OBJECTIVE

To investigate and determine the following mechanical properties of a material;

1. The elastic and plastic deformations of the material
2. The tensile and ultimate strengths of the material
3. The ductility of the material in terms of percentage of elongation and percentage reduction in cross-sectional area at fracture.

LEARNING OUTCOMES

At the end of this laboratory session, student should be able to:

1. Operate the simple 'universal testing machine' and understand its general functions and features.
2. Conduct the tensile test which is one of many mechanical tests in accordance to the standardized methods such as based on ASTM/ISO/EN/MS specifications.
3. Define experimentally the load elongation graph/curve and determine the mechanical properties of the test material by using the plotted graph.
4. Calculate the ductility of the tested materials and compare the results obtained with the theoretical data.
5. Understand and describe overall deformation and fracture behavior of the tested specimens and its relation with the 'ductility' of the ductile and brittle materials.
6. Understanding of basic laboratory practice, including design of experiment, write a clear and well-presented technical report, data acquisition, interpretation and analysis and the relationship between experimental and theory.

THEORETICAL BACKGROUND

When a sample of metal with gauge length (L_0) as shown in **Figure 1 (a)** is subjected to a uniaxial tensile force (P), deformation and elongation (L) of the metals occurs as shown **Figure 1(b)**. If the metal returns to its original dimensions when the force is removed, the metal is said to have undergone **elastic deformation.** The amount of elastic deformation a metal can undergo is small, since during elastic deformation the metal atoms are displaced from their original positions but not to the extent that they take up new positions. Thus, when the force on a metal that has been elastically deformed is removed, the metal atoms return to their original position and the metal takes back its original shape. If the metal deformed to such an extent that it cannot fully recover its original dimensions, it is said to have undergone **plastic deformation.** During plastic deformation, the metal atoms are permanently displaced from their original position and take up new positions. The ability of some metals to be deformed plastically, without fracture is one of the most useful engineering properties of metals.

The tensile test is used to obtain the **stress-strain diagram** where **mechanical properties** and overall behavior of the metals and alloys may be determined. During the test, the sample is subjected to the tensile load at a constant rate and it is pulled until failure occurs. The data of **load against elongation** obtained from the tensile test can be converted to engineering stress-strain data, and a graph of **engineering stress versus engineering strain** can be plotted.

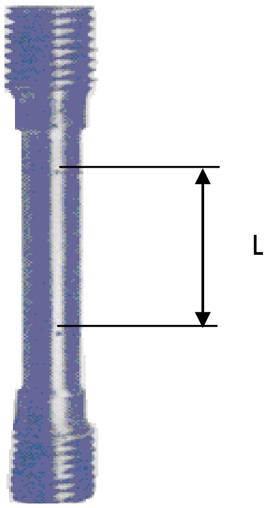

Figure 1(a)

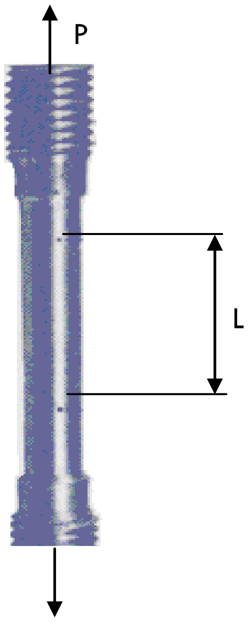

Figure 1(b)

Mechanical properties of metals and alloys that are of engineering importance for the structural design and metal forming purposes and can be determined from the tensile test results are:

1. **Modulus of elasticity**

   For the elastic region of the engineering stress-strain curve and based on the Hooke's law, modulus of elasticity E, is defined as;

   $$E = \Delta\sigma / \Delta\varepsilon \qquad (1)$$

   where $\Delta\sigma / \Delta\varepsilon$ represents the slope of the elastic region of the graph.

2. **Yield strength of the material**

   The yield strength or yield stress is given by;

   $$\sigma_y = P_y / A_o \qquad (2)$$

   where P_y = load at yield point and A_o = original cross-sectional area (within the gauge length of the test specimen). It is a very important property for use in the design of the structure or engineering components. It is also a point where the tested material begins to experience **plastic deformation.**

   Since most metallic alloys fails to show a clear or well-defined yield point on the stress-strain curve, where elastic strain ends and plastic strain begins, then the yield strength of these type of materials are chosen when a definite amount of plastic strain has occurred. Normally, a point when 0.2 percent plastic strain has taken place during the tensile test is defined as yield strength of such materials. This is also known as a *proof strength* of the material.

3. **Ultimate tensile strength**

   The ultimate tensile strength is the maximum strength reached in the engineering stress-strain curve.

   $$\sigma_{ult} = P_{ult} / A_o \qquad (3)$$

   Where, P_{ult} = Ultimate load as given by the load – elongation graph. When the material achieved its ultimate tensile strength, the test specimen develops a localized decrease in cross sectional area (commonly called as ***necking***) the engineering stress will decrease with increasing strain until fracture occurs.

4. **Percent** of **elongation**

   It is the amount of elongation (or deformation in its general term) that a tensile specimen undergoes during tensile test which represents the degree of ductility of a material. In general the higher the percent elongation, then it shows that the tested material has a higher level of ductility.

$$\text{Percent of elongation } (\%\Delta L) = 100(L - L_o)/L_o \qquad (4)$$

5. **Percentage reduction in cross-sectional area**

   The ductility of a material can also be expressed in terms of the percent reduction in area.

$$\text{Percent of reduction in area } (\%\Delta A) = 100(A - A_o)/A_o \qquad (5)$$

Percentage of elongation and percentage of reduction in area are also two material properties that are normally used to describe the “formability properties” of the materials especially in the field of metal forming. Generally, the ability of a material to undergo deformation when subjected to an applied load may be defined through these values.

EQUIPMENT & SPECIMEN

1. Tensile test machine model SMXXX complete with force and elongation indicator
2. Three types of specimen are provided:
   a) Mild steel
   b) Aluminum
   c) Brass
3. Measurement tools

TASK

1. Your experiment must be conducted to investigate and determine relationship between normal load/stress and normal elongation/strain.
2. All necessary data and results must be measured, recorded or tabulated systematically to facilitate its analysis and interpretation at the later stage of your work.
3. Comparison of experimentally determined results with the theoretical data must also be presented, analyzed and discussed in your report.

LAB REPORT

1. Title
2. Objective(s)
3. Introduction and Theory (Detail development and explanation of the underlying concept)
4. Apparatus
5. Procedures
6. Data and results
7. Analysis and discussion
8. Conclusion
9. References (Bibliography)