EXPERIMENT NO 10

Hardness measurement of sintered products

Objective:

Vickers hardness testing of sintered alumina compact

Basic Theory:

Hardness has a variety of meanings.

- In the metals industry, it may be thought of as resistance to permanent deformation.
- For the metallurgist, it means resistance to penetration.
- To the lubrication engineer, it means resistance to wear. For the design engineer, it is a measure of flow stress.
- To the mineralogist, it means resistance to scratching, and to the machinist, it means resistance to machining.
- Hardness may also be referred to as mean contact pressure.
- All of these characteristics are related to the plastic flow stress of materials.

Hardness is not an intrinsic property of any material (like density or melting point). It is rather a characteristic deriving from the composition, the thermal and mechanical history of the material and essentially from the structure (or more properly the microstructure) of the specimen involved. During sintering, the density and microstructure of the compact varies continuously depending on the sintering temperature. Using hardness test because it is simple, easy and relatively nondestructive can easily monitor this variation. Also, the hardness has a relationship with the other properties of material, for e.g., there is an approximate correspondence between hardness data and a range of tensile strength results.

Vickers hardness test involves:

- a diamond indenter, in the form of a square pyramid with an apex angle of 136
- pressed for 10-15 s into the surface of the material under test
- The result is a square shaped impression

Vickers hardness value (H_V) is calculated by dividing the applied load by the surface area of the indentation.

$$\text{Area of the indentation} = \frac{d^2}{2\sin\frac{\theta}{2}} = \frac{d^2}{1.854}$$

Where, *d* is the mean diagonal length and the included angle (2▯) of the indentation is equal to 136▯. Therefore

$$H_v = 1.854\frac{P}{d^2}$$

The biggest advantage with the Vickers test is that the hardness value is independent of the magnitude of the applied load.

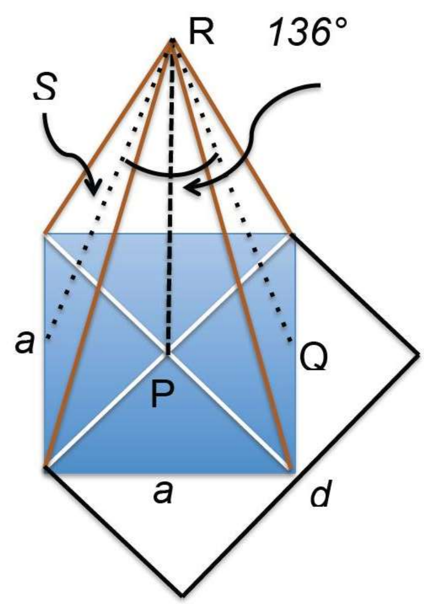

Figure 10.1: Illustrating schematically the Vickers indentation

<u>Equipment/ Raw Materials:</u>

Sample: Sintered alumina compact (obtained from experiment 7)

Other accessories/chemicals/equipment:

- Vickers Hardness Tester
- Belt grinder
- Polishing papers of different grades
- Ethanol solution

Vickers Hardness Tester

Polishing papers of different grades

<u>Procedure:</u>

1. Remove approximately, 0.2mm of the surface by grinding on a belt grinder
2. Polish the sample surfaces to mirror finish using abrasive papers
3. Clean the surface using water or with ethanol
4. Mount the clean surface of the sample facing the indenter on the tester stage
6. Focus the polished surface of the alumina compact
7. Apply a load of 2kgf for 15 s.
8. Unload the sample gently
9. Record and measure the mean diagonal length of square impression
10. Calculate the Vickers hardness value.
11. Repeat the experiment for three times in different locations on the sample in order to obtain the error in the hardness values.

<u>Lab Deliverables:</u>

1. List three types of hardness testing methods along with their principles.

Sol:

a) **Rockwell Hardness Test:**

  a. **Principle:** The Rockwell hardness test measures the depth of penetration of an indenter under a large load (major load) compared to the penetration made by a preload (minor load). The result is expressed as a Rockwell hardness number (e.g., HRC or HRB), which indicates the material's resistance to indentation.

b) **Brinell Hardness Test:**

   a. **Principle:** The Brinell hardness test involves indenting a test material with a spherical indenter under a specific load. The diameter of the indentation left on the material's surface is measured. The hardness is calculated as the load divided by the curved surface area of the indentation. The result is expressed in Brinell hardness number (BHN).

c) **Vickers Hardness Test:**

   a. **Principle:** The Vickers hardness test utilizes a diamond pyramid-shaped indenter. A load is applied to the indenter, and the hardness is determined by the size of the indentation left on the material's surface. The Vickers hardness number (HV) is calculated based on the applied load and the surface area of the indentation.

2. Mention some precautions that need to be taken when conduct a Vickers hardness test?

Sol:

- Ensure that the surface of the test specimen is flat, clean, and free from any contaminants.
- Properly mount the specimen to prevent any movement during the test. This is crucial for accurate indentation and measurement.
- Consider the thickness of the specimen, as very thin or very thick specimens may not be suitable for Vickers hardness testing.
- Follow the specified load and dwell time according to the material being tested. Excessive or insufficient load and dwell time can lead to inaccurate results.

3. Report Vickers hardness value of sintered alumina compact.

Sol: P.T.O.-->

Observations and Calculations

1. Bulk Hardness

Sample	D1 (µm)	D2 (µm)	Hardness
Cu - 10% Sn	145.6	146.10	43.6
	146.87	142.04	44.4
	145.66	137.68	43.1
Cu - 30% Sn	68.95	71.82	187.1
	68.54	69.18	195.5
	70.46	71.40	184.2

2. Component Hardness

   Cu – 10% Sn

   Intermetallics load applied 100g

D1 (µm)	D2 (µm)	Hardness
53.18	50.98	68.3
47.55	53.23	73
52.31	53.46	66.3

Matrix

D1 (µm)	D2 (µm)	Hardness
53.86	55.24	62.3
50.58	50.17	73
51.86	53.16	66.5
54.42	52.85	64.4

Cu – 30% Sn

Phase	D1 (µm)	D2 (µm)	Hardness
δ phase	19.82	19.64	476.3
	20.44	19.97	454.2
	20.04	20.13	459.6
α phase	27.35	27.35	262.8
	35.86	37.26	138.7
	36.61	38.13	132.7

Conclusion

The bulk hardness shows a higher value in case of Cu -30% Sn sample and implies to be strong enough as well. And in case of component hardness intermetallic of Cu – 10% Sn and δ phase of Cu -30% Sn seems to be the highest.