5.2 HARDNESS TESTS

Hardness is a surface property and is defined as the resistance of a material against permanent deformation of scratch, cutting, indentation or mechanical wear.
In various hardness tests, the indenters are used to introduce indentation on the surface. The shape of indenters may be a spherical ball, a cone, or a pyramid. Various hardness test methods are given as below:

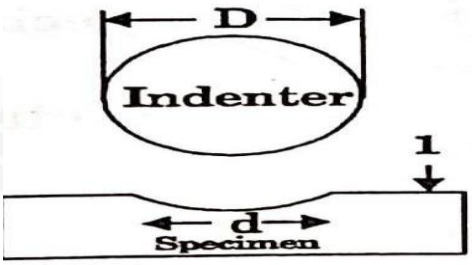
1. Brinell's hardness test
2. Rockwell's hardness test.
3. Vicker's hardness test
4. Knoop's hardness test .

Brinell Hardness test.

Principle:

A harden steel ball of diameter D is used as an indenter.It is pressed on the surface of the specimen by applying load for 10- 15 secs.Indentation is formed on the surface of the specimen.

Indenter

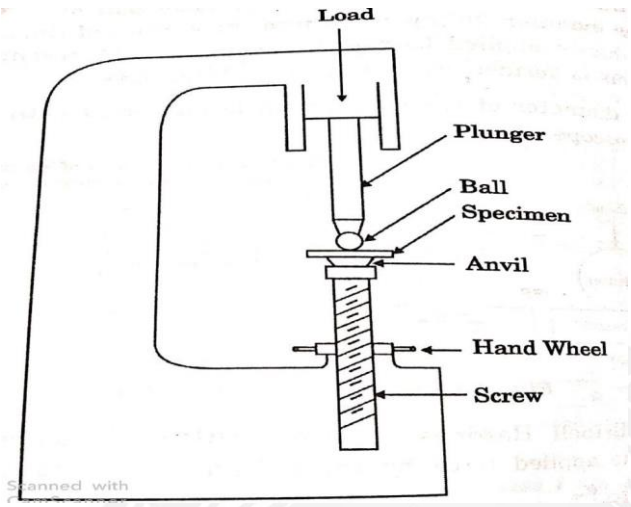


Test procedure:

1. A test specimen is placed on the anvil .It is raised with the elevating screw until it touches the indenter
2. The indenter is pressed into the surface of the specimen by a gradually applied load.
3. The load is applied for 15-30 secs.
4. The indenter makes an impression on the specimen.The diameter of the

impression is measured with the optical microscope.

5. Then we can find the harness number by using formula.



Brinell hardness test showing load, ball diameter, indented diameter and its thickness.

The Brinell Hardness Number (BHN) is then calculated as below after measuring d by an optical microscope.

Brinell Hardness number

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

Where P-load applied

D- Diameter of steel ball (mm)

d- Diameter of indentation

Advantages

- Brinell hardness test can be performed on irregular or rough metal surfaces also. The care of the surface is not important in this test as in the Rockwell and rebound test.
- This hardness test is simple to perform and is less sensitive than any other test.
- The hardness of objects with heavy weight can be tested with this process.
- Tensile properties and results of the test can correlate.

Disadvantages

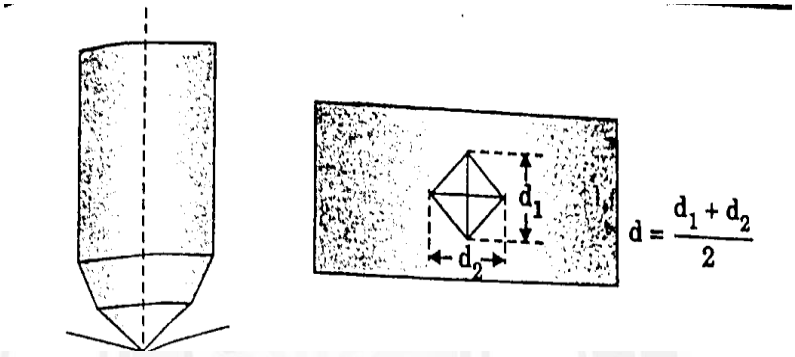
- The test cannot be performed in objects of small size due to a large indenter impression.
- It is also not appropriate for thin items as the test cause deep penetration
- A lot of time is required to perform the test due to the slow test process
- The test required a lot of concentration because the chances of error in measurements are high as it is done manually.

Vickers hardness test

Principle:

A diamond square based pyramid is used as an indenter. It is pressed on the surface of the specimen by applying load for 10-15 secs. Indentation is formed on the surface of the specimen.

Indenter and formula for VHN



Test procedure:

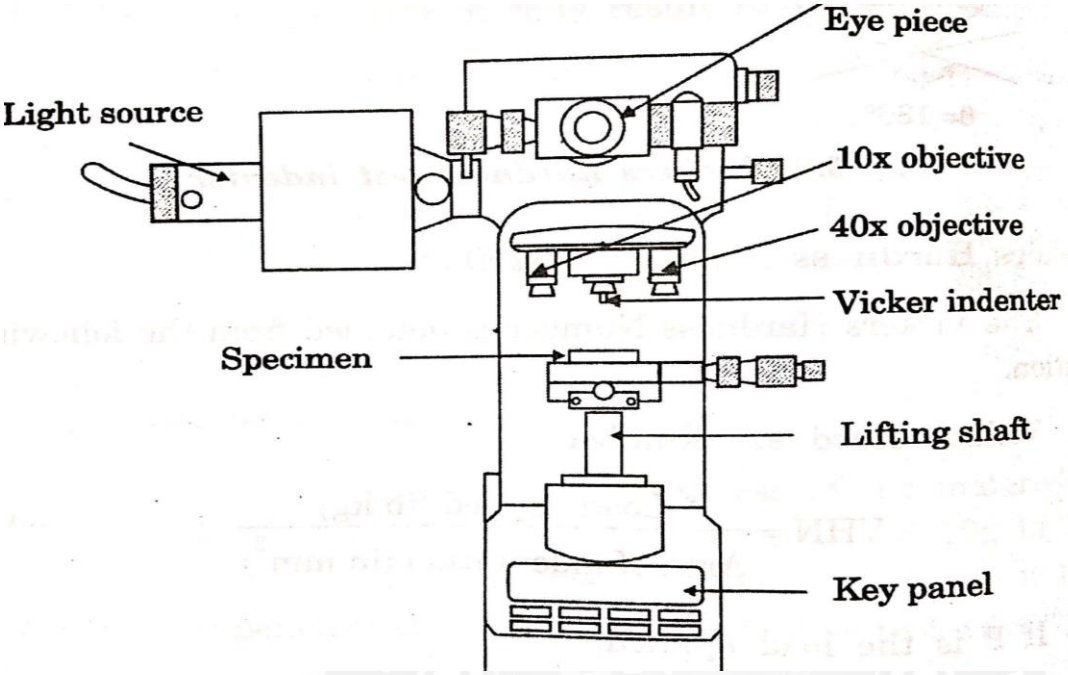
1. The specimen is placed on the anvil.
2. Load is applied and then indenter is pressed on the surface of the sample.
3. Force is maintained for a period 10 t0 15 seconds known as dwell time.
4. The indenter is removed from the sample after the dwell time.
5. Indenter leaves a square indentation.
6. Using the built-**in** optical microscope**,** measure the length of the long diagonal of the indentation
7. Then we can find the hardness number by using formula.

P – load applied

d-diameter of the indentation

Vickers Hardness number

$$VHN = \frac{1.854P}{d^2}$$



Advantages

• Greater precision in measurement compared to spherical ball in Brinell test.

• It can be used for test very hard materials, since diamond is used.

- Can be used for both microhardness (10 gf to 1 kgf) **and** macrohardness depending on the load.

Disadvantages

- Needs a very smooth and polished surface to get accurate readings
- Slower than Rockwell because of the need for optical measurement of the diagonals.
- On soft or highly reflective surfaces, the diagonal can be hard to measure accurately

Limitations

• Complicated and expensive

• Can be considered for micro hardness testers, since, they cause small size impressions