

Experiment Six (6)

Hardness Testing

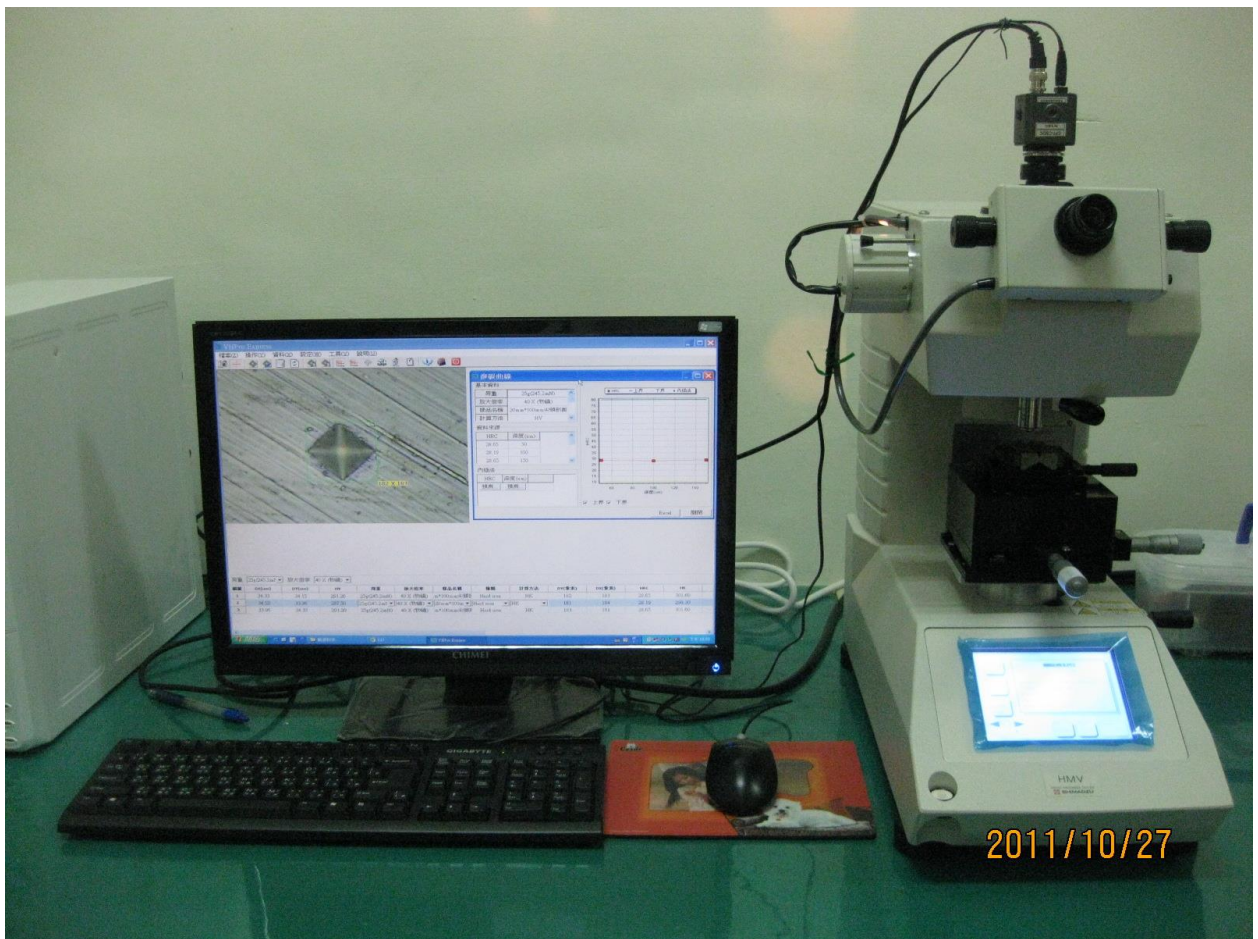
Introduction

Objective:

To Study and evaluation of Surface hardness of different materials using Micro-Hardness testing Equipment, Vicker Methods.

Apparatus:

1. Vicker hardness testing equipment, similar to the model shown.
2. Material Samples, Steel and Aluminum.



Background:

Hardness is resistance of a material to plastic indentation, scratching, surface penetration, or wear. These properties are all related to the resistance against plastic flow (permanent deformation) in the material. There are different approaches and criteria for hardness measurement. Some test methods for certain material provide convenient correlation of hardness to other mechanical properties. For example, hardness from indentation tests on steel and copper alloys can be used as a rough guide to estimate tensile strength. Hardness tests, in most cases, are rapid and repeatable, and in many instances nondestructive. Therefore, hardness test represents an important means of quality control.

All the widely used hardness measurements adopt one of the two general methods: static indentation and rebound testing. Static indentation involves pressing a ball, diamond, or other types of indenter under a specified constant load into the surface of material and measuring the length, width, or depth of the indentation. Each hardness test method, or scale, is defined with a particular type of indenter, a specified minor load, and a specified major load. The measured indentation size is then converted to a hardness number specific to the scale adopted. In general, the harder the material, the better the resistance, and thus the smaller the indentation.

Theory:

[Refer to Mechanics of Material Laboratory manual for detail information.](#)

Summary of Theory:

Vickers hardness test requires a diamond pyramid indenter with an included angle of 136° .

This technique is also called a diamond pyramid hardness test (DPH) according to the shape of the indenter. To carry on the test, the diamond indenter is pressed on to a prepared metal surface to cause a square-based pyramid indentation as illustrated in figure above.

A Vickers indenter is used in the Vickers microhardness test. The Vickers microhardness indenter is made of diamond in the form of a square-base pyramid having an angle of 136° between faces as shown in Figure 4. The indenter should be applied under a predetermined constant load for 10 to 15 s. The diagonals of the square indentation are measured using the microscope and a mean value is calculated. The Vickers hardness number (VHN) is then calculated according to the formula:

$$\text{VHN} = 2P \sin(\theta/2) / d_2 = 1854.4P / d_2 \quad (2)$$

Where P is the applied load in grams (g), θ is the indenter face angle of 136° , and d is the mean diagonal length in μm . The constant 1854.4 incorporates the value of $\sin(\theta/2)$ and other conversion factors to give VHN a unit of kg/mm^2 .

Furthermore, the strength of some metals can be determined from the plastic area under the stress-strain curve. This is of interest when the strength of the materials cannot be measured directly from the standard tensile test. In this case, the yield strength at 0.2% offset can be determined from the Vickers hardness number as shown in the expression:

The Yield Strength

$$\sigma_y = \text{VHN}(0.1)^n / 3$$

n– Surface exponents

Procedure

Procedure for microhardness test:

1. Turn on the tester.
2. Select and install the indenter (Vickers), if not already installed.
3. Place the weights selected on the loading pan. The Knob on the side will help to set the loading in Grams unit.
Pay attention, to the location of the sample 3Dtable and cameras. Use the vertical positioning knob to lower the table from the cameras before using the button selector. The button selector is a Black knob on the front of equipment that switches the cameras of indenter.
4. Place the specimen in the tester, secure and turn the 40× objective lens into place. Focus on the specimen surface with the focusing control until surface features can be seen. Select a clean area of the sample with no prior dent.
5. Gently turn the loading handle clockwise to raise the weights and the indenter, and turn the indenter into place. Slowly release the loading handle counter-clockwise to apply the load. Leave the indenter on the specimen for 10 to 15 s. (in this lab we will be using 15 seconds).
6. Raise the indenter by turning the loading handle clockwise gently, and turn the objective lens back into place.
7. Focus on the specimen surface to view the indentation.
8. Run auto Analysis. On the software selection option.
9. The software will try fit vectors onto opposite nodes of the dent and calculate the diameter of indentations.
10. If the software due to off scale, or not clearly defined edges could pick the right corners, Right Click on the mouse and select the opposite corners of indentations manually.
11. Record these values.
12. (ABOVE): Measure length of the long diagonal both diagonals (Vickers) of the indentation with the scale in the microscope. The numbers on the scale are length measured in 0.001 mm. alternatively, the diagonal lengths can be determined by moving a point on the scale from a corner to the opposite corner of the impression under microscope and noting the difference in micrometer readings (numbers on the fine scale are in 0.01 mm).
13. Calculate microhardness number using the appropriate formula.
14. Vicker testing machine will give you D_1 and D_2 and Microhardness VHP on screen. Record these 4 values.
15. Make a copy of your screen by selecting the save image, for future analysis.
16. Repeat at the same force for statistical analysis.
17. Repeat for different force in increment of 50 kgm up to 1000 gm for steel and 600 gm for aluminum.

Sample Data Acquisition form:

Material Type:	
Applied Load:	
Diagonal Length (major)* (2 minimum):	
Diagonal Length (minor)* (2 minimum):	
Average Diagonal Length:	
Average Diagonal Length:	
Physical Dimension of Sample (width x thickness)	
Listed Hardness Value	

Required CALCULATIONS:

1. Use the average values of Diagonal measurements and above formula calculate the Hardness.
2. Compare the results with the listed value by testing equipment.
3. Plot a chart of measured and calculated values of Hardness.
4. Discuss the differences.
5. How these values does compared with published data for the typical steel and aluminum materials.
6. From the Hardness values find correlation to the material Ultimate strength and Yield Strength of materials?
7. Why does the hardness value obtained for each specimen differs from on surface location to another?
8. Find the coefficient of n on the above equation to relate published yield strength of Steel and Aluminum to vicker hardness value.

DISCUSSION:

1. What are possible sources of error?
2. Were your errors within reasonable limits (< 10%)?
3. Were your increasing and decreasing graphs the same? Why not?
4. Does the surface condition has any effect of the hardness value?

Possible Charts and Tables:

A. Observed measurements:

Load (Kg)	Experimental			Corrected Experimental		
	ϵ_1 ($\mu\epsilon$)	ϵ_2 ($\mu\epsilon$)	ϵ_3 ($\mu\epsilon$)	ϵ_1' ($\mu\epsilon$)	ϵ_2' ($\mu\epsilon$)	ϵ_3' ($\mu\epsilon$)
0.5						
1.0						
1.5						
2.0						

B. TABULATION OF LOADS, STRAINS, AND STRESSES:

LOAD (gm)	STRAIN (ϵ) μ/μ	STRESS (psi) (INCREASING LOAD)	STRAIN ($\mu\epsilon$) (DECREASING LOAD)	STRESS (psi) (DECREASING LOAD)