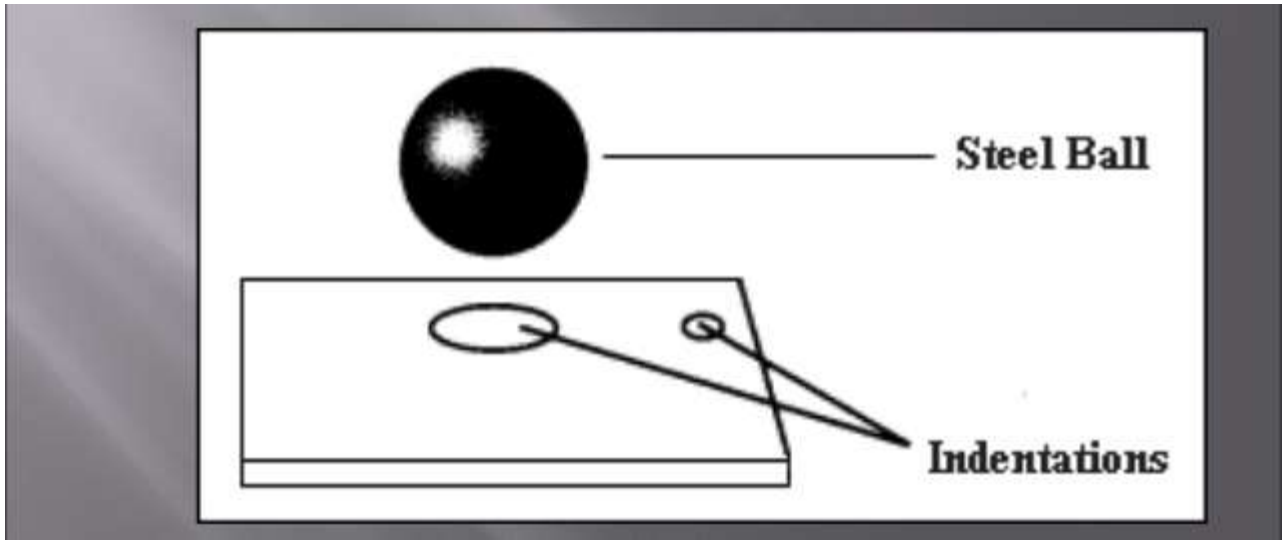
MME 222
Materials testing sessional

Experiment 1. Rockwell Hardness Test

HARDNESS

- Hardness is simply the resistance to plastic deformation or permanent deformation of material.
- The term hardness may also refer to resistance to scratching, abrasion or cutting.
- Hardness is dependent on ductility, elasticity, plasticity, strength



Introduction to hardness testing

Hardness has variety of meanings

- Metallurgist resistance to penetration
- Mineralogist resistance to scratching
- Machinist resistance to machining

Purpose of hardness testing

- The principal purpose of hardness test is to determine the suitability of a material for a given application

General types of hardness testing

Current practice in USA divides hardness testing into two categories:

 Macrohardness: Refers to testing with applied loads on the indenter of more than 1 kg and material being tested are tools, dies and sheet material in the heavier gages(in large scale)

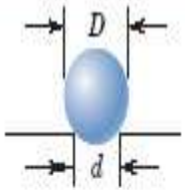
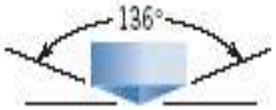
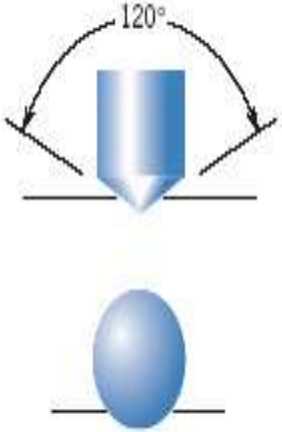
.Brinell, Rockwell

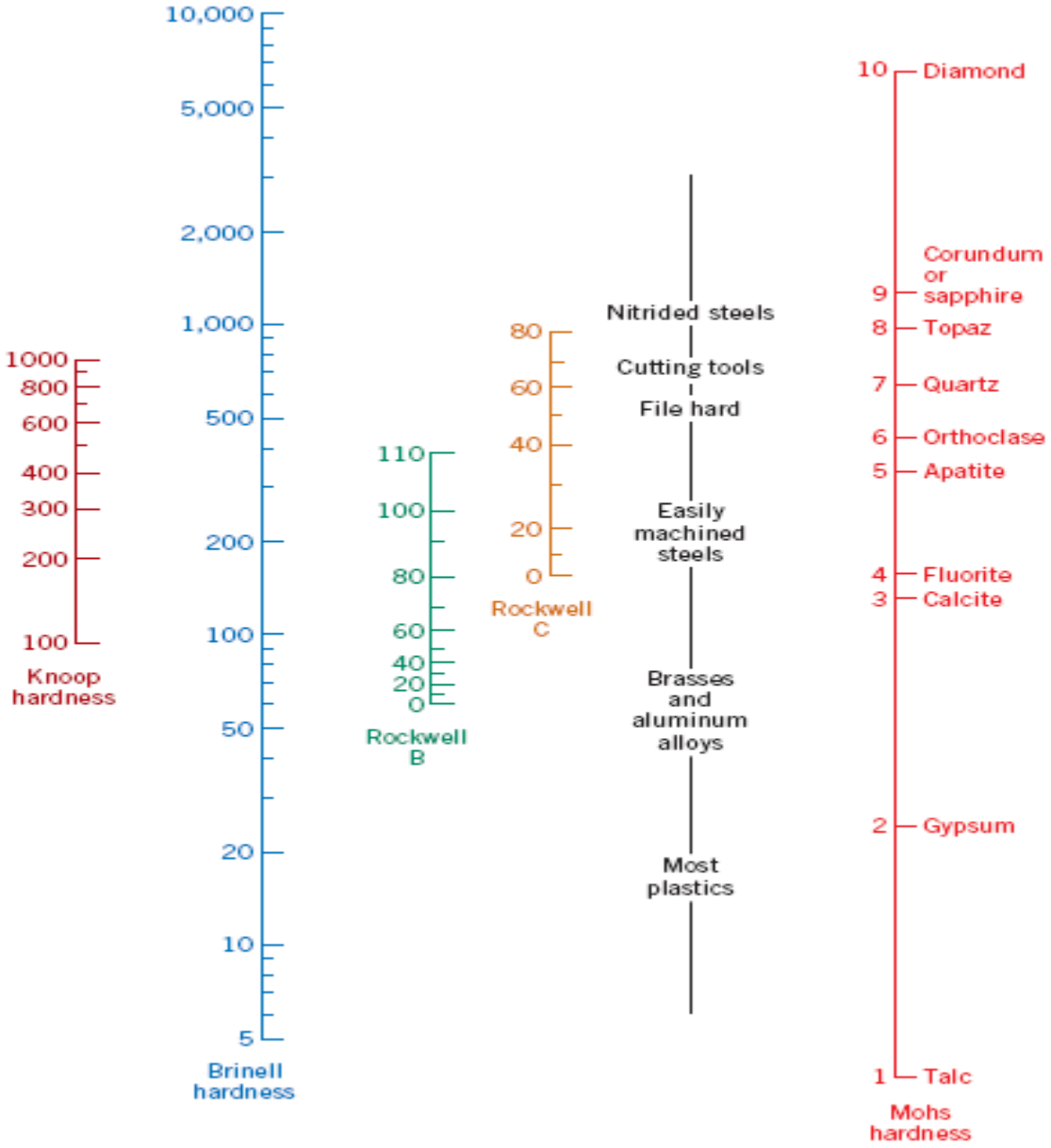
 Microhardness: Refers to testing with applied loads are 1 kg or below, and material being tested is very thin (down to 0.0125 mm or 0.0005 inch).

Vickers, Knoop

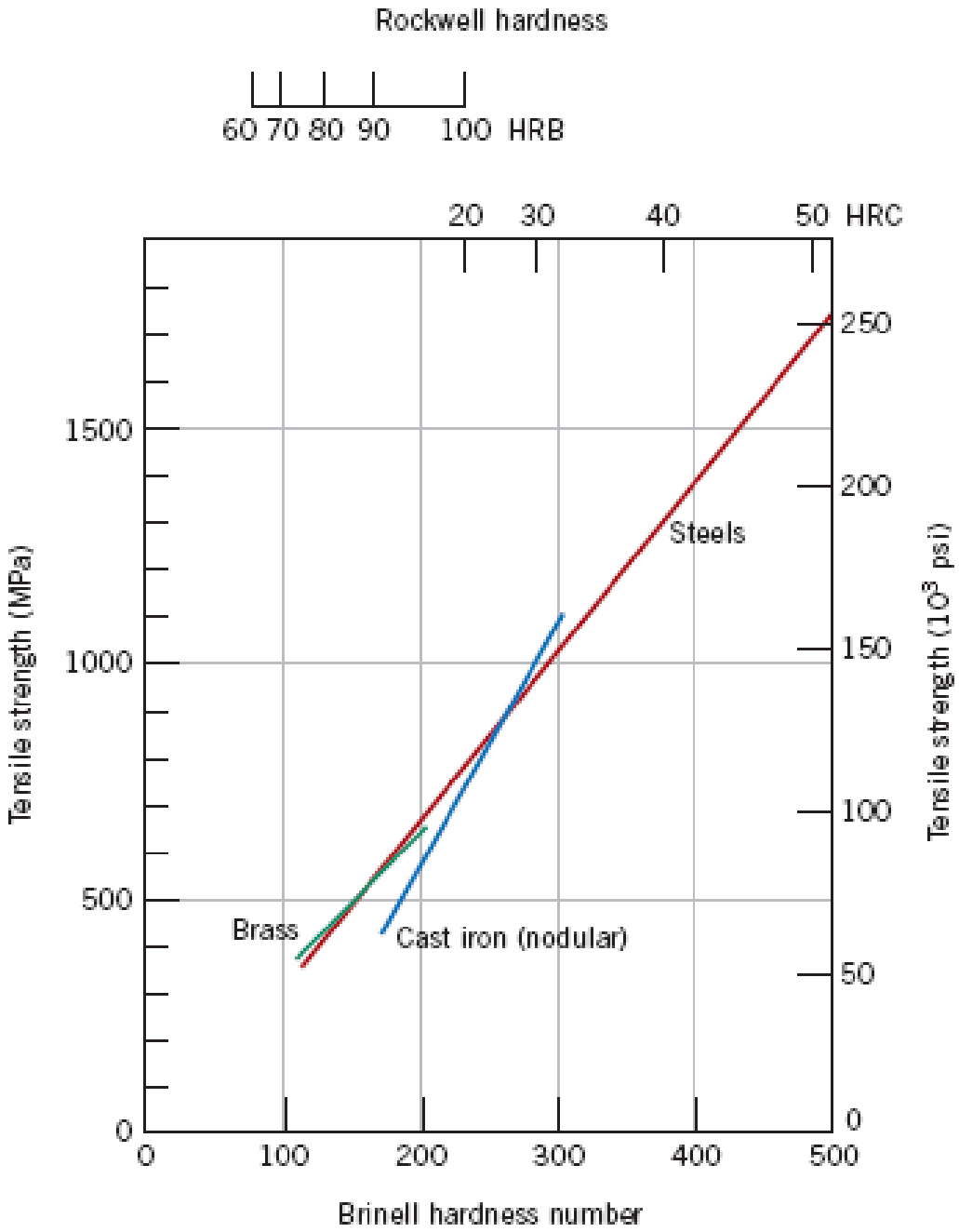
Quantitative Hardness Testing Methods

Test	Indentor	Load	Application
Brinell	10-mm ball	3000 kg	Cast iron and steel
Brinell	10-mm ball	500 kg	Nonferrous alloys
Rockwell *A*	Brale	60 kg	Very hard materials
Rockwell *B*	1/16-in. ball	100 kg	Brass, low-strength steel
Rockwell *C*	Brale	150 kg	High-strength steel
Rockwell *D*	Brale	100 kg	High-strength steel
Rockwell *E*	1/8-in. ball	100 kg	Very soft materials
Rockwell *F*	1/16-in. ball	60 kg	Aluminum, soft materials
Vickers	Diamond pyramid	10 kg	All materials
Knoop	Diamond pyramid	500 g	All materials

Test	Indenter	Shape of Indentation: Side View	Shape of Indentation: Top View	Load	Formula for Hardness Number[a]
Brinell	10-mm sphere of steel or tungsten carbide			P	$HB = \frac{2P}{\pi D[D - \sqrt{D^2 - d^2}]}$
Vickers microhardness	Diamond pyramid			P	$HV = 1.854P/d_1^2$
Knoop microhardness	Diamond pyramid			P	$HK = 14.2P/l^2$
Rockwell and Superficial Rockwell	Diamond cone; $\frac{1}{16}, \frac{1}{8}, \frac{1}{4}, \frac{1}{2}$ in. diameter steel spheres			60 kg, 100 kg, 150 kg: Rockwell 15 kg, 30 kg, 45 kg: Superficial Rockwell	



Comparison of several hardness scales.



Relationships between hardness and tensile strength for steel, brass, and cast iron.

Range of Indenters

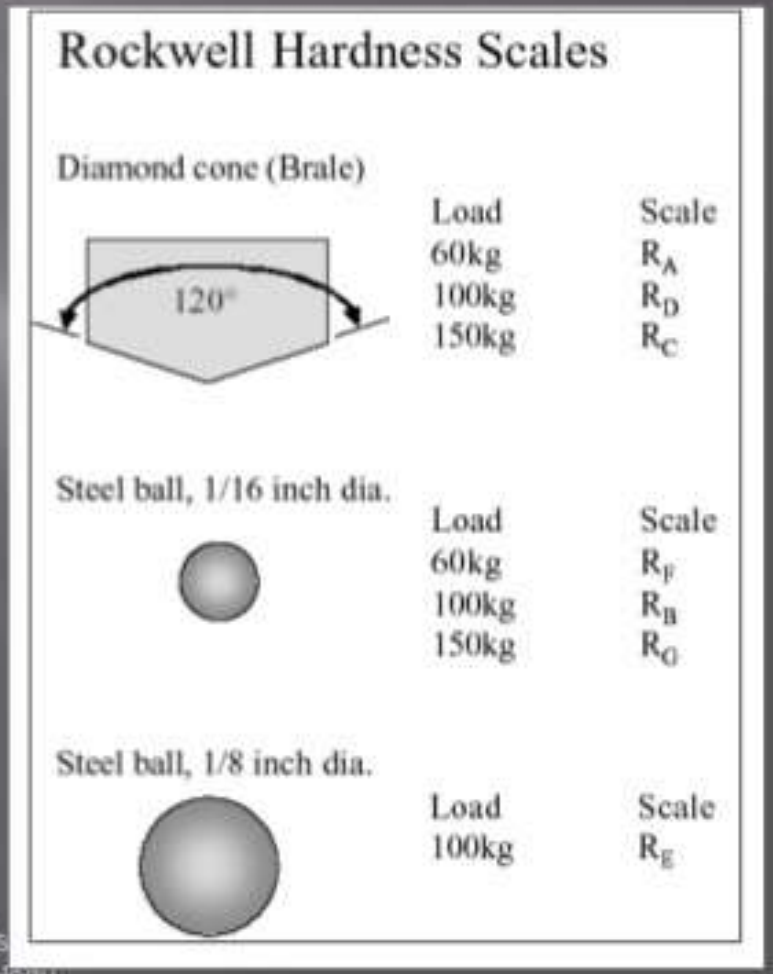
Rockwell Hardness Tests

The modern apparatus for making Rockwell hardness measurements is automated and very simple to use;

Hardness is read directly, and each measurement requires only a few seconds.

Rockwell Hardness Method

- Select Scale - load and indentor depending on the scale
- Press a point into material
  - - Diamond Point (Brale)
  - - 1/16" ball
  - - 1/8" ball
  - - ¼" ball



Rockwell Hardness test

- In Rockwell testing the minor load is 10 kg and major load (60, 100, or 150 kg) is used regardless of the type of indenter
- TEST PROCEDURE Apply a minor load of 10 kg. Then the dial is set to zero and then major load is applied. Then apply major load 60 to 150 kg according to the scale used for 4 to 5 seconds. Release the major load only. Machine will show the Rockwell Hardness Number HR on the machine. All these operation will be done by machine automatically. 100 number means most hard and 0 means least hard
- Rockwell test principle.. It consists of measuring the additional depth of heavy load indenter beyond the depth of previously applied light load (minor).

Rockwell Hardness test

- Types of indenters used Diamond cone indenters are used for testing hard materials such as hardened steel and cemented carbides. Hardened steel ball indenter are used for testing softer materials such as fully annealed steel, softer grades of cast iron , wide variety of non-ferrous metals and some nonmetallic materials
- Advantages of Rockwell hardness testing: The most widely used method for determining hardness. Simple to perform Highly skilled operators are not required. Different types of loads and indenters can be used. The entire operation completes within 10 sec. Results are displayed digitally on the screen

Rockwell Hardness test

Factors

- Type of material, Specimen thickness Test location

Type of Materials

- Hard materials such as steel or tungsten carbide diamond indenter would be used.

Specimen Thickness

- The material around the indentation is cold worked. The extent of cold work area depends on the type of material and previous history of the testing

Work hardening, also known as strain hardening or cold working, is the strengthening of a metal by plastic deformation

Test location

- If an indentation is placed with in the cold worked area (previous indentation). The reading usually will be higher than that obtained had it been placed out side this area. As a precaution three diameter from the centre of one indentation to another is sufficient for most material. The distance from edge should be minimum of 2.5 diameter of indentation.

Rockwell Hardness Test

The Rockwell tests are the most common method used to measure hardness because they are so simple to perform and require no special skills.

Several different scales may be utilized from possible combinations of various indenters and different loads, which permit the testing of virtually all metal alloys (as well as some polymers).

Indenters include spherical and hardened steel balls and a conical diamond (Brale) indenter, which is used for the hardest materials.

With this system, a hardness number is determined by the difference in depth of penetration resulting from the application of an initial minor load followed by a larger major load; utilization of a minor load enhances test accuracy.

The scale is designated by the symbol HR

Rockwell Hardness Tests

For each scale, hardnesses may range up to 130; however, as hardness values rise above 100 or drop below 20 on any scale, they become inaccurate; and because the scales have some overlap, in such a situation it is best to utilize the next harder or softer scale.

Inaccuracies also result if the test specimen is too thin, if an indentation is made too near a specimen edge, or if two indentations are made too close to one another.

Specimen thickness should be at least ten times the indentation depth, whereas allowance should be made for at least three indentation diameters between the center of one indentation and the specimen edge, or to the center of a second indentation.

Testing of specimens stacked one on top of another is not recommended.

Also, accuracy is dependent on the indentation being made into a smooth flat surface.