Job 3:

To perform hardness test on steel using Rockwell hardness testing machine.

Apparatus:
- Shimadzu Hardness testing machine
- Steel sample
- Indenter
    1. Diamond cone indenter
    2. Steel ball indenter

Objective
- To measure hardness
- To come to know the indirect strength of material

Hardness
It is defined as Resistant to permanent deformation or resistance to scratches.

Process:
1. **relative hardness measurement process**

MOH'S scale:
It is used to measure relative hardness. "Hardness is resistance to scratching relative to one another"
2. **depth of penetration measurement process**
    "The depth of indentation is measured left by an indenters of specific shape with specific force for specific time."

Machines:
- Brinell hardness testing machine
- Vickers hardness testing machine
- Rockwell hardness testing machine
- Knoop daimond hardness testing machine
- Micko hardness testing machine
- Moh's hardness testing machine
- Selescope hardness testing machine
- Durometer.

Principle of Rockwell hardness testing machine:
The principle of this machine depends upon the following equation

$$HR = E-e$$

Where **e** is permanent deformation and **E** is deformation of reference line and **HR** is derived from net increase in depth of penetration due to force on indentors which is increased from specific minor load and then to total specific load and then back to minor load.
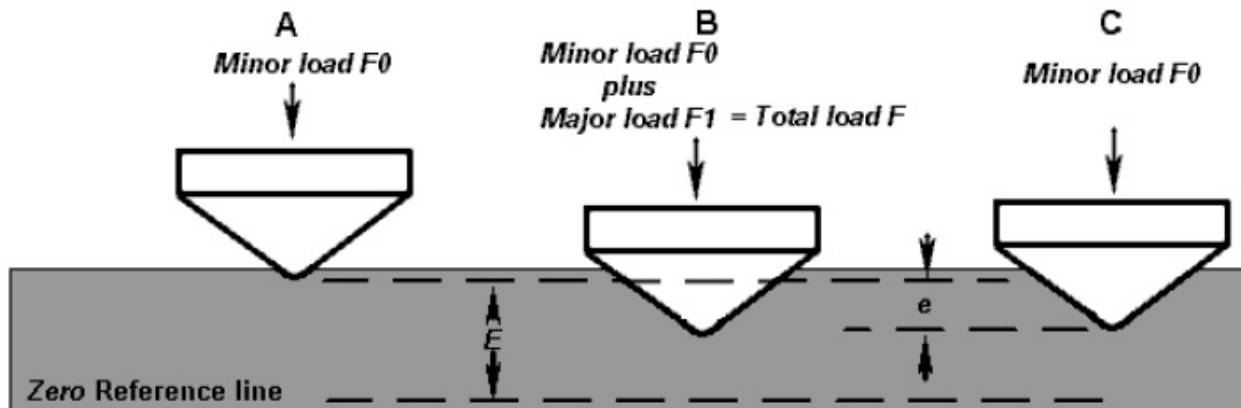
$$HR \propto Hardness \propto 1/e$$

Test Method Illustration
A = Depth reached by indenter after application of preload (minor load)
B = Position of indenter during major load
C = Final position reached by indenter after elastic recovery of sample material
D = Distance measurement taken representing difference between preload and major load position

Procedure:
- Fix the material in machine.
- Apply a minor load with the help of liver to produce a depth reached by indenters with in the material. At this stage elastic deformation will be produced.
- Make reading of HR zero.
- Apply minor and major load with the help of another liver to produce elastic and permanent deformation.
- Remove the minor and major load for elastic recovery.
- Note the reading of HR.

Scale	Types of indenter	Color	Minor load	Major load	E	Material
B	Steel ball indenter	Red	10	90	130	Low carbon
C	Diamond cone indenter	Black	10	140	100	High carbon

OBSERVATIONS AND CALCULAIONS

Sr No.	Specimen	Type of indenter	Minor load	Major load	Hardness#	Mean
1	Low carbon	1/6" Ø steel ball indenter	10	90	HR89B	HR90B
2					HR89B	
3					HR92B	
1	High carbon	diamond cone indenter	10	140	HR66B	HR66.5C
2					HR66.5C	
3					HR67C	

The Brinell Hardness Test:

The Brinell hardness test method consists of indenting the test material with a 10 mm diameter hardened steel or carbide ball subjected to a load of 3000 kg. For softer materials the load can be reduced to 1500 kg or 500 kg to avoid excessive indentation. The full load is normally applied for 10 to 15 seconds in the case of iron and steel and for at least 30 seconds in the case of other metals. The diameter of the indentation left in the test material is measured with a low powered microscope. The Brinell harness number is calculated by dividing the load applied by the surface area of the indentation.

COMMENT:

The hardness of high carbon is higher than that of low carbon. It means that the the indirect strength of high carbon is more than that of low carbon. The reason is that In high carbon, the carbon atoms are smaller than the gaps between the iron atoms, which prevents the iron atoms from shifting as much when there's a force/impulse.