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Tensile testing of metal samples

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ABSTRACT

Metals and alloys are part of structural materials. The quality of finished structures depends on their strength, elasticity, plasticity and hardness. Therefore, there is a need to check the metal for tension. The article presents the experience of testing metal samples for tensile strength. Several samples from various metals were tested. During the study, the behavior of the sample was observed. The study establishes the following main strength characteristics of the material under study: tensile strength, yield strength, elongation. In practice, the strength properties were determined by the primary stretching curves in the coordinates "load-absolute elongation".

Key words: metal samples, stretching, elasticity, fluidity, plastic deformation.

1. INTRODUCTION

In most cases, the metal parts in the construction work under a lot of stress, static loads. Therefore, it is necessary to conduct static tests using different stress state schemes in the sample [1]. Any new material must be tested before it can be used [2]. Among the main types of static tests are:

- stretch;
- compression;
- bend;
- torsion.

The most common type of test for evaluating the mechanical properties of a metal is the uniaxial tensile test [3].

A tensile force is applied to the material. After that, the sample's reaction to the voltage is measured.

Tests are performed at a constant speed, and the load is measured using a load sensor [4]. This allows you to find out information about the temporary tensile resistance, conditional yield strength, elongation and relative contraction [5].

Tensile testing methods are standardized.

Most of the samples studied have heads of various configurations. In figure 1 (according To G. V. Klevtsov), the heads of various configurations for mounting in the grips are marked
[6].

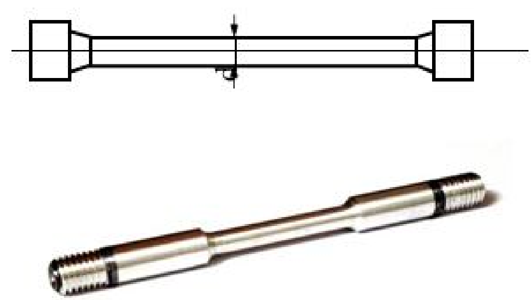

Figure 1: General view of tensile test specimens

When testing for tension, according to the provisions of GOST 1497, the metal resistance to small plastic deformations is characterized by a limit of proportionality, the limit of elasticity and fluidity, and the resistance to significant plastic deformations, which are expressed by a temporary resistance.

2. THEORETICAL FRAMEWORK

The mechanical properties of metal in tension are divided into two types:
- strength;
- plastic.

Strength properties are characterized by the resistance of the sample material to deformation or destruction.
To study the properties of a material, it is better to use a stretching diagram that establishes the relationship between normal stress and strain, notes A. H. Valiullin [6].

Plastic properties are determined by comparing the sizes of samples before deformation and after destruction.
For polycrystals of various metals, as G. V. Klevtsov notes, the entire variety of stretching curves is reduced to three types [6]. Figure 2 shows a brittle stretch.

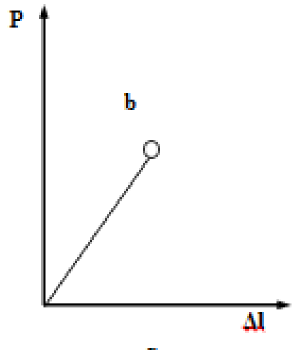

Figure 2: Brittle stretch

Figure 3 shows the failure after uniform deformation.

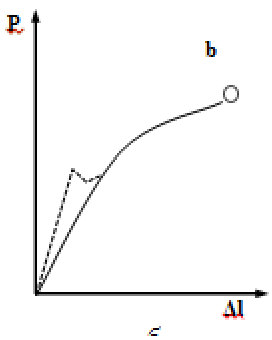

Figure 3: After the destruction of uniform deformation

Figure 4 shows the destruction after the formation of the neck.

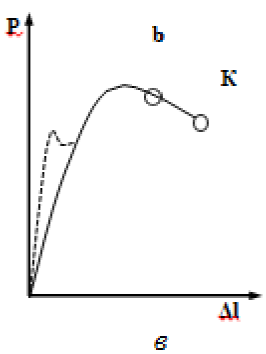

Figure 4: Destruction after the formation of the neck

Depending on the type of chart, the set of characteristics that can be calculated from it and their physical meaning changes.
The elastic limit is defined as the stress at which the residual elongation reaches 0.05% of the calculated sample length [7].
The physical yield point is the stress at which the sample deforms without appreciably increasing the load.
The conditional yield strength is the stress at which the residual elongation reaches 0.2% of the calculated sample length [8].

At the beginning of the test, when the sample is stretched, the deformation is reversible [9].
That is, if you stop stretching to a certain point, the sample under study will return to its previous state due to elastic deformation [10]. However, as soon as the stretching reaches the "point of no return", the metal can no longer elastically return to its original size.
Plastic deformation is irreversible [11].
During plastic deformation, the metal narrows and breaks in a specific place [12]. This often occurs at the Central point of the sample where the maximum volume load is observed [13].
The ultimate strength is the ratio of the maximum load (over the entire test period) to the initial cross-sectional area of the sample [14].
The elastic limit is a conditional stress that corresponds to the appearance of residual deformations of a certain specified value (0,05%; 0,001%; 0,003%; 0,005%).
The proportionality limit is a conditional stress that corresponds to deviations from the linear course of the deformation curve, which was set by a certain tolerance.
Note that the law of proportionality between stress and strain
Conditional break resistance is the ratio of the load at the time of failure to the initial cross-sectional area in the neck of the sample after the break.
The value of the proportionality limit is shown in figure 5.

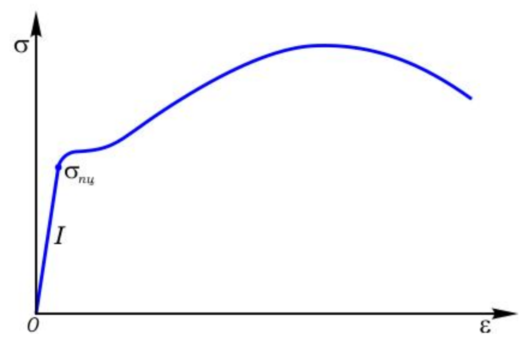

Figure 5: The value of the proportionality limit

The value of the conditional yield strength is shown in figure 6 (according to G. V. Klevtsov).
The yield strength value is influenced by various factors: sample thickness, heat treatment mode, presence of any impurities and alloying elements, microstructure and type of crystal lattice.

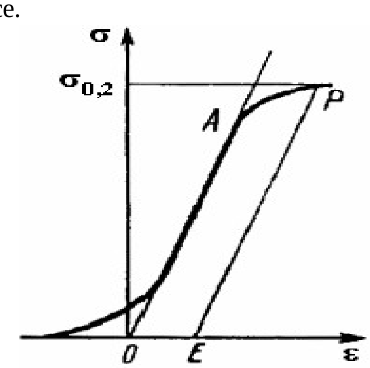

Figure 6: The value of the conditional yield strength

Cutting of blanks for samples is carried out on metal-cutting machines, scissors, stamps using oxygen and anodic-mechanical cutting, as well as other methods that provide allowances for the zone of metal with changed properties when heated and riveted [15]. When manufacturing, measures are applied that exclude the possibility of changing the properties of the metal when heated or riveted, which occur as a result of mechanical processing. The cutting depth at the last pass does not exceed 0.3 mm.

Sometimes the flow area is undulating. This applies primarily to plastic materials and is explained by the fact that first a local thinning of the section is formed, after which this thinning passes to the neighboring volume of the material and the process develops until a General uniform elongation occurs as a result of the propagation of such a wave, which corresponds to the flow area [16].

After the appearance of the yield point, the material acquires the ability to resist stretching and the diagram rises up.

The load for stretching the sample depends on its geometry.

For tensile testing, proportional cylindrical and flat samples with a diameter and thickness of 3.0 mm or more in the working part are used. The use of short samples is most preferable.

3. RESULTS AND DISCUSSION

The purpose of the study is to analyze metal samples during the stretching process.

The following tools were used to perform the work:
- breaking machine;
- calliper;
- measuring ruler;
- a set of steel samples.

Length of circular cross-section samples:
- short-4-5 diameters;
- normal-10 diameters.

Before the start of testing, the samples were measured in two mutually perpendicular directions in three places. The measurement accuracy is 0.5 mm. The width and thickness of flat samples were measured along the edges in the center of the measured plane. The cross-section area is determined with an accuracy of 0.5%. The accuracy of measuring the length of the sample is 0.1 mm.

Standard strength characteristics were calculated from the position of points on the tensile diagram in the form of conditional tensile stresses. In practice, the strength properties were determined by the primary stretching curves in the coordinates "load-absolute elongation".

During operation:
- the mechanical characteristics of the strength of the material were determined;
- the mechanical characteristics of the plasticity of the material are determined based on the results of measuring the size of samples before deformation and after destruction;
- the elastic modulus of the material is set.

To do this, the cross-section dimensions of the working part of the sample were measured: diameter, width and thickness.

Out of the three dimensions, the smallest dimensions were selected for calculating the cross-sectional area. The results of measurements and calculations were recorded in the test report.

The initial estimated length was marked on the surface of the sample. The sample was placed in the grips of the test machine. An extensometer was placed on the working part of the sample. A value was set for the speed of the moving traverse. With the help of a test machine, the sample was stretched until it broke. A "load – strain"stretching diagram was recorded.

The transverse dimensions of the samples were measured at the point of rupture.

For a cylindrical sample, the minimum diameter of the neck was set in two mutually perpendicular directions.

For a flat sample, the largest width and the smallest thickness in the middle part were measured at the break point.

The cross-sectional area in the neck was calculated from the measured cross-sectional dimensions of the sample at the site of the break.

Then the value of the calculated length of the sample after the break was determined. To do this, the parts of the folded sample along the neck were folded so that their axes formed a straight line. A caliper was used to measure the distance between the marks that limit the calculated length.

The tension diagram in the "stress – strain" coordinates was constructed by performing the following actions:
- the value of the proportionality limit was determined;
- the yield strength of the material is determined;
- the strength limit of the material is determined.

The tension diagram shows the relationship between the tensile load that acts on the sample and its deformation.

In the diagram, the load was recorded on the ordinate axis, and the absolute elongation of the sample was recorded on the abscissus axis. Figure 7 shows a sample diagram of a stretch diagram.

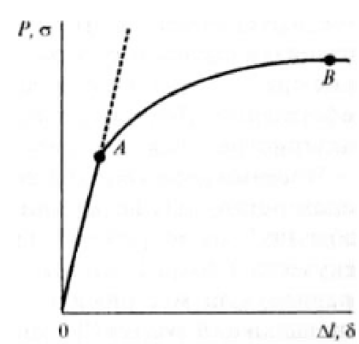

Figure 7: Diagram of the stretch diagram

The curve of change in absolute elongation depending on the applied tensile load consists of a straight section OA and a curved section AB, which corresponds to the transition to the area of plastic deformations. It is characterized by a gradual decrease in the tangent of the angle of inclination of the curve of the abscissus axis.

4. CONCLUSION

According to the results of measurement of metal samples before and after the study, the relative elongation and relative narrowing were revealed. A tension diagram was constructed in the "stress – strain" coordinates. The tensile test was determined by the resistance of the metal to small plastic deformations, characterized by the limit of proportionality, the limit of elasticity and fluidity. When stretched, the plasticity of the metal was determined – the amount of plastic deformation before destruction, which is estimated by the relative elongation of the sample and its narrowing.

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