TENSILE TESTING OF METALS

Objective

The tensile test measures the resistance of a material to a static or slowly applied force. This laboratory experiment is designed to demonstrate the procedure used for obtaining mechanical properties as modulus of elasticity, yield strength, ultimate tensile strength (UTS), toughness, uniform elongation, elongation and reduction in area at rupture. Besides the true stress- true strain curve can also be determined with the help of the tensile test.

Introduction

In this test the load is applied along only one axis, and the rate of loading is constant. This test is done on a universal mechanical testing machine which is typically screw-driven or hydraulically powered. In some cases the machine may be computer controlled. The primary data generated are load vs. elongation which are to be converted into stress vs. strain data.

In modern tensile testers, load is measured using a load cell, in older or simpler testing machines, a purely mechanical or hydraulical device may be employed for measuring the load. Strain can be measured from the displacement of the crosshead or directly from the specimen. Typical devices for measuring strain are mechanical dial indicators, electrically-resistive strain gages attached to the specimen, or extensometers that employ either an optical device, a strain gage or an inductive or capacitive transducer. Strain transducers have the advantage that they measure only the displacement in the gage length of the specimen. This eliminates error due to the deformation in the ends of the specimen, slack in the load train, and the stiffness of the testing machine.

There are different types of specimen depending on the type of the grips and on the form of the available material (sheet, rod, etc.). Generally all specimens have two main parts, the gage section and the ends. The dimensions of the specimens are standardized (TS, DIN, ASTM etc.) A good surface finish is required so that surface flaws do not provide stress concentrations to cause premature failure.

Engineering stress $S = \frac{Load}{A_O}$ True stress $\sigma = \frac{Load}{A_i}$

Engineering strain $e = \frac{\Delta l}{l_o}$ True strain $\varepsilon = \ln (l/l_o)$

0.2% yield stress is the stress for 0.2% permanent strain

$TS = \frac{Load\ \max}{A_o}$ True fracture stress $\sigma_f = \frac{Load_f}{A_f}$

% elongation$= \frac{(l_f - l_o) \times 100}{l_o}$

% reduction in area$= \frac{(A_o - A_f) \times 100}{A_o}$

Procedure

A servo-hydraulic or servo-mechanical testing machine is used. The specimen of known dimensions are loaded in the machine and strained at a constant rate. The load is measured by a load cell. The crosshead movement and/or strain are recorded; for strain measurement an extensometer is used.

The X-Y plots are obtained. However the computer can also plot an engineering stress-strain curve directly, using the appropriate conversion factors and specimen area and gauge length. After the specimen is broken, the final length and diameter are measured. The fracture type and the fracture surface are investigated, in order to determine the fracture mode.

Results

1. Plot a load - elongation curve for each specimen.
2. Determine the engineering stress-strain curve and the true stress- true strain curve.
3. Determine the 0.2% yield stress, UTS, % elongation, % reduction in area, modulus of elasticity. Determine the mathematical expression for the true stress true strain curve for the second material.
4. Identify the fracture mode, i.e. ductile or brittle.
5. Find the mechanical properties of the tested material from Handbooks and make comparisons. Or if the material is not known try to guess it with the help of the mechanical properties.

Discussion

If the material is given compare your test results of strength and ductility with book values. Why is there a significant difference? Answer questions listed below.

Tensile Test Questions

1. Which modulus did you find from the initial portion of the stress-strain curve? If you not use an extensometer but determined strain from the crosshead movement, would the initial slope still allow you to determine an accurate modulus? Explain.
2. Write the definition using symbols for shear modulus, bulk modulus and Poisson's ratio. Write the equations relating these two modulus to Young's modulus.
3. What is the approximate value of Poisson's ratio for metals? What is the physical significance of Poisson's ratio, i.e. what does it represent resistance to?
4. What is the area under the stress-strain curve equivalent to? What does the area under the <u>elastic</u> portion of the stress-strain represent?
5. What % elongation and % reduction in area measures of?
6. Explain the different deformation mechanisms which are active in the different regions of the tensile stress-strain curve. (elastic, yielding, strain hardening, necking etc.)

References

1. Dieter, *Mechanical Metallurgy,* McGrawHill.
2. Dowling *E.D.,Mechanical Behavior of Materials,* Prentice-Hall.
3. Kayalı S, Ensari C. and .Dikey F., *Metalik Malzemelerin Mekanik Deneyleri,* İTÜ Yayını.

CHECKLIST FOR TENSILE REPORT

1. Neatness of bound report.
2. Organization of report in sections.
3. Introduction section.
    - . What mechanical properties can be determined in a tensile test.
    - . Why are tensile properties of materials important in engineering.
    - . What properties can be determined.
    - . What is the TS (Türk Standartları) standard number for this test.??
4. Experimental Procedure.
    - . Describe specimen. What measurements are made.
    - . What tensile machine is used.
    - . Brief detail of test, i.e. what did you do.
    - . Give details of the recording system for data. What data is produced.
    - . What measurements are made after the test
5. Data Analysis.
    - . Define all the properties you determined.
    - . Describe the program used for data analysis.
    - . Describe how you plot the engineering stress-strain curve.
    - . How did you find 0.2% yield stress, UTS, true fracture stress, % elongation, % reduction in area and other properties
    - . How did you determine the mathematical expression for the true stress - true strain curve.
6. Results
    - . Display measured values of specimens. List values of all the mechanical properties determined in the test with correct units.
    - . Show graphs of the stress strain curves. All axes identified with scales.
7. Discussion
    - . Compare alloys, which is strongest, highest ductility, etc... Compare your results with values from a reference.
    - . If your results are different, explain.
8. Conclusion
    - . A brief summary of what you accomplished.
9. References, tables and figures.
10. Appendix
    - . Original graph of load vs. strain correctly identified.