii) For bcc matetrials carbon content is more, so its more brittle

Note

The toughness increases as density increases.

Ex- Fcc materials are more tough than BCC.

DESIGN CONSIDERATION OF TRANSITION TEMPERATURE



1. Fracture Transition Plastic (FTP) :- (T_1)

   In this temperature fracture changes from total ductile to total brittle.

2. T_3 = Fracture Appearance Transition Temperature (FATT) :

   50% cleavage & 50% fracture occurs.

3. T_4 = Ductile Transition Temperature (DTT)

   Cv is very low.

4. T_5 = Nil Ductile Temperature. (NDT)

   In this temp. the fracture initiates.

   Below NDT, ductile fracture is negligible

Metallurgical Factors Affecting Transition Temperature

Chemical Composition :-

(a) Carbon %

The 20J Cv transition temperature is raised by 14°C for each 1% increase in carbon level in the steel. This Hence, higher the C%, higher the transition temp.
∴ It should be less

(b) Manganese %

Transit^n Temp lowered by 50°C for each 0.1% increase in manganese content in steel. It should be high

∴ Mn : C ratio should be 3 : 1.

(c) Phosphorus %

It has a strong effect of raising the transit^n Temperature

(d) Oxygen %

It raises the transition temperature

(e) Nickel.

Upto 2% is beneficial as it raises not toughness

(f) Molybdenum.

It also raises the transit^n temperature rapidly

(g) Grain size.

A decrease in grain size will increase the transition temperature