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Properties of Materials Laboratory

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Introduction and Objective:

-Hardness can be defined as a measure of a material's resistance to localized plastic deformation (e.g., a small dent or a scratch, penetration, abrasion).

- A variety of tests for hardness are in use, depending on which of the above situations is of most interest, hardness testing is widely used in industries because of its simplicity, faster results, cheap procedure and many more advantage.

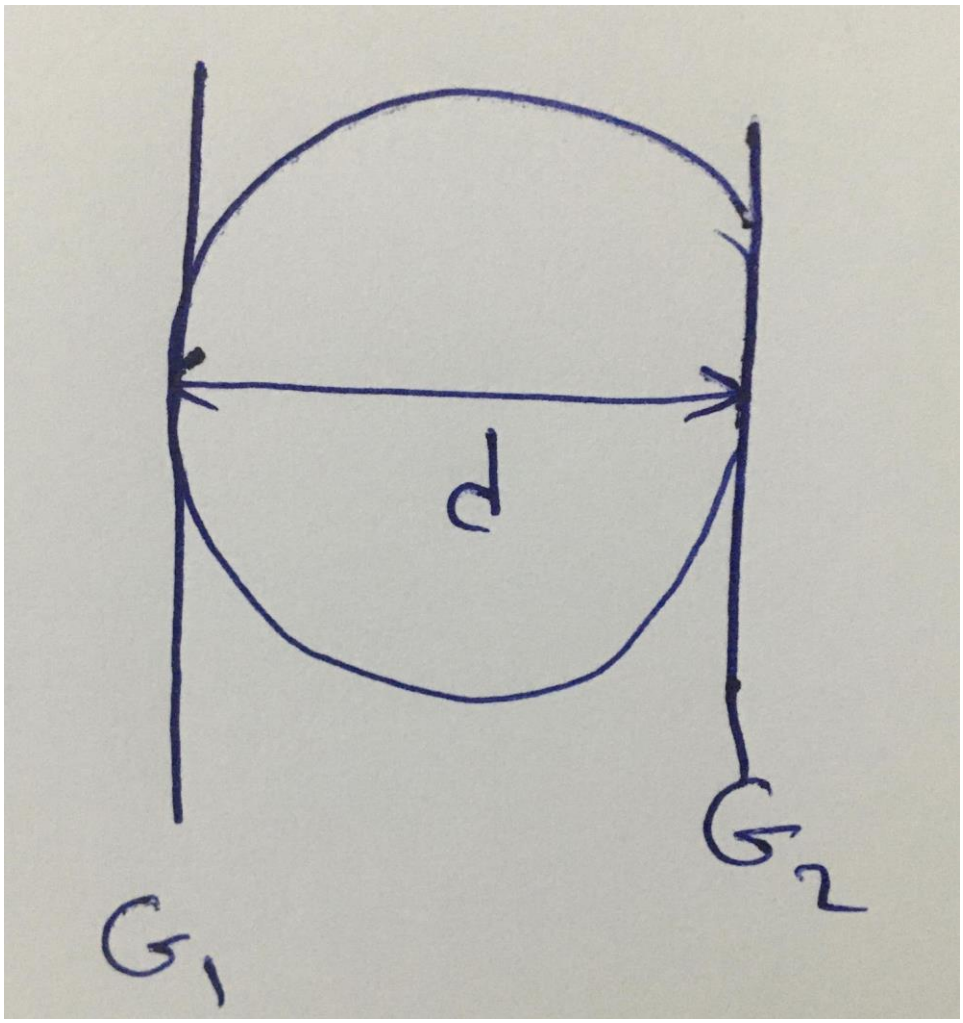
-Three different tests are used in this experiment (Brinell, Vickers and Rockwell) tests which measure resistance to penetration. The amount of deformation that occurs when a small, hard steel ball or diamond point is pressed into a material surface at some designated load is the measure of the hardness of the material.

Materials and Equipment's:

1) Specimens of steel, aluminum and brass of different thickness and treatments
2) Hardness test device, which consists mainly of penetrator, wheel and an anvil to hold specimens.
3) During all the tests, we used only one machine with different tools for each test such as light, indenter and a scope for Brinell and Vickers tests.
4) During Rockwell tests, we used a similar machine, but it gave us digital results without the need of any manual calculations.

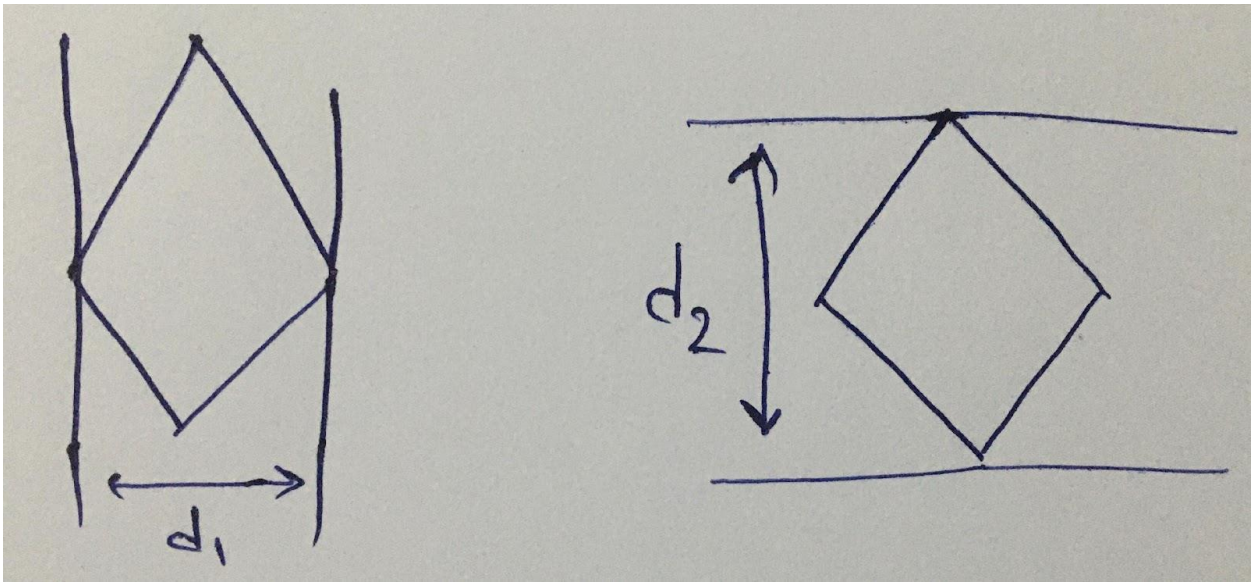
Experimental Procedure:

This experiment was implemented to determine the hardness of the three following materials; brass, aluminum and steel using Brinell, Vickers and Rockwell methods to determine its hardness which is the metal's resistance to surface indentation under standard test conditions.
*Before reading the procedure please note that: F: load (N)
D: indenter (mm)
d: indentation (mm)
We started the experiment using the Brinell method by following the following steps below:
1. We set the indenter (diameter) on 2.5mm which is forced into the surface of the test piece. We fitted the lens with a power of 2.5x and a light so that we could see the indentation (d).
2. We started with Aluminum. After applying a constant force of 306.5 N to the machine, we put the specimen in the device and started lifting it.
3. We turned the indicator 3 rotations and time was set for 15 seconds.
4. When the test time was over, we looked through the microscope at the vertical line to the right and to the left. The value of the vertical line to the left is (G1) and to the right is (G2).
G2 = (3*100) + 55 (micrometer) = 355
G1 = (5*100) + 8 (micrometer) = 508
We calculated the diameter of circular indentation (d) using this equation: d = 0.004 (G1-G2) = 0.004 (508-355) = 0.612 mm
The actual Brinell Hardness number (BHN or HB) is 104 which we found from the table.
We continued our experiment on brass using the Brinell method. We applied a force of 612.9 and found G1 and G2.
G1 = 457 mm
G2= 645 mm
d = 0.004 (G2-G1)
d = 0.004 (457 - 645) = 0.752 mm
For Steel, we applied a force of 1839 N, following the same steps as in brass and aluminum we found that G1 = 357 mm and G2 = 612 mm
d = 0.004 (G2-G1) = 0.004 (612-357) = 1.02 mm
And from the table the Brinell hardness number (HB) = 219
Brinell hardness number is basically determined by forcing a material of known diameter under a known load into a surface and measuring the diameter of the indentation with a microscope.



Then, we took away Brinell's indenter and replaced it with Vickers indenter.
Vickers hardness test is known as the diamond pyramid hardness test because it uses a diamond indenter, in the form of a right pyramid with a square base and an angle of 136 degrees between opposite faces, which is forced into the prepared surface of the test material under a selected load. The indenter produces a square indentation, the diagonals of which are measured.
1. We set the magnification power of the lens at 5x and changed the light to Vickers. The test time was 15 seconds and 3 rotations for the three materials: aluminum, brass, and steel.
When testing brass, the load applied is 612.9 N
Steel 1839 N Aluminum 306.5 N
In Vickers there are two diameters and after finding them we find the average of them which gives us the diagonal length.
0.002(G1-G2) = d1 0.002(G1-G2) = d2
d = (d1 + d2)/2
- Aluminum : G1=392mmG2=665mm d1 = 0.002 (665-392) = 0.546 mm
G1 = 590 mm G2= 299 mm
d2 = 0.002 (590-299) = 0.582 mm
d = (0.546 + 0.582)/ 2 = 0.564 mm
The Vickers hardness number = 0.564 (from the table)

- Brass:G1=255mmG2=854mm d1 = 0.002 (854-255) = 1.198 mm
G1 = 721mm G2 = 112 mm
d2 = 0.002 (721-112) = 1.218 mm
d = (1.198+1.218)/2 = 127.1 mm
The Vickers hardness number = 127.1 (from the table)
- Steel:G1=663mmG2=242mm d1 = 0.002 (663-242) = 0.842 mm
G1 = 169 mm G2= 610 mm
d2 = 0.002 (610-169) = 0.882 mm
d = (0.842 + 0.882)/2 = 0.862 mm
The Vickers hardness number = 0.862 (from the table)
Note that hardness numbers are unit-less.
The Vickers test is more suitable than the Brinell test because the indentation made by the diamond is much smaller than that made in the Brinell test.



Lastly, we implemented the Rockwell hardness test. This test gives direct reading. We set the diameter at 1.588 mm, the test time was 15 seconds and 3 rotations for the three materials; steel, brass and aluminum.
There are two scales in the Rockwell hardness test the C scale which is donated in black and is used for hard metals and the B scale which is donated in red and is used for softer materials. For brass,,steel, and aluminum the B scale is used.
Steel : F= 1839 N / 3 rotations / 15 seconds HRB = 97
Brass : F =612 N / 3 rotations / 15 seconds HRB = 77
Aluminum : F = 306.5 / 3 rotations / 15 seconds HRB = 69

Discussion and Results:

In this experiment we used three different tests, they are (Brinell, Vickers, Rockwell).

For Brinell and Vickers each one of them has its own tools like: light, indenter, and a scope.

Brinell: We did our tests on three materials (aluminum, steel, brass). First, we put the aluminum segment, the test-time set to 15 seconds, the force we took it from the table and the scope was 2.5x.

After 15 seconds we use the scope to find G1 and G2 which is the diameter for the circle showed, after we found (d)=0.004(G1-G2) and then we can find the hardness.

For Vickers, we have to find 2 diameters to calculate the average. Scope 5x and the force 100, also the test-time 15 seconds. We did the same steps as in Brinell, 3 rotations/ 15 seconds, we took our reads after we adjust the scope and the distances on the defect, and we took the read on the micrometer too.

For Rockwell, we took the readings directly from the machine, it was digital, so we didn't need to calculate distances or anything else.

So, in Brinell and Vickers, we found the distances and then found the HBR but in Rockwell we found HBR directly.

Result:

<u>In Brinell: (HBR)</u>

Al= 104

Brass=

Steel= 219

<u>In Vickers: (HBR)</u>

Al= 583

Brass= 127.1

Steel= 249.6

<u>In Rockwell: (HBR)</u>

Al= 69

Brass= 77

Steel= 69

Conclusion:

In this lab we focused on measuring or testing the hardness of three metals (aluminum, steel, and brass). Using three methods of testing: Brinell, Vickers and Rockwell, that were explained in details in the procedure part. Each one of these methods has its own readings which are listed in tables. We came to realize that the easiest and most direct method to adopt was the Rockwell hardness test because its digital and needed no calculations(diameter). We also found that Vickers is more suitable than Brinell test because the indentation made by the diamond is much smaller than that made in the Brinell test.

References:

Experimental Laboratory Manual in Materials Science and Engineering

YouTube videos

Notes from the experiment