Chapter One: Properties and Testing of Metals

Lecture 02 Hardness Test and Impact Test

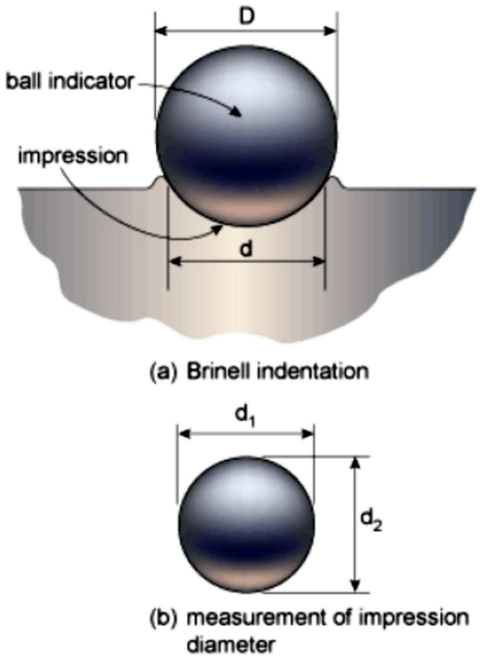
1.2.2 Testing of Hardness

It is a very important property of the metals and has a wide variety of meanings. It embraces many different properties such as resistance to wear, scratching, deformation, and machinability etc. It also means the ability of a metal to cut another metal. The hardness of a metal may be determined by the following tests.

a) Brinell hardness test
b) Rockwell hardness test
c) Vickers hardness (also called Diamond Pyramid) test

Brinell hardness test

Dr. J. A. Brinell invented the Brinell test in Sweden in 1900. The oldest of the hardness test methods in common use today, the Brinell test is frequently used to determine the hardness of forgings and castings. Therefore, Brinell tests are frequently done on large parts. The Brinell hardness number is a function of the test force divided by the curved surface area of the indent. The Brinell hardness test method consists of indenting the test material with a 10 mm diameter hardened steel or carbide ball. The average of the two diagonals is used in the following formula to calculate the Brinell hardness.



Metal Hardness Formula

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

BHN – *Brinell Hardness Number in* kg/mm^2

P – *load in kgf*

D – *steel ball diameter in mm*

d – *depression diameter in mm*

Fig. 1.5 Brinell hardness test

Brinell hardness for several materials	
Lead	5 -22 HB
Pure Aluminium	15 HB
Copper	35 HB
Hardened AW-6060 Aluminium	75 HB
Mild steel	120 HB
stainless steel annealed	200 HB
Hardened tool steel	600–900 HB

Vickers Hardness Test

The Vickers hardness test method consists of indenting the test material with a diamond indenter, in the form of a right pyramid with a square base and an angle of 136 degrees between opposite faces subjected to a load of 1 to 100 kgf. The full load is normally applied for 10 to 15 seconds. The two diagonals of the indentation left in the surface of the material after removal of the load are measured using a microscope and their average calculated. The area of the sloping surface of the indentation is calculated. The Vickers hardness is the quotient obtained by dividing the kgf load by the square mm area of indentation.

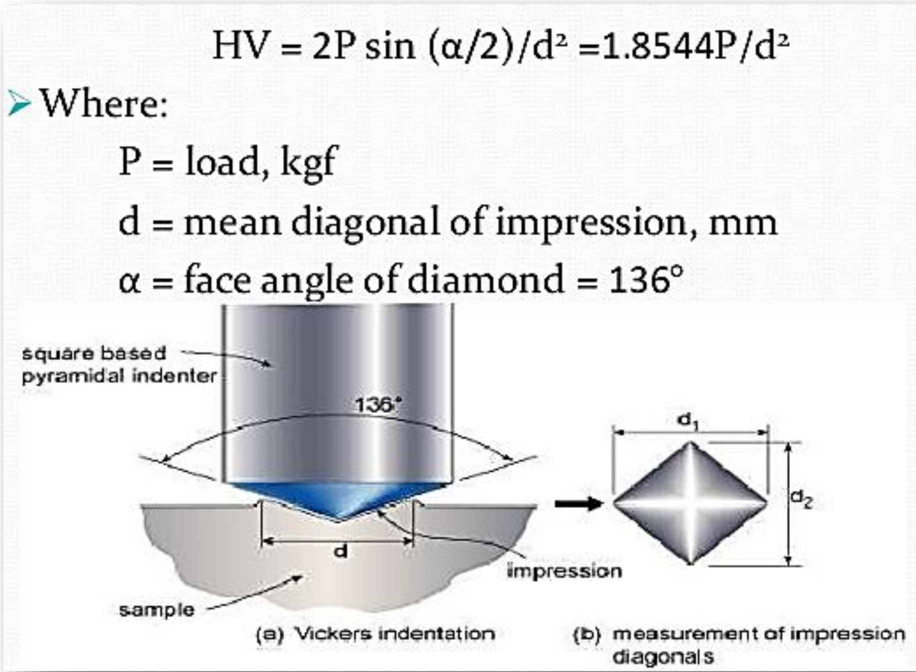


Fig. 1.6 Vickers hardness test

Vickers hardness for several materials	
Material	Value
316L stainless steel	140HV30
347L stainless steel	180HV30
Carbon steel	120HV5
Iron	80HV5
Martensite	1000HV
Diamond	10000HV

Rockwell hardness test

Stanley P. Rockwell invented the Rockwell hardness test. Rockwell hardness test enabled the user to perform an accurate hardness test on a variety of sized parts in just a few seconds. There are two types of Rockwell tests:

1. Rockwell: the minor load is 10 kgf, the major load is 60, 100, or 150 kgf.
2. Superficial Rockwell: the minor load is 3 kgf and major loads are 15, 30, or 45 kgf.

In both tests, the indenter may be either a diamond cone or steel ball, depending upon the characteristics of the material being tested.

The principles of the Rockwell Test are:

1. The indenter moves down into position on the part surface
2. A minor load is applied, and a zero-reference position is established
3. The major load is applied for a specified time (dwell time) beyond zero
4. The major load is released leaving the minor load applied

The resulting Rockwell number represents the difference in depth from the zero-reference position as a result of the application of the major load.

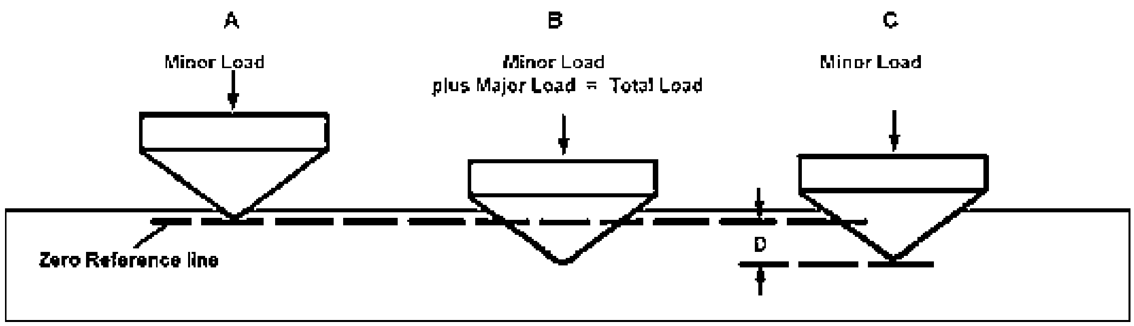


Fig. 1.6 Rockwell hardness test

Hardness vs. Minimum Thickness						
	Rockwell Superficial Hardness Scales			Rockwell Regular Hardness Scales		
	15-N	30-N	45-N	A	D	C
	15 KFG	30 KFG	45 KFG	60 KFG	100 KFG	150 KFG
Thickness in In. (mm)	N Brale Indenter			B rale Indenter		
0.006 (0.15)	92	-	-	-	-	-
0.008 (0.20)	90	-	-	-	-	-
0.010 (0.25)	88	-	-	-	-	-
0.012 (0.30)	83	82	77	-	-	-
0.014 (0.36)	76	78.5	74	-	-	-
0.016 (0.41)	68	74	72	86	-	-
0.018 (0.46)	X	66	68	84	-	-
0.020 (0.51)	X	57	63	82	77	-
0.022 (0.56)	X	47	58	79	75	69
0.024 (0.61)	X	X	51	76	72	67
0.026 (0.66)	X	X	37	71	68	65
0.028 (0.71)	X	X	20	67	63	62
0.030 (0.76)	X	X	X	60	58	57
0.032 (0.81)	X	X	X	X	51	52
0.034 (0.86)	X	X	X	X	43	45
0.036 (0.91)	X	X	X	X	X	37
0.038 (0.96)	X	X	X	X	X	28
0.040 (1.02)	X	x	X	X	X	20

Table 1 Rockwell hardness test values

1.2.3 Impact Test

When metal is subjected to suddenly applied load or stress, it may fail. In order to assess the capacity of metal to stand sudden impacts, the impact test is employed. The impact test measures the energy necessary to fracture a standard notched bar by an impulse load and as such is an indication of the notch toughness of the material under shock loading. Izod test and the Charpy test are commonly performed for determining impact strength of materials. These methods employ same machine and yield a quantitative value of the energy required to fracture a special V notch shape metal.

The beams may be simply loaded (Charpy test) or loaded as cantilevers (Izod test). Fig. 1.7 shows the impact testing set up arrangement for Charpy test.

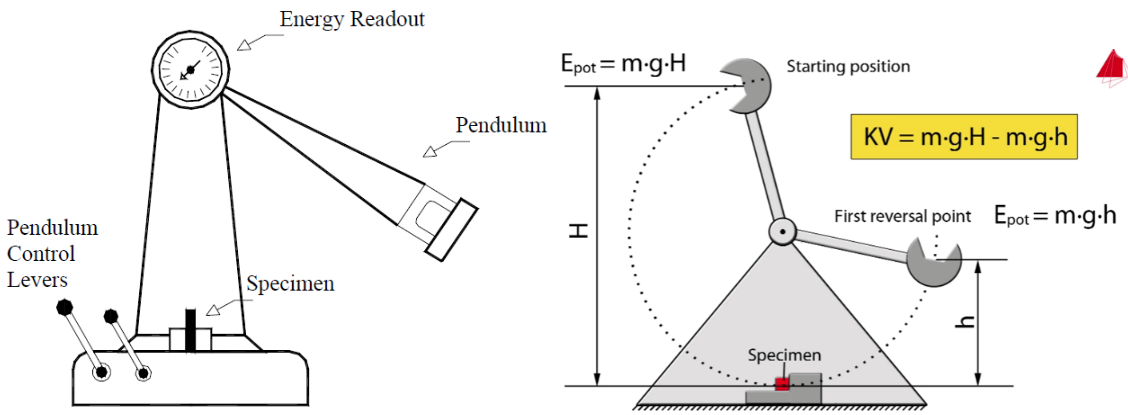


Fig. 1.7 Impact test

Charpy tests show whether a metal can be classified as being either brittle or ductile. This is particularly useful for ferritic steels that show a ductile to brittle transition with decreasing temperature. A brittle metal will absorb a small amount of energy when impact tested, a tough ductile metal absorbs a large amount of energy. The appearance of a fracture surface also gives information about the type of fracture that has occurred; a brittle fracture is bright and crystalline; a ductile fracture is dull and fibrous.

1.3 CHOICE OF MATERIALS

The choice of materials for the engineering purposes depends upon the following factors:

1. Availability of the materials,
2. Properties needed for meeting the functional requirements,
3. Suitability of the materials for the working conditions in service, and
4. The cost of the materials.

YouTube: https://youtu.be/NK1iRSMbSz0