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Mechanical Traction Tests of Different Types of Materials "Steel-Copper-Brass-Aluminum"

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ABSTRACT

The strain test is a physics experiment to measure the degree of resistance to breaking of any material. The strain test used to characterize materials, regardless of the form of the requested object, or the performance of a mechanical assembly. In this article we have made tests or pulling experience for different types of materials such as steel; Copper; Brass and Aluminum. This test involves placing a small bar of material to be studied between the jaws of a strain testing machine which pulls on the bar until it breaks. It records the elongation and the applied force, which is then converted into deformation and stress.

Key Words: *Materials, Strain, Elongation, Stress, Deformation.*

1. INTRODUCTION

The resistance of materials is a science whose object is the study of the mechanical properties of solid materials developed by man using the theoretical principles of physics and mechanics of solids. Research in this area is mainly oriented towards industrial applications, such as new uses of plastics, ceramics and other non-metallic products in areas formerly reserved for metals.

Knowledge of the optical, electrical, chemical and mechanical properties of various materials allows researchers to choose the most adopted material for precise use. So you have to do some tests to study the behavior of materials. When a stress independent of time is applied, the behavior of the material at a given moment is studied. The constraints are then of different natures: traction, compression, torsion, bending and shearing.

Among all the mechanical tests, the tensile test is certainly the most fundamental test, it is used to determine the main mechanical characteristics such as the modulus of elasticity, the fish coefficient, the elastic limit, the resistance to rupture, elongation at rupture and the coefficient of necking. The objective of this work is to make known the operation of the tensile test for the different types of steel-copper-aluminum materials, to measure the elongation by the tensile machine and compared by the theoretical elongation to estimate the accuracy measurement.

2. THEORETICAL STUDY

The tensile test is an experiment to determine the strength characteristics of the test material. A part is subjected to traction or compression when it undergoes two equal and directly opposite forces on the neutral axis of the part. It involves placing a specimen of the material to be studied between the jaws of a traction machine that pulls on the material until it breaks. Force and elongation are recorded, which can be converted into stress strain.

This type of test is standardized by national or international regulations:

• Geometry of the specimens.
• Testing machine and their calibration.
• Experimental techniques implemented results tabulation and presentation.

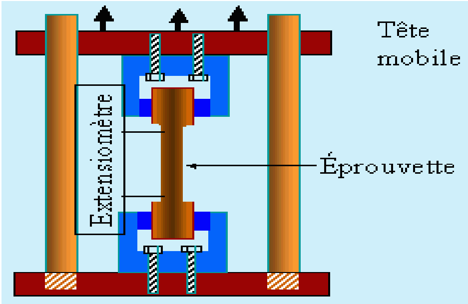

Figure.1.: Traction machine.

Gradually and gradually applied to a cylindrical or parallelepiped test piece (plane), increasing forces (a tensile force increasing whose intensity varies from 0 to F), which will gradually deform and then break.

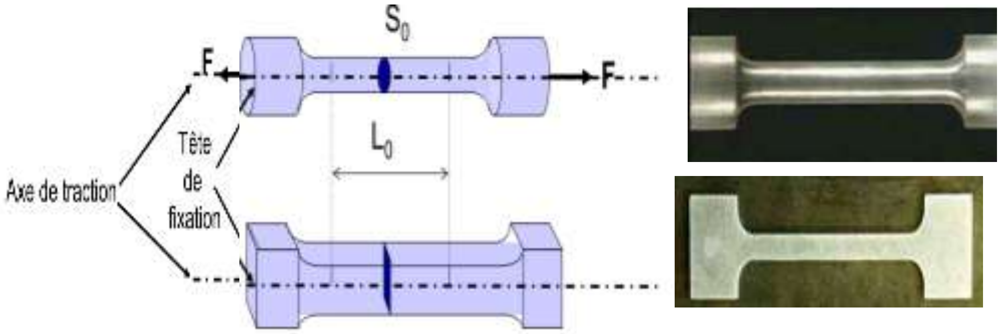

Figure.2.: Traction test tubes.

Figure.3: Striction and forms of test piece breaking.

The sample of initial length **Lo**, of section **S_0**, undergoes an increasing force until rupture. The graph reflects the relationship between the lengths of the specimen and **F/S**.

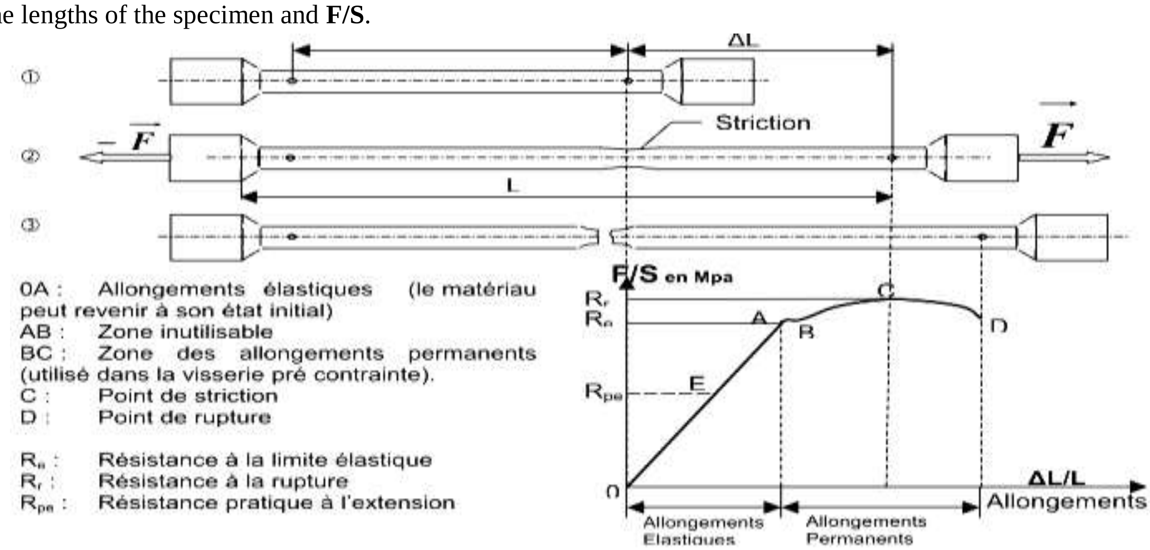

Figure.4.: Representation of the different elongations.

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2.1. Theoretical results of the test

With this test, the elongation graph is obtained as a function of the applied load:

Resistance elastic R_e: $R_e = \frac{F_e}{S_o}$ (1)

Tear resistant R_r : $R_r = \frac{F_r}{S_o}$ (2)

Coefficient of elongation **A%** and necking **Z%**: $A\% = \frac{Lu - Lo}{Lo} \times 100 \; Z\% = \frac{Su - So}{So} \times 100$ (3)

Relative elongation: $\varepsilon = \frac{\Delta L}{L_o}$ (4)

Poisson coefficient: For elastic materials, the decrease in straight sections is proportional to the relative elongation.

$\nu \frac{\Delta L}{Lo} = -\frac{\Delta d}{do}$ Noting $\frac{\Delta d}{do} = \varepsilon_y$ we obtain $\varepsilon_y = -\nu \varepsilon_x$. (5)

2.2. Stress

2.2.1 Normal stress and tangential stress

Is $(G, \vec{x}, \vec{y}, \vec{z})$ the local coordinate system assigned to the cut along the right section Σ of normal $\vec{x}$.

Let's project the constrained vector $\overrightarrow{C_{(M,\vec{x})}}$ in the reference $(G, \vec{x}, \vec{y}, \vec{z})$: $\overrightarrow{C_{(M,\vec{x})}} = \overrightarrow{\sigma_M} + \overrightarrow{\tau_M}$

$\overrightarrow{\sigma_M}$: Normal stress (projection of the constrained vector on the normal at the cutoff).

$\overrightarrow{\tau_M}$: Tangential stress (projection of the constrained vector in the plane).

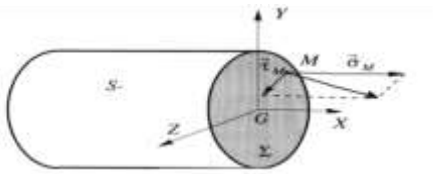

Figure.5. Representation of the normal and tangential stress of a beam.

2.2.2. Tensile stress

When a beam is stressed in tension the tangential stress $\overrightarrow{\tau_M}$ is zero and the normal stress $\overrightarrow{\sigma_M}$ is worth:

$$\sigma = \frac{F}{S} \quad (6)$$

Experience shows that there is proportionality in the elastic zone between the stress **σ** and the relative strain elongation **ε**. For a large number of materials (metals, etc.), the tensile test (shows that there is an elastic zone for which the tensile force F is proportional to the elongation **ΔL**, in other words, the ratio **F / ΔL**, is constant, analogy with a spring **(F = kx)** This property is enunciated by Hooke's Law:

$$\sigma = E * \varepsilon \quad (7)$$

2.3. Condition of resistance

For safety reasons related to the use of the device, the preceding constraint σ must remain below a permissible limit stress, called practical resistance to the extension $\mathbf{R_{pe}}$. This will be the case for all constructions of this type. The practical resistance $\mathbf{R_{pe}}$ is set by standards or by the manufacturer. In the general case, $\mathbf{R_{pe}}$, is defined starting from the elastic limit $\mathbf{R_e}$. During the whole duration of its service, a part must preserve an elastic behavior. This condition is expressed by the following inequality:

$$\sigma_{\max i} \le R_e \quad (8)$$

DOI : 10.31695/IJERAT.2019.3398

The problems of uncertainty on the value of $\mathbf{R_e}$, of the constraint, of the modeling of the study, leads us therefore to express the condition of resistance by:

$$\sigma_{\max i} \leq \frac{R_e}{s} = R_{pe} \tag{9}$$

2.4. Coefficient of concentration of stresses (K_t)

Most industrial parts are not cylindrical; they have singular shapes (holes, grooves, grooves, threads ...). We define a stress concentration coefficient called $\mathbf{K_t}$ such that the maximum stress has the value Equ.10, with the values of Kt being experimental.

$$\sigma_{\max i} = K_t . \sigma_{nom} \tag{10}$$

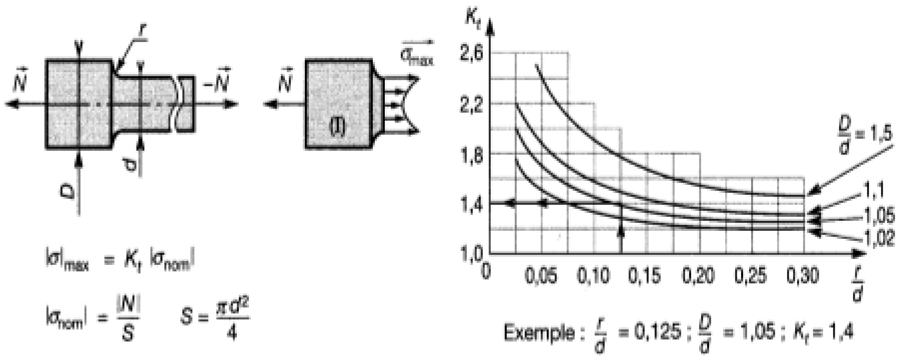

Figure.6. Diagram of stress concentration coefficient (K_t).

3. MATERIAL USES

3.1. Description Testing Machine Traction WP300

The WP300 universal material testing machine, this device for testing materials is a universal table machine designed for technical education. Its flexible structure makes it possible to perform a multitude of different tests involving traction or compression forces. Thanks to its simple and clear design, the device is perfect for student experiments and just as well for demonstration purposes. Its small size and relatively low weight allow its mobile use and its installation on standard laboratory tables.

3.2. Apparatus Basic

In its basic version, the device does not require any particular power supply. The test force is produced by a hand-operated hydraulic system and displayed on a large, easily read indicator needle.

The elongation of the samples is recorded by means of a mechanical dial indicator. The device can also be equipped with an electronic force measurement system so the displacement (elongation). All the accessory parts are screwed to the sleepers, which makes it possible to transform the test device easily and quickly for different tests.

Figure.7 Tensile testing machine WP300.

3.3. Samples Traction

DOI : 10.31695/IJERAT.2019.3398

The test specimen used for this test is round specimens with **M10** thread (fig.7), according to **DIN 50125** (German standard), aluminum, copper and steel. These different materials used are standard dimensioned parts intended to be subjected to a thermo-mechanical test, designed to know the behavior of a material when it is subjected to a stress such as traction, shear, compression, torsion, flexion, shock or creep.
The dimension of the tensile test pieces is:
L_0: initial effective length of the test piece equal to **30mm**;
D: initial diameter of the specimen equal to **6mm**;
A_0: initial section of the test piece equal to:

$$A_0 = \frac{\pi * D^2}{4} = \frac{\pi * 6^2}{4} = 28.27mm^2 \quad (11)$$

The tests are conducted on four different samples of aluminum, copper, brass and steel.

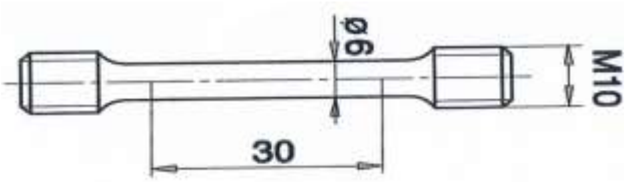

Figure.8 .Test tube used for tensile test.

4. BASIC PRINCIPLE OF THE TENSILE TEST

In the tensile test, a uniaxial tension state is produced in a sample of material. This state of tension is caused by an external load applied to the sample in the direction of the length by a tensile force fig.9. A homogeneous distribution of normal stresses prevails in the section of the sample.
The maximum test force applied in the circumstances determines the strength of the material. The property applied tensile strength **R_m** is calculated from the maximum test force **F_B** and the initial section **A_0** of the sample.

$$R_m = \frac{F_B}{A_0} \quad (12)$$

The maximum test force is best achieved with the accompanying needle on the force display. In the actual tensile test, the sample section is reduced, the sample shrinks, and the effective stresses are significantly higher. The elongation at break ***Δl_r*** relates the change in length of the sample to its initial length **L_0** and is calculated using the length **Lu** of the sample (Fig. 11) after breaking by the following:

$$\Delta l_r = \frac{L_U - L_0}{L_0} * 100 \quad (13)$$

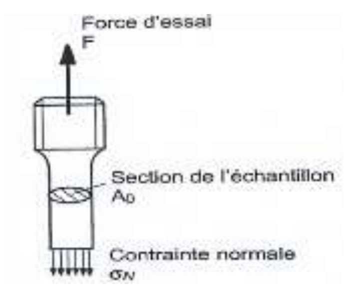

Figure.9.: stress in the sample.

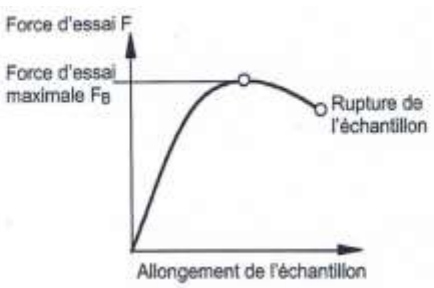

Figure.10.:Curve of force-lengthening.

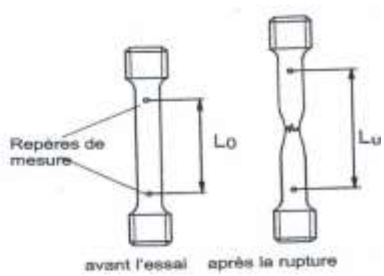

Figure.11.:The sample before and after the break.

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5. EXPERIMENTAL RESULTS

Tensile tests on specimens machined according to the standard of the universal tensile machine, four specimens of Steel, Copper (Bronze), Brass and Aluminum were made. According to the tests carried out one can summarize the results in the following tables:

Table.1. Measurement values and results.

N° of Sample	Material	Type of the alloy	Max test force F_B (KN)	Length after breakage Lu (mm)
1	Aluminum	AL MG SI 0.5 F22	6.7	35.20
2	Copper	E- CU	11.00	33.80
3	Brass	Cu Zn 39 Pb 3	14.45	33.40
4	Steel	9 S Mn 28	16.80	34.60

Table.2. Resistance values.

N° of Sample	Material	Type of the alloy	Tensile strength Rm (N/mm²)	Max deformation
1	Aluminum	AL MG SI 0.5 F22	237	0,062813
2	Copper	E- CU	389	0,013391
3	Brass	Cu Zn 39 Pb 3	511	0,096719
4	Steel	9 S Mn 28	594	0,022091

In Table 1, shows the measurement values of the four samples after the break are collected in the table. These measurement values make it easy to calculate tensile strength and elongation at break according to formulas 12 and 13. From Table.2, the values obtained during the test are real practical values for the four samples that show the tensile strength of the maximum applied force and the maximum elongation for each material.

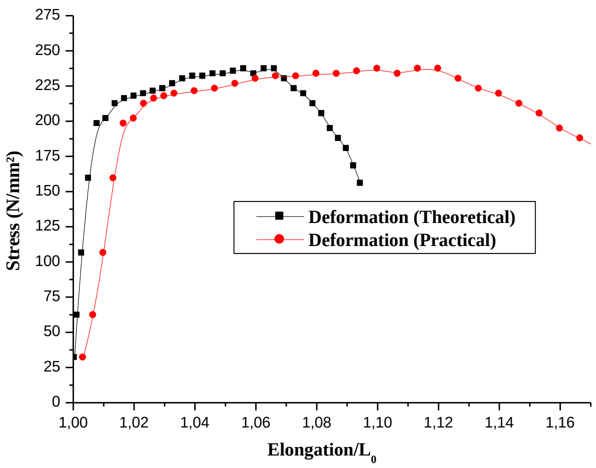

Figure.12.: Aluminum stress-strain.

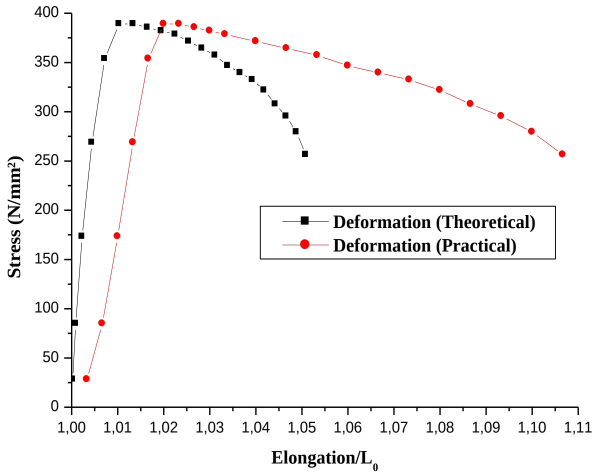

Figure.13. : Copper stress-strain.

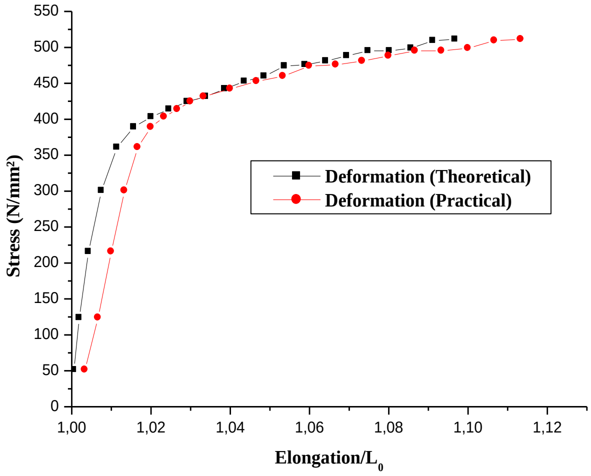

Figure.14. : Brass stress-strain.

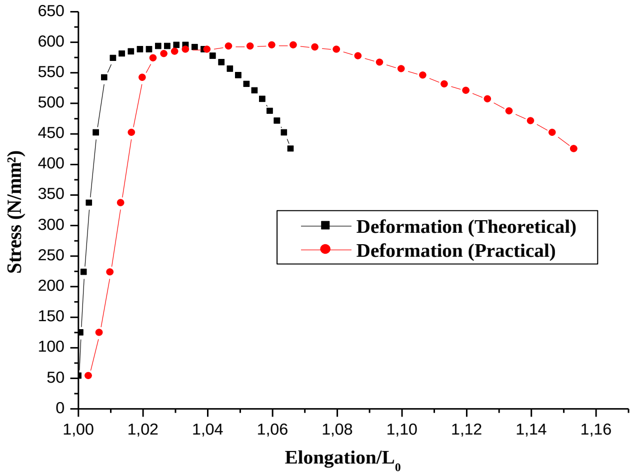

Figure.15. : Steel stress-strain.

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The tensile test was carried out including civil engineering and public works, according to these tests results were obtained and the stress-strain diagram was plotted for each material tested. The following may be adjusted to the following:

• Elongation ***Δl (Theoretical)*** <***Δl (Practical)***;

• The values of the modulus of elasticity are different such that ***E (Theoretical)*** >>> ***E (Practical)***;

• in Figures (12; 13; 14 and 15), which represents the behavior of material to be studied and it is clearly clear that it breaks down three intriguing deflating elastic parity, plastic parity and rupture for each material used as presented;

• Steel is more resistant than brass to tensile and the latter is stronger than copper, and copper is more resistant than aluminum to tensile, indicating the fragility of the material and the modulus of Young on the resistance of materials to the yard of traction. According to the results obtained by the tensile tests it can be said that the higher the modulus of elasticity and the higher the tensile strength.

6. CONCLUSION

The tensile tests are part of the methods of investigation of the mechanical properties of the materials. They are particularly interesting and allow a predictive approach of the behavior of the alloy in fraction. This test is the best known for material testing. It makes it possible to determine the tensile strength, one of the essential characteristic values of a material. The elongation at break also makes it possible to determine the tenacity of the material.

This work has allowed us to better know the tensile test for the different materials and the deformation operation, the elongation, the stresses, and we need to know them also of all the mechanical characteristics.

Whatever the results obtained in a manipulation they are not always like the theoretical results, because the phenomenon is in question consists in the reliability of material (comparator, ... etc), and maintenance has a very big role to play to solve all the problems in the apparatus, it is also concluded that the steel is stronger than the materials tested by the tensile test, which indicates the fragility of the material and the Young's modulus on the strength of the materials. According to the results obtained it can be said that the higher the modulus of elasticity and the higher the tensile strength and the theoretical curves are coincident with the experimental curves.

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