HARDNESS TEST OF METAL SPECIMEN

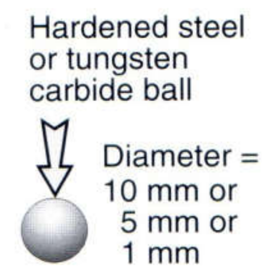
HARDNESS TESTING

Hardness is the ability to withstand indentation or scratches

- Rockwell Hardness (H_R)
- Brinell hardness (H_B)
- Vickers hardness

Brinell hardness test

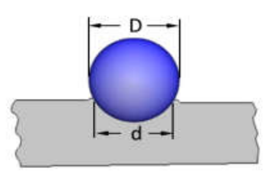
- Uses ball shaped indentor.
- Cannot be used for thin materials.
- Ball may deform on very hard materials
- Surface area of indentation is measured.



- Indentation is done with steel ball
- A load of 3000 kg (500 kg for softer materials) is applied for10 – 30 s.
- Dia of the indentation is measured to obtain the hardness (Brinell Hardness No.) from the relationship

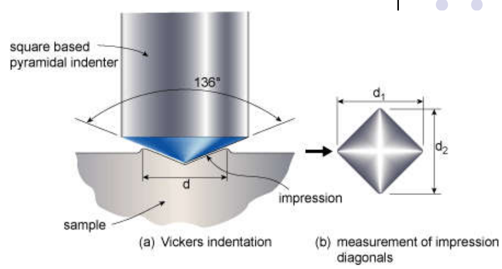
$$BHN = \frac{P}{\left(\frac{\pi D}{2}\right)\left(D - \sqrt{D^2 - d^2}\right)} = \frac{P}{\pi D t} \quad (\text{kgf/m}^2) \qquad (1)$$

P = Applied load
D = Diameter of ball
d = Dia of indentation
t = Depth of impression



Vickers hardness test

- Uses square shaped pyramid indentor.
- Accurate results.
- Measures length of diagonal on indentation.
- Usually used on very hard materials



Rockwell hardness tests

- Gives direct reading.
- Rockwell B (ball) used for soft materials.
- Rockwell C (cone) uses diamond cone for hard materials.
- Flexible, quick and easy to use.

Two most common indenters are
Ball – B and
Cone – C

- 120^o diamond cone called Brale indenter and 1.6 or 3.2 mm diameter steel balls
- C - Scale – Brale indenter + 150 kg load Used for hard materials like hardened steels.
- B-Scale – Steel ball indenter + 100 kg load

Test conditions

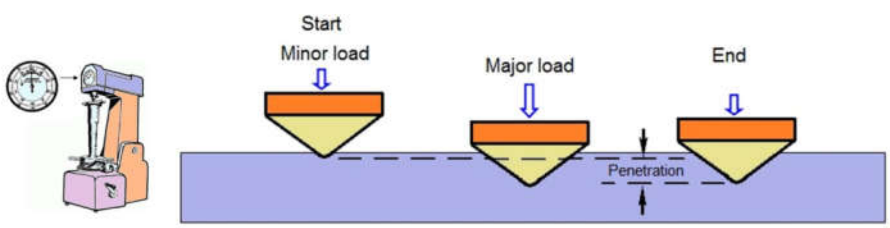
- Standard Ref : ASTM E-18

Scale	Indentor	Initial/Minor load (kgf)	Major Load (Kg.f)	Kind of material may be tested
HRA	Diamond Cone, 120^o	10	60	Much harder such as carburized steel, cemented carbides
HRB	Ball, 1.58mm	10	100	Soft steels, copper, aluminum, brass, grey cast iron
HRC	Diamond Cone, 120^o	10	150	Hard steels, Ti, W, Va, etc

Hardness testing machine

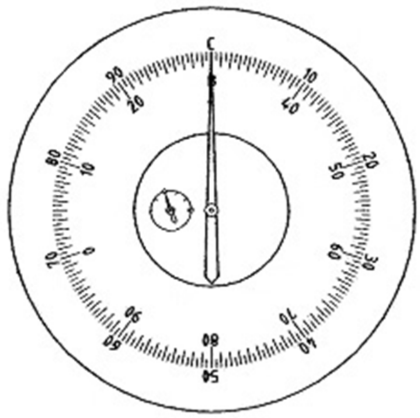
- The indenter is pressed into the metal
- Softer materials leave a deeper indentation

Schematic test setup



Hardness testing machine

- Dial gauge



Procedure (Rockwell Hardness)

- Keep the Lever at Position A (Unload)
- Place the sample on testing table
- Set the load : 100kg for Ball indentor, 150kg for diamond indentor
- Adjust the dial as, small pointer at 0 and long pointer at 50
- Turn the hand wheel to raise and dial gauge has made two and half turns than it set 0. set small pointer at 3

- Turn the lever A to B (Load applied)
- Turn back lever after dial gauge reaches steady position
- Read the value against long pointer
- Use Black scale for Diamond indentor (Scale C)
- Use Red scale for Ball indentor (Scale B)
- The dial consists of 100 divisions, each division representing a penetration depth of 0.002 mm

ASSIGNMENT

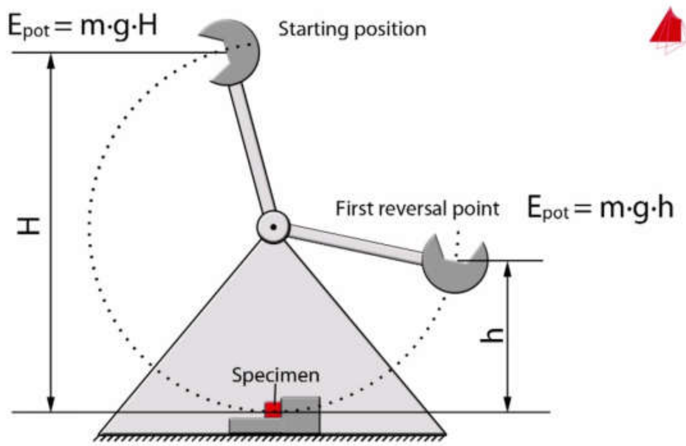
1. What result have you obtained in your laboratory test? Do you think the result is justified by the test method?
2. Write down the names of materials you can find hardness in the all three scales.
3. What is the importance of Minor Load in Hardness test?

IMPACT TEST

Basic principle

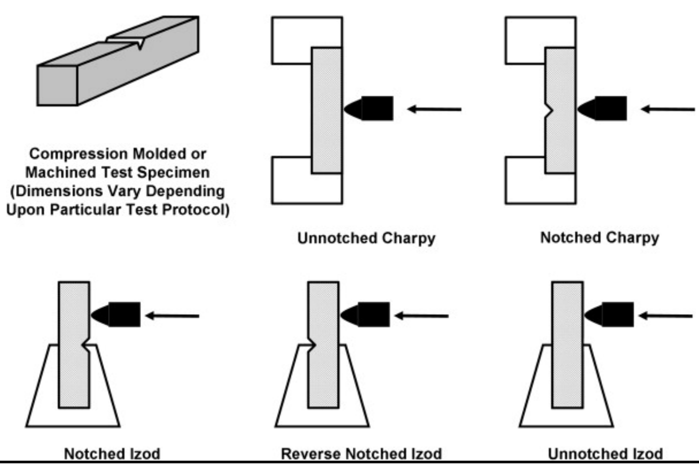
- **The notched test specimen is broken by the impact of a heavy pendulum or hammer, falling at a predetermined velocity through a fixed distance.**
- **The test measures the energy absorbed per unit area by the fractured specimen.**
- Standard Ref : ASTM E-23

Schematic Setup



Types of Test

1. Izod test
2. Charpy test



Izod test

Specimen : 75mmx10mmx10mm
V-notch angle is 45°and the depth of the notch is 2mm

- **Specimen is placed vertically on the anvil with the notch facing the Hammer**

Charpy test

Specimen : 55mmx10mmx10mm
V-notch angle is 45°and the depth of the notch is 2mm

- **Specimen is placed vertically on the anvil as a simply supported beam**

Procedure

- Prepare the test pieces and measure the actual dimensions
- Ensure that everybody is in safe distance.
- Release the pendulum without sample and read out the dial reading
- Move the pendulum up to its locked position
- Place the sample in position according to test condition (Chapry/Izod)
- Release the pendulum and read the reading
- Calculate the energy absorbed by sample
- Return the pendulum to its locked position.

Result

- Represent your result in Energy per unit area (Joule/mm^2)

Assignment

- What is the necessity of making a notch in impact test specimen?
- Suppose same material is tested in different temperature, what will be its effect in the energy absorption? Justify your answer..

Buckling test of slender column

THEORY

- A long slender bar subjected to axial compression is called a column.
- The term column is frequently used to describe a vertical member
- The vertical members of a building frame or any structural system which carry mainly compressive loads are called as columns.
- A compression member is generally considered to be column when its unsupported length is more than 10 times its least lateral dimension.

Euler formula

- This formula was derived in 1757, by the Swiss mathematician Leonhard Euler.
- The critical load/Euler Load is the maximum load which a column can bear while staying straight.
- The "critical load" is the greatest load that will not cause lateral deflection (buckling). For loads greater than the critical load, the column will deflect laterally.

$$P_{cr} = \frac{\pi^2 EI}{(KL)^2}$$

where

P_{cr} = Euler's critical load (longitudinal compression load on column),

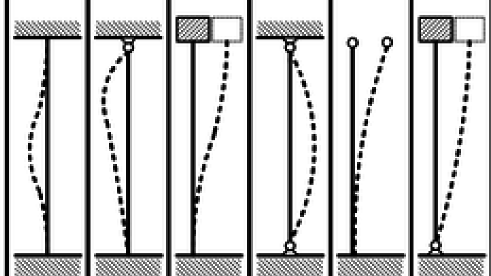
E = modulus of elasticity of column material,

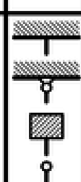
I = minimum area moment of inertia of the cross section of the column,

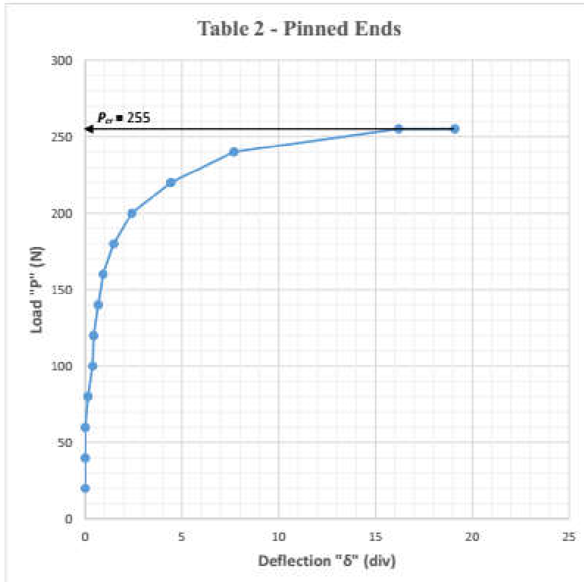
L = unsupported length of column,

K = column effective length factor

K Value

Buckled shape of column shown by dashed line						
Theoretical K value	0.5	0.7	1.0	1.0	2.0	2.0
Recommended design value K	0.65	0.80	1.2	1.0	2.10	2.0

End condition key		
		Rotation fixed and translation fixed
		Rotation free and translation fixed
		Rotation fixed and translation free
		Rotation free and translation free



Objective

- To determine Euler load /critical load/buckling load of slender columns experimentally .
- To determine Euler load /critical load/buckling load of slender columns theoretically from Euler formula for slender columns.
- To compare the experimental critical loads and theoretical critical loads.

Procedure

- Measure Dia, length etc.
- Look for support condition and Apply load
- Read max. load (N)
- Calculate theoritical load and compare with experimental value.

Assignment (individual)

1. Assumptions of Euler formula
2. Derive the equation of Euler Critical load for pin ended column.
3. Derive the equation of Euler Critical load for fixed ended column.
4.