

# ME-372 : Heat transfer and Metrology lab

## Experiment No.- 1 B

### Vickers Hardness Measurement



# Contents

## ☐ **Theory**

- Introduction of Hardness
- Types of Hardness
- Sample preparation

## ☐ **Procedure**

## ☐ **Experimental setup**

## ☐ **Results**

## ☐ **Conclusion**

# Introduction

- Hardness is the property of material which resist the plastic deformation against scratching / indentation on the surface of workpiece.
- Hardness measurement is non-destructive test, that also provide useful information about the strength of material.
- Higher the hardness of the material, the more it is difficult to make an indentation or scratch.

## Objective:-

- To study the Vicker's hardness testing machine and perform the Vicker's hardness test.

## Principle of hardness test:-

- The basic principle of hardness test is forcing an indenter into the sample surface, whose hardness is to be measured. Then followed by measuring dimensions of the indentation (actual surface area of the indentation).

Hardness number =  $\text{Applied load} / \text{Actual surface area of the indentation}$

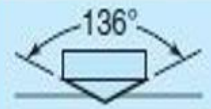



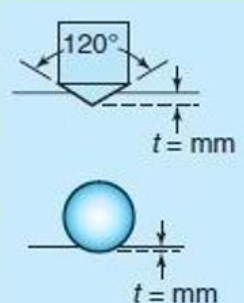

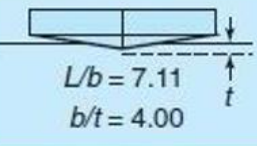
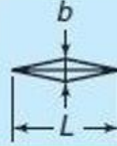


Micro-hardness tester

# Types of hardness test

## Major types of Hardness test are:-

1. Vicker Hardness test
2. Brinell Hardness test
3. Rockwell Hardness test
4. Knoop Hardness test

Hardness Test	Applied load	Indenter	Shape of indenter	
			Side view	Top view
Vicker	1 – 120 kgf	Diamond Pyramid Square base		
Micro-Vicker	0.1 – 1 kgf			
Brinell	1 – 3000 kgf	Ball		
Rockwell	1 – 250 kgf	Diamond Pyramid Square base, Ball		
Knoop	0.1 – 2 kgf	Diamond Pyramid Rhomboid base		

## Vicker's Hardness Test

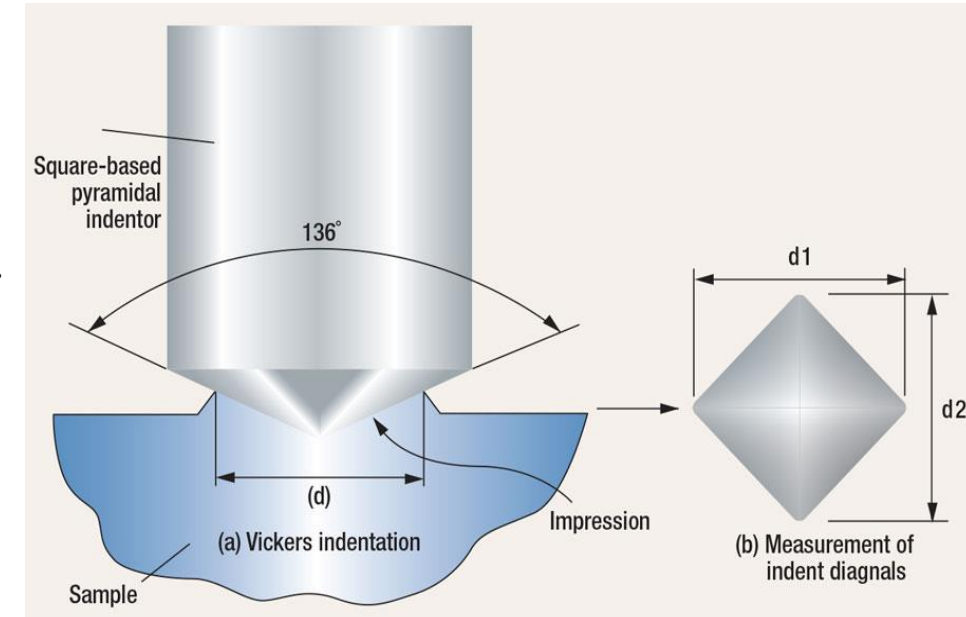
- The Vickers method has a test load range from 1 gf up to 120 kgf. So, this method can be used for hardness testing across all load ranges from the micro to the macro range.
- The indenter is tungsten carbide, Diamond pyramid with square base indenter with a plane angle of  $136^\circ$ .

### Advantages:

- It can be used with all materials and from softer to harder hardness range.
- There is only one type of indenter, which can be used for all Vickers methods.

### Disadvantages:

- The surface quality of the specimen must be good. Because the indent is measured optically.
- In general, evaluation of the hardness value is laborious.



$$HV = \frac{2F \sin\left(\frac{136^\circ}{2}\right)}{d^2}$$

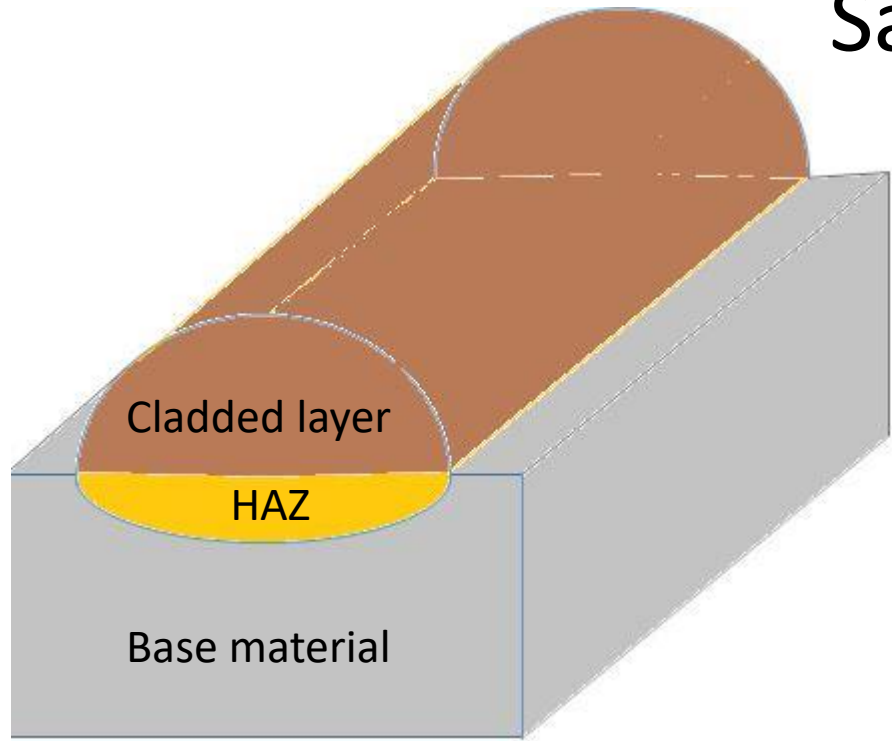
HV = the Vicker's hardness number

F = the imposed load in kgf

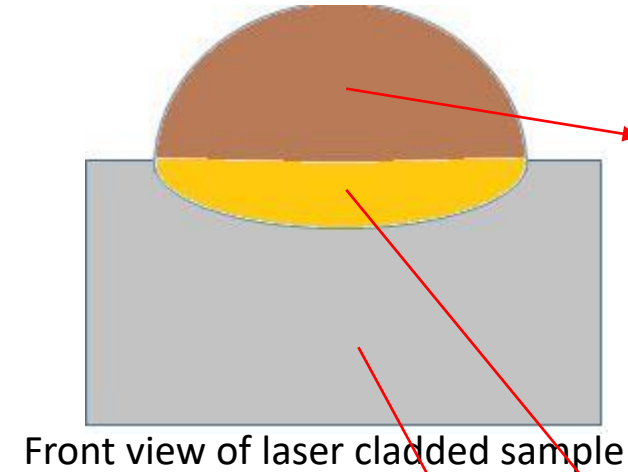
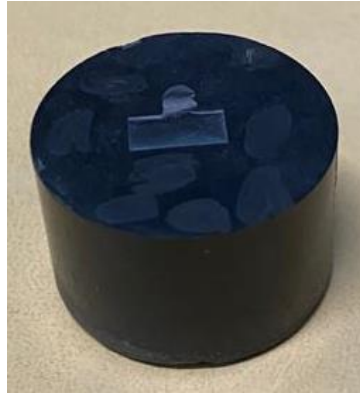
d = Average diagonal of indenter in mm



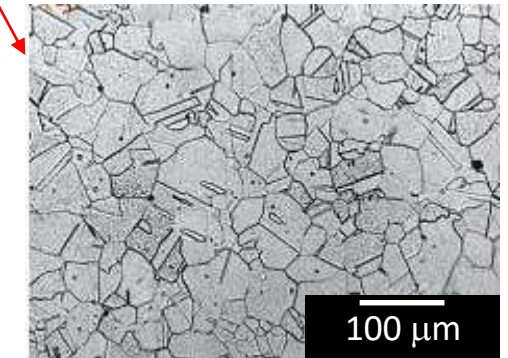
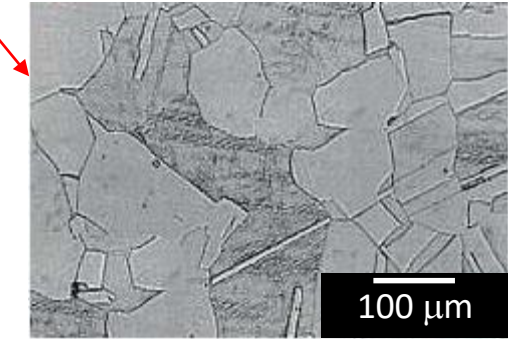
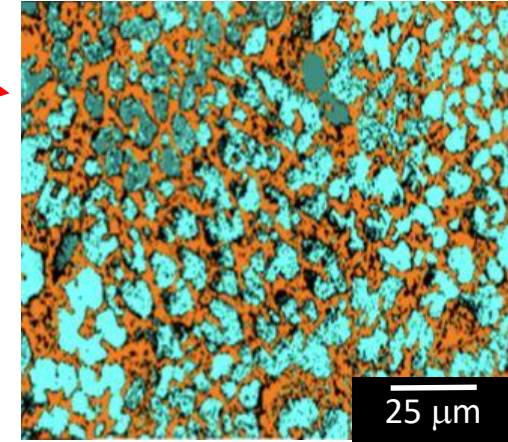
# Sample preparation



Isometric view of laser cladded sample



Front view of laser cladded sample



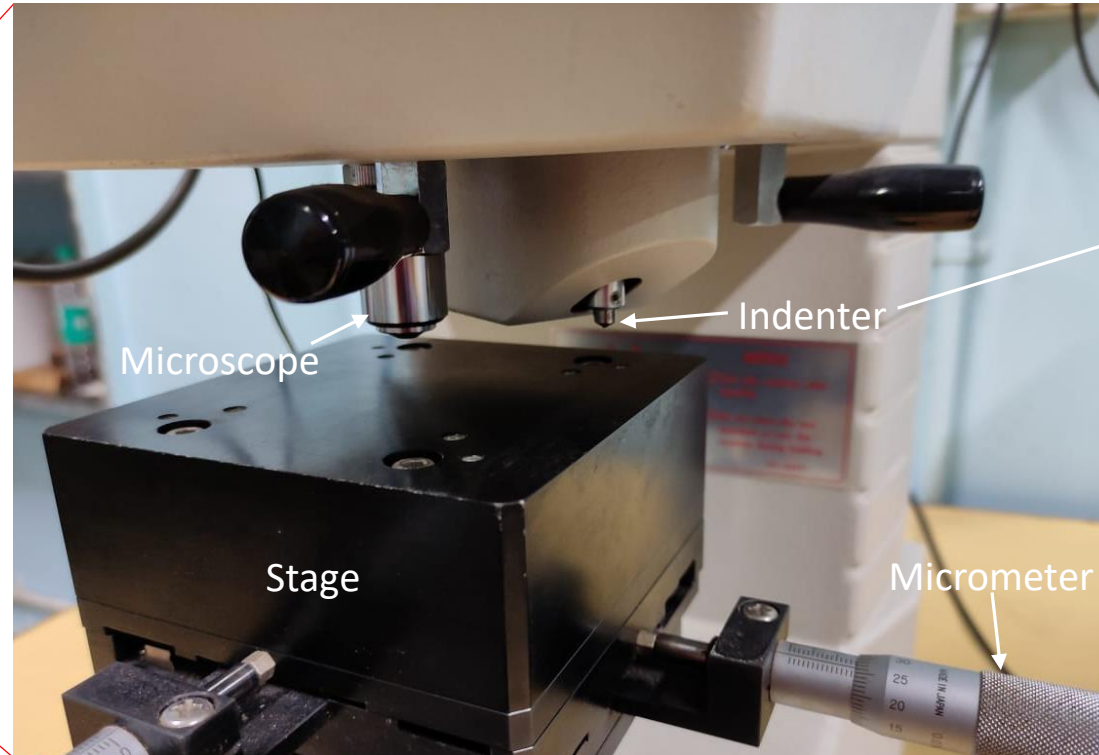
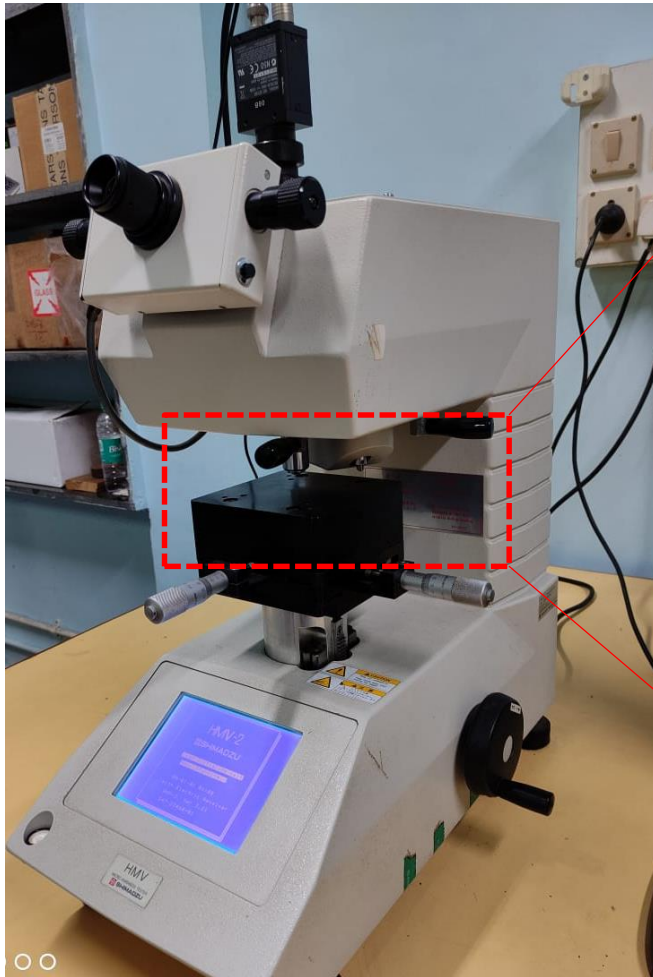
- Sample is prepared by laser cladding of Ni-Cr powder on base metal of Stainless steel material.
- Laser cladding, also known as laser metal deposition of one material to the surface of another. The laser cladding process allows property improvements for the surface of material.



Bakelite powder hot mounted

Cladded sample

# Micro-Hardness Tester



Diamond indenter with square base

Experimental setup of Micro-hardness testing machine of company SHIMADZU

# Procedure

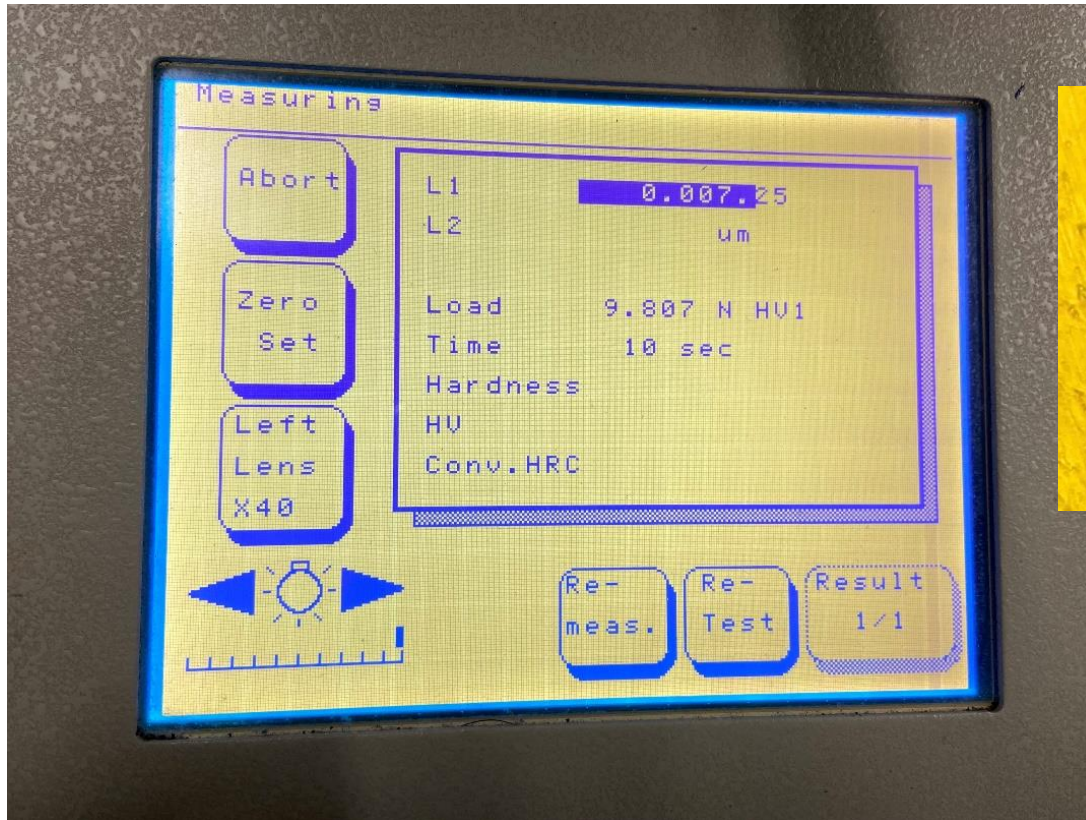
1. Take a well-polished flat sample. because the surface quality must be good enough to allow correct optical evaluation of the indent.
2. Place it under microscope and identify the place where to test hardness.
3. The indenter is pressed into the sample by an accurately controlled test force.
4. The force is maintained for a specific dwell time, normally 10 - 15 seconds.
5. When the dwell time is completed, the indenter is removed leaving a indent on the surface of sample.
6. The size of the indent is determined optically by measuring two diagonals of the indent using microscope.
7. Calculate indent diagonals ( $d_1$  &  $d_2$ ) using apparatus and get hardness results.

## **Precaution:-**

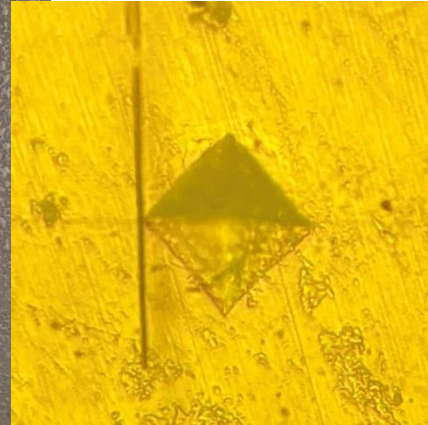
To avoid affecting the test result, care must be taken to ensure that the test is not disturbed by any shock or vibration (i.e.- an anti-vibration table may be required).



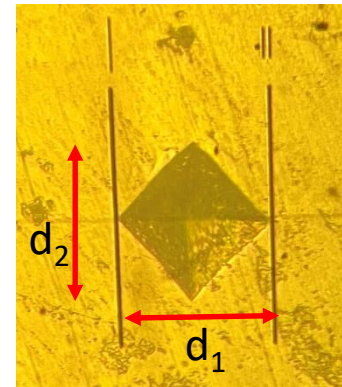
# Micro-Vicker's Hardness Measurement



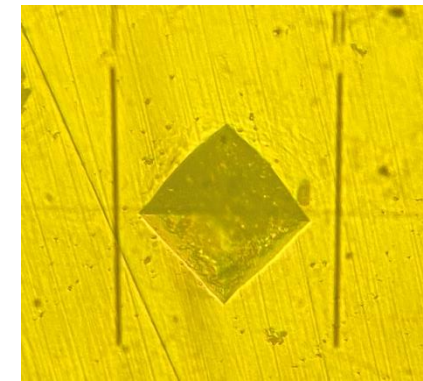
Micro-hardness tester screen



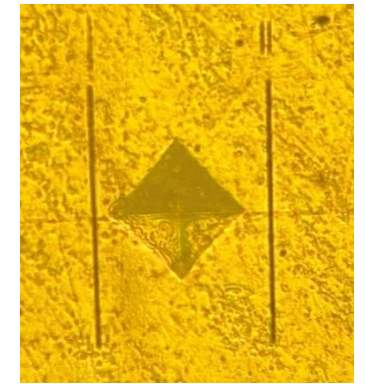
The Vicker's method is the most common testing method in practice due to its diverse applications.



Base metal  
624 HV



HAZ  
556 HV



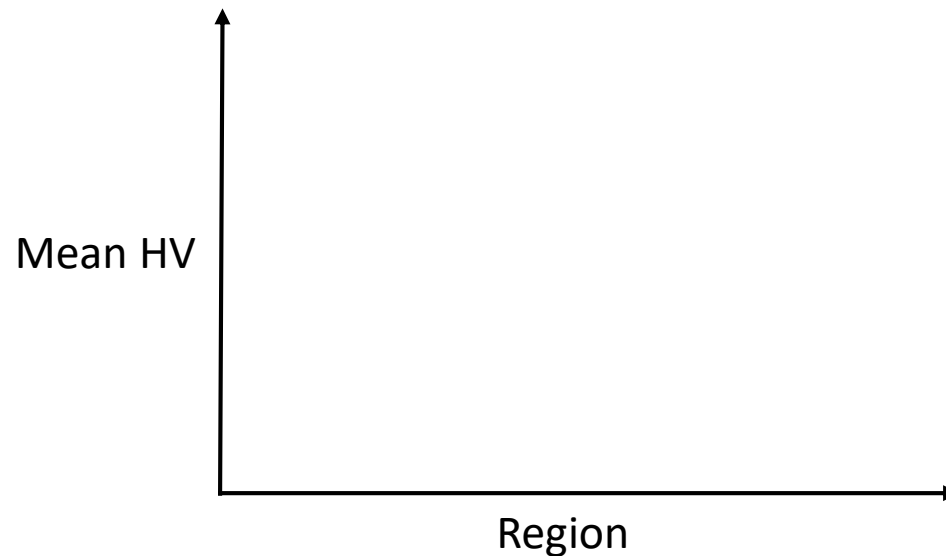
Cladded region  
874 HV

# Results and Analysis

**Question 1.** Present the results about the hardness of base metal, HAZ zone & the cladded region. Find the mean and slandered deviation.

Phases	R1	R2	R3	Mean HV	St. deviation
Base metal					
HAZ					
Cladded region					

**Question 2.** Plot diagram of mean Vicker's hardness (HV) vs Region with error bar.



**Question 3.** Write conclusions and sources of error.

**Question 4.** Write the definition of Brinell, Rockwell and Knoop hardness tests with their two advantages and two disadvantages. And also write their conversion formula to the Vicker's hardness number.

**Question 5.** Vickers hardness test was conducted on a material with an applied load of 10 kgf. If the measured diagonal distances of the indentation made by the diamond indenter,  $d_1$  and  $d_2$  were  $210\text{ }\mu\text{m}$  and  $227.5\text{ }\mu\text{m}$  respectively. Calculate the Vickers hardness (HV) of the material.