**NATURE AND PROPERTIES OF MATERIALS**

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**Lab Report ME-222**

**Experiment No. : 3**

**STUDIES OF YOUNG’S MODULUS WITH STRAIN GAUGE FOR STEEL AND ALUMINIUM**

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**AIM OF THE EXPERIMENT**

* Introduction to mechanical testing techniques
* Determination of mechanical properties of specific materials

**IMPORTANCE OF EXPERIMENT**

It is incumbent on engineers to understand how the various mechanical properties are measured and what these properties represent; they may be called upon to design structures/components using predetermined materials such that unacceptable levels of deformation and/or failure will not occur. In the processing/structure/properties/performance scheme, reasons for studying mechanical properties of metals are as follows:

Components made of steel alloys that are exposed to external stresses and forces must be processed so as to have appropriate levels of mechanical characteristics (i.e., stiffness, strength, ductility, and toughness).

Thus, it is essential that the designer or engineer understand the significance of these properties, and, in addition, develop a sense of perspective as to acceptable magnitudes of property values.

**INTRODUCTION (Important Terminology)**

* **Elastic deformation**. When the stress is removed, the material returns to the dimension it had before the load was applied. Valid for small strains (except the case of rubbers). Deformation is *reversible, non-permanent.*
* **Plastic deformation**. When the stress is removed, the material does not return to its previous dimension but there is a *permanent*, irreversible deformation. In tensile tests, if the deformation is *elastic*, the stress-strain relationship is called Hooke's law.
* **Yield Strength:** A value called "yield strength" of a material is defined as the stress applied to the material at which plastic deformation starts to occur while the material is loaded.
* **Modulus of Elasticity**: Rate of change of strain as a function of stress. The slope of the straight line portion of a stress-strain diagram.
* **Secant Modulus of Elasticity**: Ratio of stress to strain at any point on curve in a Stress-Strain Diagram. It is the slope of a line from the origin to any point on a stress-strain curve.
* **Tangent Modulus of Elasticity**: The instantaneous rate of change of stress as a function of strain. It is the slope at any point on a Stress-Strain Diagram.
* **Ultimate Tensile strength**. When stress continues in the plastic regime, the stress-strain passes through a maximum, called the*ultimate* *tensile strength*(UTS) , and then falls as the material starts to develop a *neck* and it finally breaks at the *fracture point* .
* **Ductility**. The ability to deform before braking. It is the opposite of **brittleness**. Ductility can be given either as percent maximum elongation max or maximum area reduction.
* **Modulus of Toughness** – measure of material resistance to failure in tension (MPa); total area under the stress – strain curve.
* **Modulus of Resilience** – measure of material resistance to plastic deformation (MPa); area under the stress – strain curve to the yield point

**THEORY**

A tensile test, also known as tension test, is probably the most fundamental type of mechanical test performed on material. Tensile tests are simple, relatively inexpensive, and fully standardized. By pulling on something, we can very quickly determine how the material will react to forces being applied in tension. As the material is being pulled, we find its strength along with how much it will elongate. As we continue to pull on the material until it breaks, we obtain a good, complete tensile profile. A curve will result showing how it reacted to the forces being applied. The point of failure is of much interest and is typically called its "Ultimate Strength" or UTS on the chart.

**Stress:**

*F/A* (N/m2)

where F = force (load) and A is the cross-sectional area (width \* thickness) of the gage section

Engineering Stress:

*F/A0* A0 = initial cross-sectional area

True stress:

*F/At* At = instantaneous cross-sectional area

**Strain:**

*L/L0* (dimensionless)

where ΔL is the elongation and Lo is the original gage length

**EXPERIMENTAL CONDITIONS**

Mode: Uniaxial tensile

Temperature: 25oC

Strain rate: 10 mm/min

**PROCEDURE**

* Analyse the surface of the sample carefully to detect any surface imperfections or marks formed due to machining
* Measure the dimensions of the mild steel and aluminium samples having no surface imperfections
* Set software parameters and then mount the mild steel/aluminium sample tightly in the sample holder.
* Switch on the tensile testing machine, observe the graph obtained.
* Repeat the same with all the 4 samples
* Mark carefully the points corresponding to the (i) yield points, (ii) maximum stress, (iii) fracture stress, (iV) plastic region, (v) elastic region, (vi) proportional limit, (vii) elastic limit, etc.
* Report the values of (i) Young’s modulus, (ii) modulus of elasticity, (iii)

secant modulus of elasticity, (iV) tangent modulus of elasticity, (v) modulus at 100% elongation, (vi) modulus at 200% elongation, (vii) stiffness, (viii) toughness, (iX) lower yield stress, (x) upper yield stress, (xi) tensile strength, (xii) fracture strength, (xiii) strain hardening exponent, (xiv) strain energy, (xv) strain rate, (xvi) % elongation, (xvii) % reduction in area, (xviii) % of error etc.

* Calculate the (i) engineering stress/extension ratio, (ii) true stress/ strain and (iii) true stress/extension ratio curves from the engineering stress/strain curve and draw it on the same figure as the engineering stress/strain curve.

**OBSERVATION TABLES AND GRAPHS**

SAMPLE SPECIFICATIONS

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Sample | Gauge Length  (mm) | Width (mm) | Thickness (mm) | Area (mm2) |
| MS1 | 71.48 | 12.40 | 2.96 | 36.68 |
| MS2 | 76.12 | 13.38 | 4.78 | 63.98 |
| AL1 | 87.66 | 15.32 | 3.50 | 53.74 |
| AL2 | 82.96 | 15.72 | 3.54 | 55.50 |

**Sample MS1**

**Standard force Vs Deformation**

**Sample MS2**

**Standard force Vs Deformation**

**Sample AL1**

**Standard force Vs Standard travel**

**Sample AL2**

**Standard force Vs Standard travel**

**Sample comparison**

**Comparison of Samples**

**Engineering Stress-Strain:**

**Sample MS1**

**Stress vs Strain**

**Sample MS2**

**Stress vs Strain**

**Sample AL1**

**Stress vs Strain**

**Sample AL2**

**Stress vs Strain**

**Formula Used:**

Modulus of elasticity = The slope of the straight line of a stress-strain diagram.

Resilience=Area of Stress Strain curve till Yield Point

Toughness=Total area of stress strain curve

**Calculation:**

**For MS1:**

Modulus of elasticity= (450-100) / [(0.001-0) \* 10-6]

=350GPa

Resilience= (summation up to straight line)

∑ [1/2\* (stress1+stress2) \* ABS(strain2-strain1)]

=1.90 MPa

Toughness=∑ [1/2\* (stress1+stress2) \* ABS(strain2-strain1)]

=30.04\*10-6 MPa

**Result:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Sample | Area(mm2) | Modulus of elasticity(GPa) | Resilience  (MPa) | Toughness  (MPa) |
| MS1 | 36.68 | 350 | 1.90 | 30.04 |
| MS2 | 63.98 | 560 | 4.32 | 35.60 |
| AL1 | 53.74 | 120 | 0.30 | 8.47 |
| AL2 | 55.50 | 142 | 0.24 | 6.98 |

**DISCUSSION**

In this experiment we learn about properties like yield strength, ultimate Tensile strength, young’s modulus, toughness, stiffness etc. we also observe that mild steel sample break from centre where as aluminium is from one end we can’t predict point of breakage by taking only area because of impurities and structure of material.

**CONCLUSION**

* In this experiment we measured yield strength, ultimate Tensile strength, young’s modulus, toughness, stiffness etc. of materials like rubber samples having different percentage of carbon.
* Samples with more carbon content are stronger and tougher

**PRECAUTIONS**

* Sample must be properly held in the holder so that it does not come out during the experiment
* Care should be taken and a safe distance should be maintained from them while handling the machine.
* Operate the machine carefully

**REFERENCES**

* Lab Manual , Kamal K Kar.
* Wikipedia.org
* William D. Callister, Jr., and David G. Rethwisch, Material Science and Engineering an Introduction, 8th Ed.