Al-Mustaqbal University
College of Engineering & Technology
Biomedical Engineering Department

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Lecture No.: - 6 -

Lecture Title: [Tensile Testing]

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Exp.No.6 Tensile Testing

1. 1 Introduction

Tensile test are performed for several reasons. The results of tensile tests are used in selecting materials for engineering applications. Tensile properties frequently are included in material specifications to ensure quality. Tensile properties often are measured during development of new materials and processes, so that different materials and processes can be compared. Finally, tensile properties often are used to predict the behavior of a material under forms of loading other than uniaxial tension. The uniaxial tensile test is the primary method to evaluate the material and obtain the parameters.

Standards for tensile testing were amongst the first published and the development of such standards continues today through the ASTM and ISO organizations. Reliable tensile data, which is now generated largely by computer controlled testing machines, is also crucial in the design of safety critical components automotive, aerospace and biomedical applications.

1.2Objectives

1-To understand the principle of tensile test.

2-To understand the Stress-Strain curve and learn how to use it in determining various mechanical properties of different materials : Modulus of Elasticity, Yield Strength, Ultimate Tensile Strength, Elongation at break.

1.3 Materials and Equipment

1. Tensile testing machine
2. Test specimens

3. Micrometer

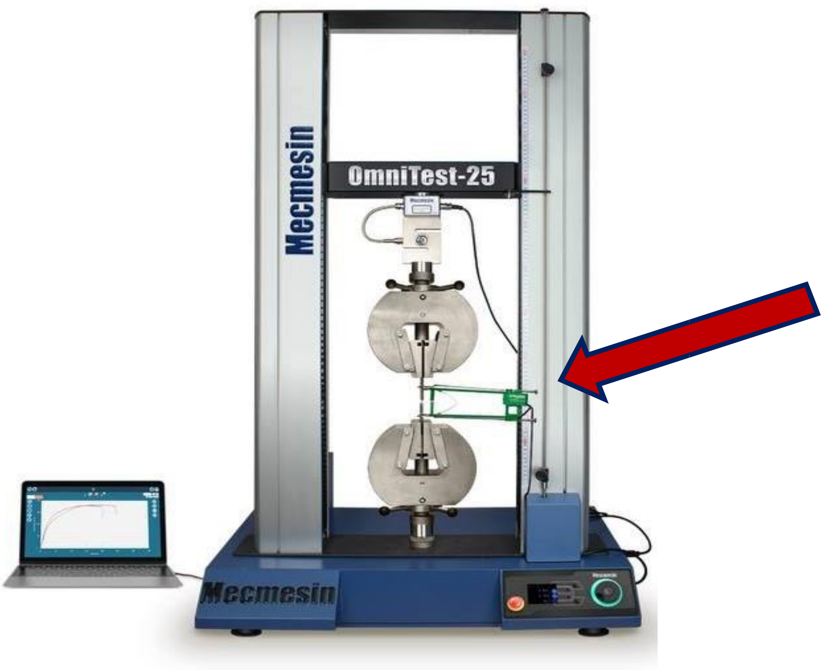
4. Calipers

The most common testing machine used in tensile testing is the universal testing machine. This type of machine has two crossheads; one is adjusted for the length of the specimen and the other is driven to apply tension to the test specimen.

The tensile testing machine consists of an electro-mechanical test system that applies uniaxial loading in a uniform manner to test specimens. It is general purpose in its capabilities and applications. The system performs load versus elongation (stress versus strain) tests which involve controlling forces from a few ounces to several-thousand pounds, gripping specimens ranging from delicate fibers to high strength metals or composites, and measuring the resulting forces (stresses) and deformations (strains). Measurement of the stresses and strains is accomplished by the use of highly sensitive load and strain transducers that create an electrical signal that is proportional the applied stress or strain. This electrical signal is measured, digitized and then processed for display, analysis and report of stress, strain and other computed material characteristics.

1.4 Apparatus used:

Tensile testing machine shown in figure below:



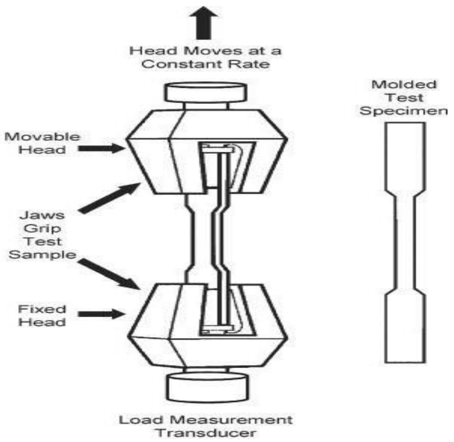
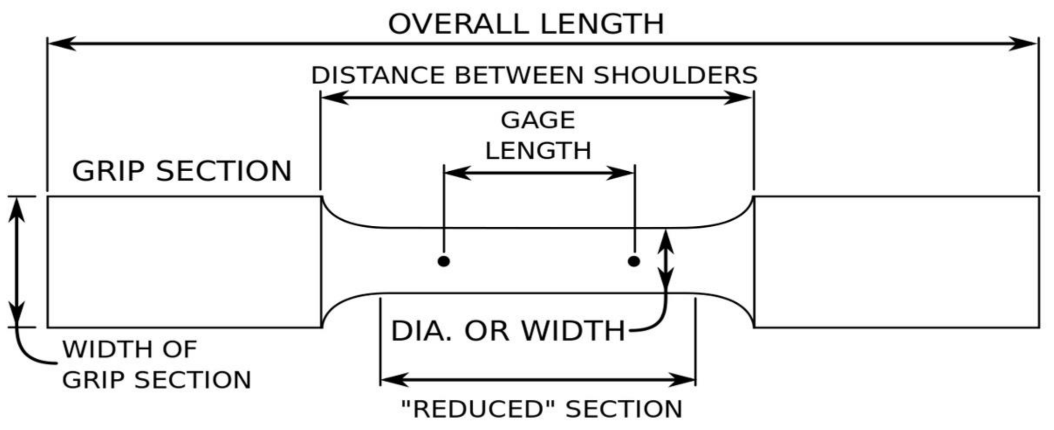


Diagram of Test Specimen and Mounting Jaws

1.5 Tensile specimen



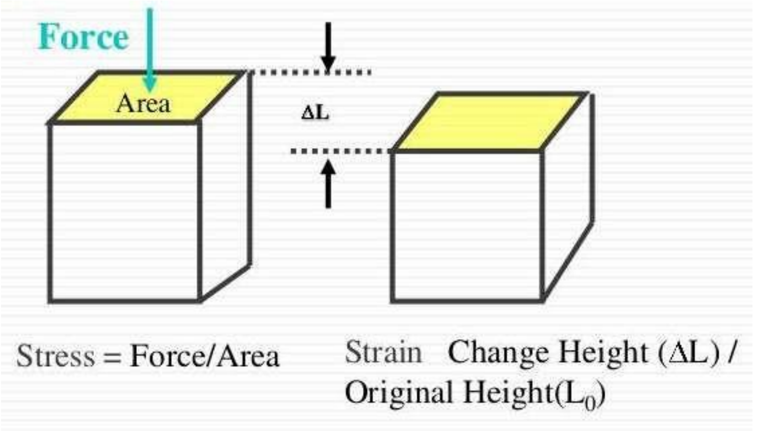
The preparation of test specimens depends on the purposes of testing and on the governing test method or specification. A tensile specimens is usually a standardized sample cross-section. It has two shoulders and a gage (section) in between. The shoulders are large so they can be readily gripped, whereas the gauge section has a smaller cross-section so that the deformation and failure can occur in this area .

1.6 Theory

When a specimen is subjected to an external tensile loading, the metal will undergo elastic and plastic deformation. Initially, the metal will elastically deform giving a linear relationship of load and extension. These two parameters are then used for the calculation of the engineering stress and engineering strain to give a relationship as illustrated in Figure 3 using equations 1 and 2 as follows

$$\sigma = \frac{F}{A_o} \text{ ....(1)}$$

$$\varepsilon = \frac{\Delta L}{L_o} = \frac{L_f - L_o}{L_o} \text{ ....(2)}$$



Where:

σ is the engineering stress

ε is the engineering strain

P is the external axial tensile load

$\boldsymbol{Ao}$ is the original cross-sectional area of the specimen ($\boldsymbol{Ao} = \boldsymbol{w}.\ \boldsymbol{t}$)

$\Delta\ \boldsymbol{L}$ is the deflection of specimen

$\boldsymbol{Lf}$ is the final length of the specimen

$\boldsymbol{Lo}$ is the original length of the specimen

The unit of the engineering stress is Pascal (Pa) or N/m2 (SI Metric Unit) A typical stress-strain curve is shown in the figure below:

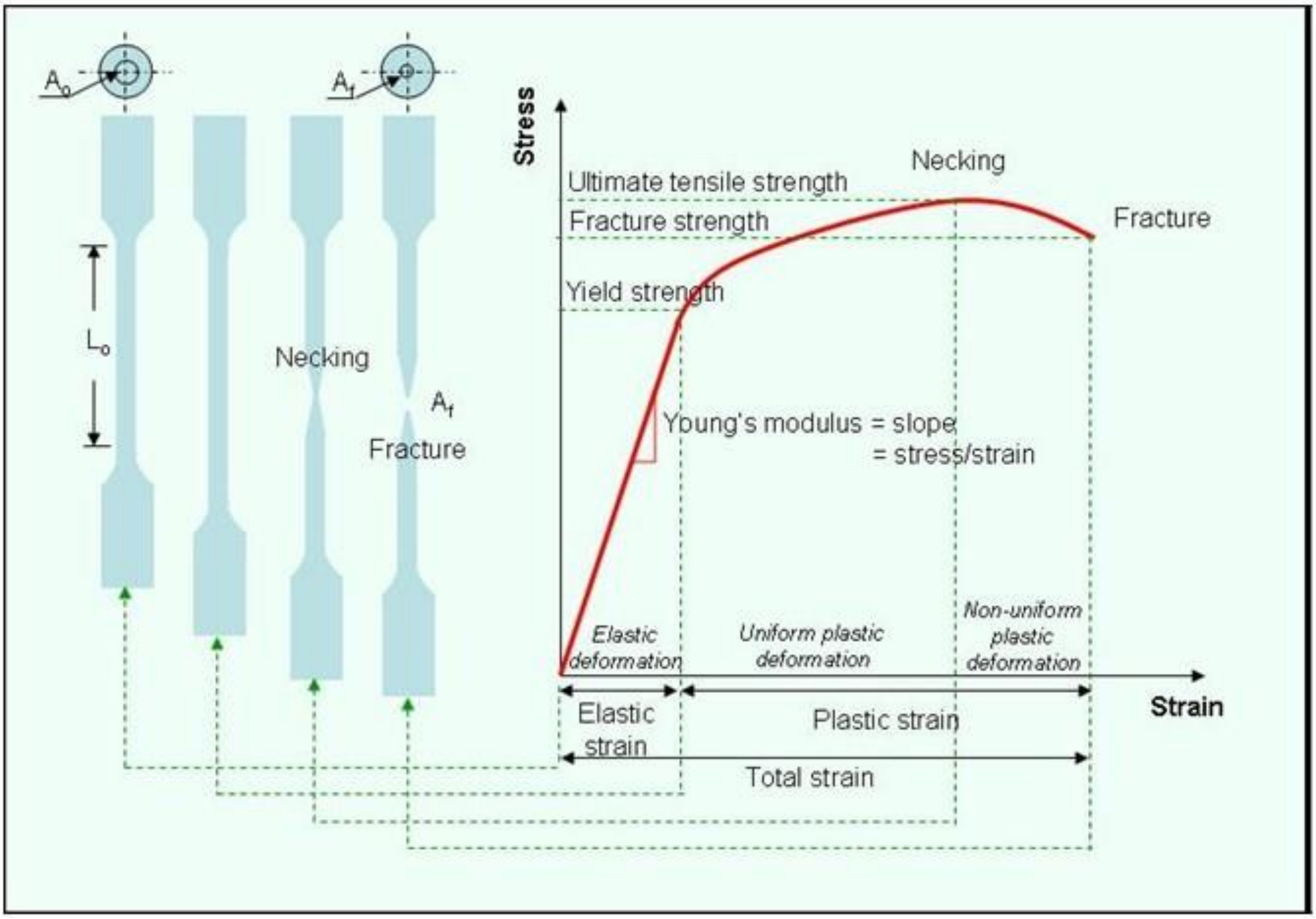
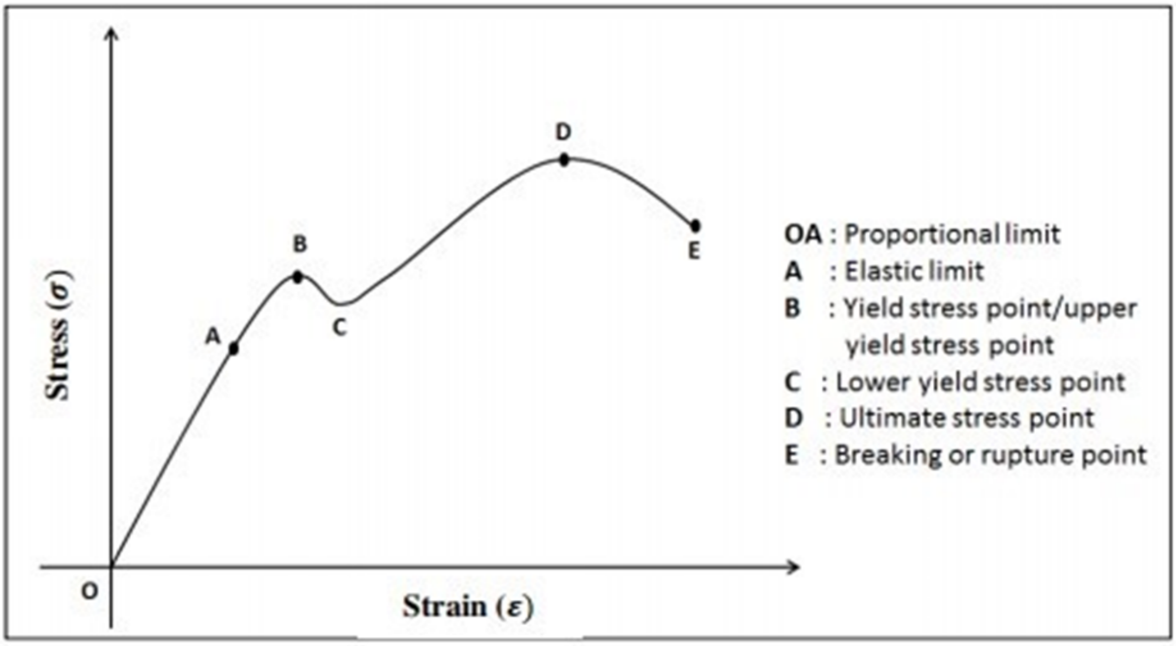
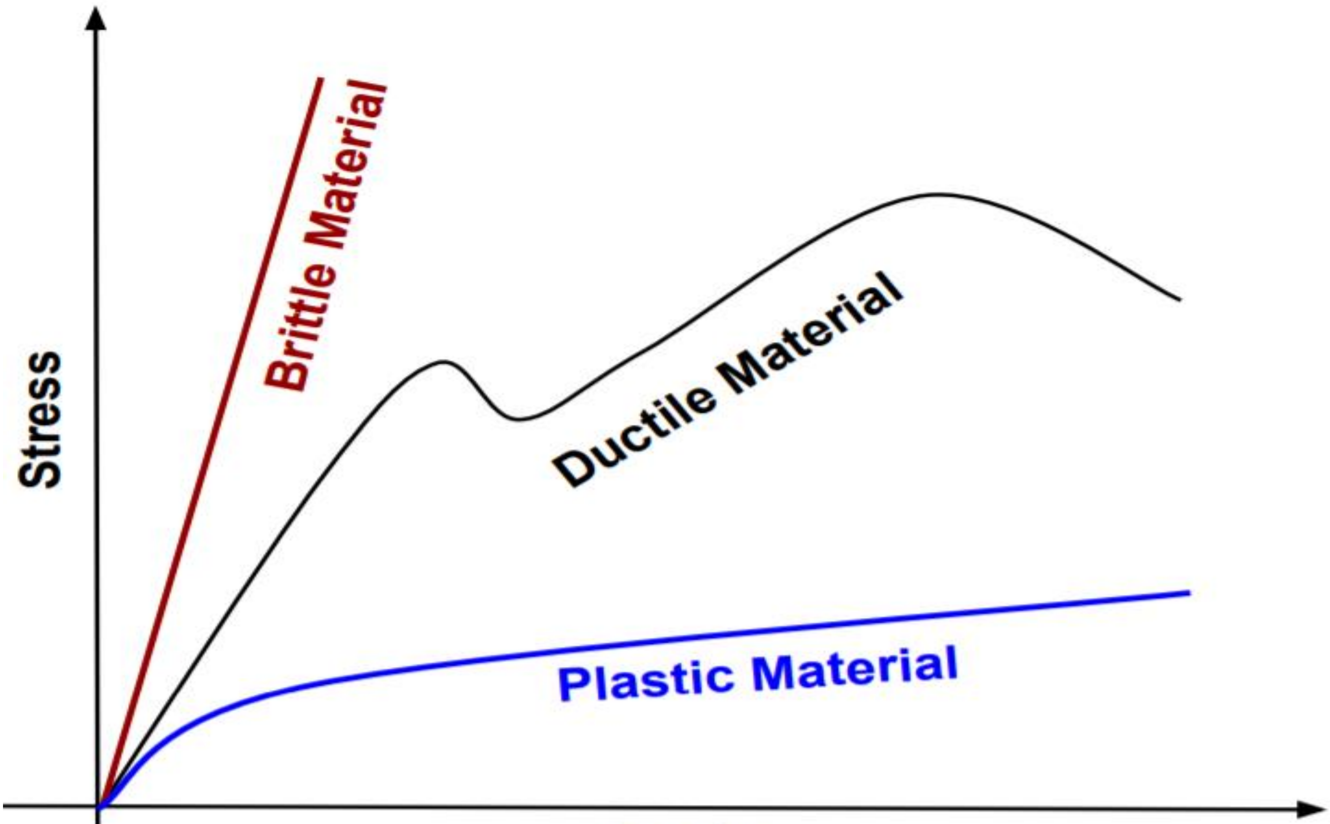


Figure1 : Stress-strain curve from a uniaxial tensile test



Stress versus Strain Curve



Definitions

• Gauge Length (L) - length of the test specimen on which elongation is measured at any moment during the test [m]
• Original Gauge Length (L_0) - gauge length before application of load [m]
• Final Gauge Length (L_u) - gauge length after rupture of the test specimen [m]
• Elongation - increase in the original gauge length at the end of the test
• Stress (σ)- load at any moment during the test divided by the original cross-sectional area of the test specimen [Pa/ (N/m^2)]
• Strain- It is the ratio of change in length to the original length ($\boldsymbol{\varepsilon} = \Delta \boldsymbol{L}/\boldsymbol{L}$)
• Elastic Modulus-a measure of the stiffness of the material, but it only applies in the linear region of the stress – strain curve ($E = \boldsymbol{\sigma} / \varepsilon$) , [Pa]
• Yield Stress (σ_y)-when the material exhibits a yield phenomenon, a point is reached during the test at which plastic deformation occurs without any increase in the load [Pa/(N/m^2)]
• Ultimate Tensile Stress (σ_u)-the maximum load the specimen sustains during the test [Pa/ (N/m^2)]

During elastic deformation, the engineering stress-strain relationship follows the Hooke's Law and the slope of the curve indicates the modulus of elasticity or Young's modulus (E).

1.7 Experimental procedure

1- The specimens provided are made of material we needed. Measure and record specimen dimensions (diameter and gauge length) in a table provided for the calculation of the engineering stress and engineering strain. Marking the location of the gauge length along the parallel length of each specimen for subsequent observation of necking and strain measurement.

2- Fit the specimen on to the universal Testing Machine (UTM) and carry on testing. Record load and extension for the construction of stress- strain curve of each tested specimen.

3- Calculate Young's modulus, yield strength, ultimate tensile strength, fracture strain and % elongation of each specimen and record on the provided table.

4- Analyze the fracture surfaces of broken specimens and sketch and describe the results

5- Discuss the experimental results and give conclusions.

1.8 Discussion

1- From the given excel data, plot the stress –strain curve, then calculate the Young's Modulus for each specimen , the elongation at break, and discuss the results for the given samples.

2- Compare the Young's Modulus for each curve with the literature values.

3- Discuss any source of error in the experiment.

4- From Stress-Strain curves, what is a ductile material and a brittle material, discuss that