FACULTY OF ENGINEERING AND TECHNOLOGY

Department of Mechanical Engineering

MEPS102:Strength of Material

Lecture 38

Topic: Material Testing

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Universal Testing Machine

✓ A universal testing machine (UTM), also known as a universal tester, materials testing machine or materials test frame, is used to test the tensile strength and compressive strength of materials. An earlier name for a tensile testing machine is a tensometer. The "universal" part of the name reflects that it can perform many standard tensile and compression tests on materials, components, and structures (in other words, that it is versatile).

Universal Testing Machine: Component

- ✓ Several variations are in use. Common components include:
- ✓ Load frame - Usually consisting of two strong supports for the machine. Some small machines have a single support.
- ✓ Load cell - A force transducer or other means of measuring the load is required. Periodic calibration is usually required by governing regulations or quality system.
- ✓ Cross head - A movable cross head (crosshead) is controlled to move up or down. Usually this is at a constant speed: sometimes called a *constant rate of extension* (CRE) machine. Some machines can program the crosshead speed or conduct cyclical testing, testing at constant force, testing at constant deformation, etc. Electromechanical, servo-hydraulic, linear drive, and resonance drive are used.

Universal Testing Machine: Component

- ✓Means of measuring extension or deformation - Many tests require a measure of the response of the test specimen to the movement of the cross head. Extensometers are sometimes used.
- ✓Output device - A means of providing the test result is needed. Some older machines have dial or digital displays and chart recorders. Many newer machines have a computer interface for analysis and printing.
- ✓Conditioning - Many tests require controlled conditioning (temperature, humidity, pressure, etc.). The machine can be in a controlled room or a special environmental chamber can be placed around the test specimen for the test.
- ✓Test fixtures, specimen holding jaws, and related sample making equipment are called for in many test methods.

Rockwell Hardness Testing

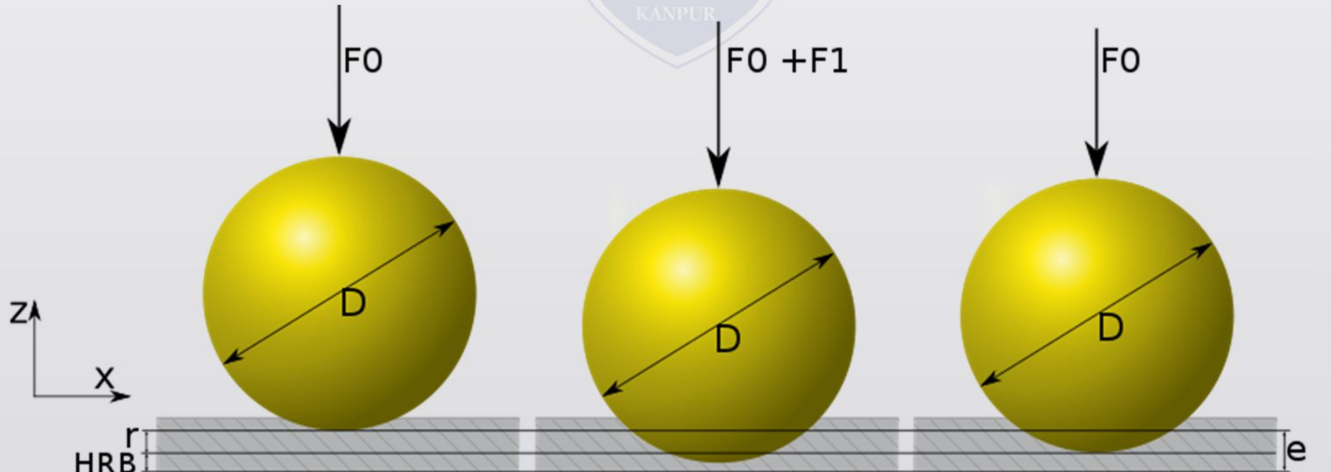
- ✓ The Rockwell scale is a hardness scale based on indentation hardness of a material.
- ✓ The Rockwell test measuring the depth of penetration of an indenter under a large load (major load) compared to the penetration made by a preload (minor load).
- ✓ There are different scales, denoted by a single letter, that use different loads or indenters.
- ✓ The result is a dimensionless number noted as HRA, HRB, HRC, etc., where the last letter is the respective Rockwell scale.
- ✓ When testing metals, indentation hardness correlates linearly with tensile strength.

Rockwell Hardness Testing

- ✓ The determination of the Rockwell hardness of a material involves the application of a minor load followed by a major load.
- ✓ The minor load establishes the zero position.
- ✓ The major load is applied, then removed while still maintaining the minor load.
- ✓ The depth of penetration from the zero datum is measured from a dial, on which a harder material gives a higher number. That is, the penetration depth and hardness are inversely proportional.
- ✓ The chief advantage of Rockwell hardness is its ability to display hardness values directly, thus obviating tedious calculations involved in other hardness measurement techniques.

Rockwell Hardness Testing

- ✓ The equation for Rockwell Hardness is $HR = N - \frac{d}{s}$ where d is the depth (from the zero load point), and N and s are scale factors that depend on the scale of the test being used (see following section).
- ✓ It is typically used in engineering and metallurgy. Its commercial popularity arises from its speed, reliability, robustness, resolution and small area of indentation.



Brinell Hardness Testing

- ✓ The Brinell scale characterizes the indentation hardness of materials through the scale of penetration of an indenter, loaded on a material test-piece.
- ✓ The typical test uses a 10 mm (0.39 in) diameter steel ball as an indenter with a 3,000 kgf (29.42 kN; 6,614 lbf) force. For softer materials, a smaller force is used; for harder materials, a tungsten carbide ball is substituted for the steel ball. The indentation is measured and hardness calculated as:

$$BHN = \frac{2P}{\pi D(D - \sqrt{D^2 - d^2})}$$

BHN = Brinell Hardness Number (kgf/mm^2)

P = applied load in kilogram-force (kgf)

D = diameter of indenter (mm)

d = diameter of indentation (mm)

Vickers Hardness Test

- ✓ The Vickers test is often easier to use than other hardness tests since the required calculations are independent of the size of the indenter, and the indenter can be used for all materials irrespective of hardness. The basic principle, as with all common measures of hardness, is to observe a material's ability to resist plastic deformation from a standard source. The Vickers test can be used for all metals and has one of the widest scales among hardness tests. The unit of hardness given by the test is known as the **Vickers Pyramid Number** (**HV**) or **Diamond Pyramid Hardness** (**DPH**).

Vickers Hardness Test

- ✓ It was decided that the indenter shape should be capable of producing geometrically similar impressions, irrespective of size; the impression should have well-defined points of measurement; and the indenter should have high resistance to self-deformation.
- ✓ A diamond in the form of a square-based pyramid satisfied these conditions. It had been established that the ideal size of a Brinell impression was 3⁄8 of the ball diameter. As two tangents to the circle at the ends of a chord 3d/8 long intersect at 136°, it was decided to use this as the included angle between plane faces of the indenter tip.

Vickers Hardness Test

- This gives an angle from each face normal to the horizontal plane normal of 22° on each side. The angle was varied experimentally and it was found that the hardness value obtained on a homogeneous piece of material remained constant, irrespective of load.
- Accordingly, loads of various magnitudes are applied to a flat surface, depending on the hardness of the material to be measured. The HV number is then determined by the ratio F/A, where F is the force applied to the diamond in kilograms-force and A is the surface area of the resulting indentation in square millimetres. A can be determined by the formula

$$A = \frac{d^2}{2\sin\left(\frac{136^0}{2}\right)}$$

Vickers Hardness Test