About logarithmic deformation

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Abstract: As known, the conditional stress is determined by the ratio of the load to the size of the initial cross-section of the sample, and the relative elongation as the ratio of the increase in length to the graduated initial length of the sample. A conditional stress-strain diagram is a load-elongation diagram for a specimen whose cross-sectional area and length are equal to one.

Key words: voltage; logarithmic deformation; plasticity.

1. Introduction

Thus, for the most necessary and widespread processes in practice (metallurgy, machine-building), we have determined the true (logarithmic) relationship between stresses and plastic deformations. Let's use the appropriate formulas

Let's determine the relationship between the height of the slab's board obtained by the punch's action and the punch's diameter for a separate case. After that, let's consider calculating the work spent in the mentioned process and get the corresponding results in the form of an equation for calculating the work.

2. Let's consider the laboratory experiments on stretching.

Consider the true stress diagram, or logarithmic diagram, which gives a true picture of deformation. It represents the ratio of the load and the cross section at the current moment. That is, the ratio of two variables, this approach fully characterizes the plastic property of the test material. Let's follow the event. (Change in volume due to scarcity may not be considered).

$$XP = X_0 l_0 (1)$$

where $X -$ is the magnitude of the current cross-section of the sample; l- current length; i.e. X_0 და l_0 The sample is the initial settings. If Pwe denote the current load by and σ the true (logarithmic) voltage, then we get

$$P = \sigma \cdot X \quad (2)$$

$$That\ is\ \sigma = \frac{P}{X_0} \cdot \frac{l}{l_0} = \sigma_0 (1 + l) \quad (2)$$

where $\sigma_0 -$ Conditional stress: $l = \frac{l - l_0}{l_0}$ is the linear relative deformation of elongation, at the moment of maximum load $dp = 0$,(2) from this we get:

$$\sigma dX + X d\sigma = 0 (4)$$

Based on the incompressibility condition:

$$l dX + X dl = 0 (5)$$

(4) and *As a result of a simple mathematical operation using (5*), the true voltage is expressed as follows:

$$\frac{d\sigma}{d} = \frac{dl}{l} = d\varepsilon \quad (6)$$

From *(6) we can get the logarithmic deformation image:*

$$\varepsilon = \int_{l_0}^{l} \frac{dl}{l} = l_n \frac{l}{l_0} = l_n (1 + l) (7)$$

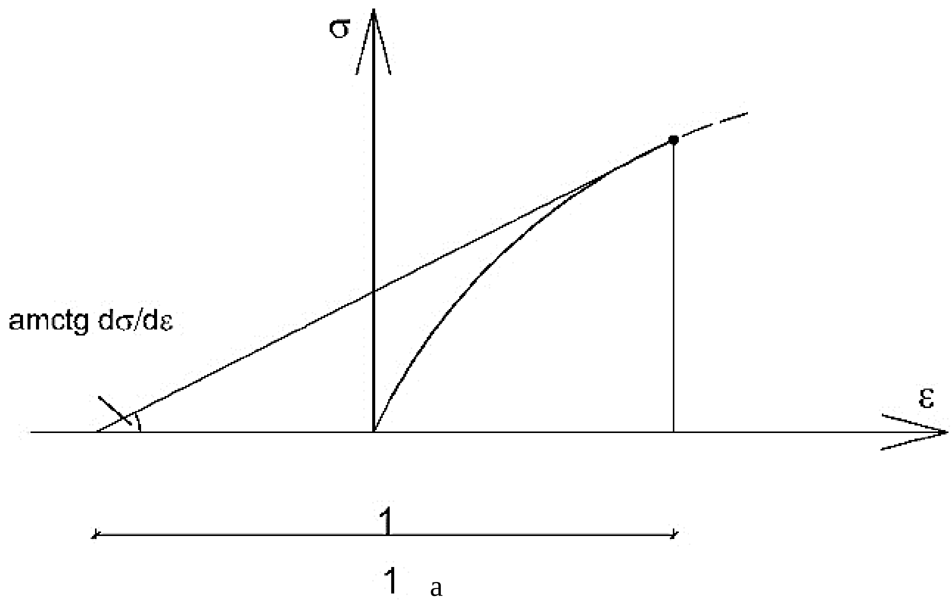
Maximum load moment

$$\frac{d\sigma}{d\varepsilon} = \frac{\sigma}{l}\ That\ is\ \frac{d\sigma}{dl} = \frac{\sigma}{(1+l)} = \sigma_0 \ (8)$$

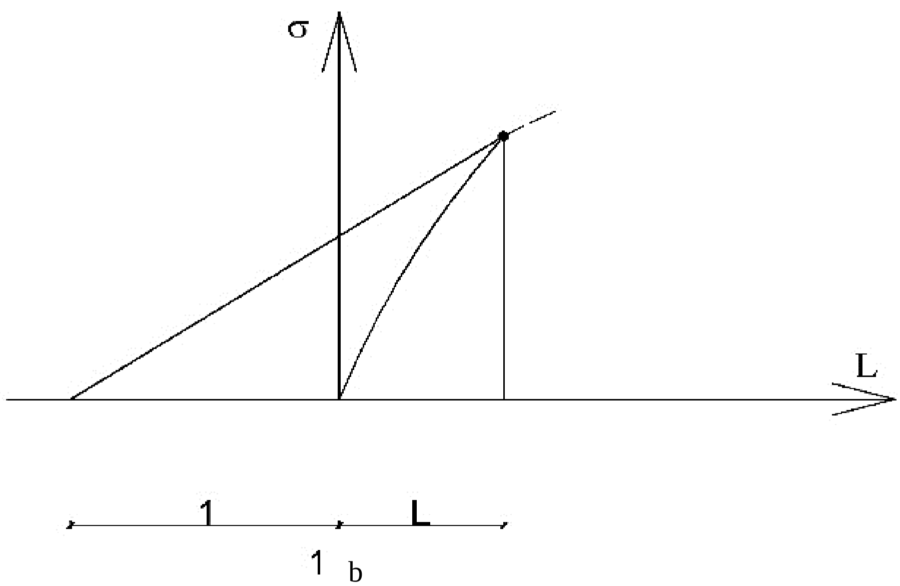
Now let's build the corresponding diagrams. Let's measure the true stress σ and logarithmic strain on the coordinate axis ε. As can be seen from diagrams (a) and (b), the true stress is defined as the tangent of the angle of inclination to the shoulder curve at the point in question. (figure a) similar to (figure b) for linear relative deformation (σ − ε).

Thus, Figures (a) and (b) show the true stress-strain curve in simple tension for determination at the point corresponding to the moment of necking on the specimen.

The use of logarithmic deformation in practice has two main advantages:



a



b

1. Unlike relative linear deformation, logarithmic deformation has the property of additivity, which follows from the definition of deformation itself. This property can be illustrated as follows. Let's take a sample whose graduation (working) working length is l_1, apply an axial load to it. Let's say the next mission of the deformation is the length l_2, then the deformation $\varepsilon_1 = l_n \frac{l_2}{l_1}$;if we continue the stretching process $l_2$from to $l_3$then the further deformation $\varepsilon_2 = l_n \frac{l_3}{l_2}$, and the total deformation

$$\varepsilon = l_n \frac{l_2}{l_1} + l_n \frac{l_3}{l_2} = l_n \frac{l_3}{l_1}$$

2. Experiments show that in the case of large plastic deformations, almost always following pressure treatment, the material can be considered as compressible. The condition of volume constancy will take the following form using relative linear deformations.

$(1 + l_1)(1 + l_2)(1 + l_3) = 1$(9)

Using logarithmic deformations (9) is simplified

$\varepsilon_1 + \varepsilon_2 + \varepsilon_3 = 0$*(10 a)*

Both of these images are fair for any deformations. At the same time, in the case of small deformations, which correspond to the elastic deformations of the metal, it is possible to ensure the product of deformations and (9) reaches the following form

$\varepsilon_1 + \varepsilon_2 + \varepsilon_3 = 0$*(10 b)*

In the cylindrical coordinate system (r, θ, z), expression (10a) will be replaced by (10g) .

$\varepsilon_\theta + \varepsilon_r + \varepsilon_z = 0$(10g)

where ε_θ- logarithmic tangential deformation;

ε_r- logarithmic radial deformation and $\varepsilon_r$algorithmic linear deformation. Multi-line tests have shown that the steel volume decreases by 0.6% and copper by 1.3% during stamping processing of metals. Fibrous materials e.g. Wood and cast iron gain their initial volume after unloading during compression.

Now let's consider an example that will serve as an illustration of the volume constancy condition (10a), the deformation will be Let's imagine a plastic plate of constant thickness (h_0) which is pierced at a slow rate without friction $2b_0$by a Poisson of diameter (Fig. 2) The tile of the current process will change shape and will take the form shown in (Fig. 2.). A, H is the height of the cylindrical hole obtained on the nose. Its thickness at distance z from the edge of the board is h. We assume that each element of the board is deformed by the main tensile stress. For a tile with $\frac{h_0}{b_0}$a small size, this assumption is as realistic as possible. We will write the condition

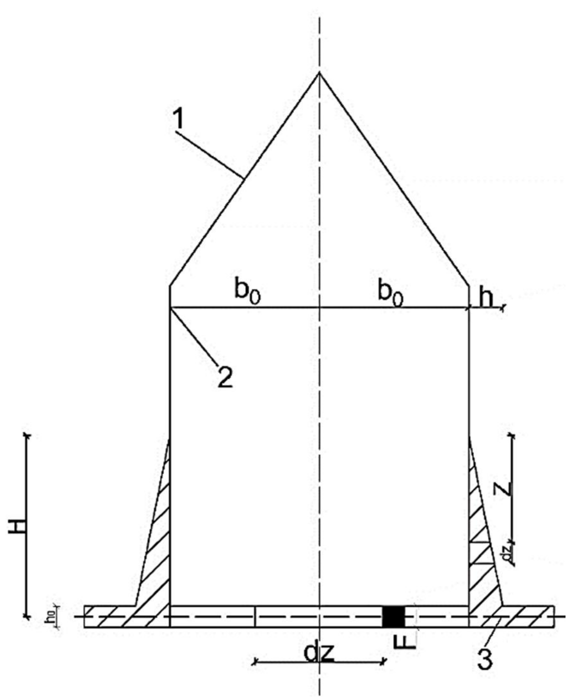


Fig. 2

of constancy of volume for each element.

$$2\pi s ds h_0 = 2\pi b_0 dz h \quad (11)$$

$$l_n \cdot \frac{b_0}{s} + l_n \cdot \frac{h_0}{h} + l_n \cdot \frac{dz}{ds} = 0$$

$$(10g)\ \varepsilon_r + \varepsilon_\theta + \varepsilon_z = 0$$

In this case, ε_r, ε_θ და $\varepsilon_z$the logarithmic deformations are in the radial, tangential, and along-board directions respectively, if the element is deformed only in the tangential direction, then the other two (radial and longitudinal) will be equal.

From (11) we get

$$\frac{s}{b_0} = \left(\frac{h}{h_0}\right)^2; h = h_0\sqrt{\frac{s}{b_0}} \quad (12)$$

otherwise$\frac{ds}{dz} = \sqrt{\frac{b_0}{s}}$;$\int_0^{b_0} \sqrt{s} \cdot ds = \int_0^H b_0\, dz$(13)

Hence: $\left[\frac{2}{3} s^{\frac{2}{3}}\right]_0^{b_0} = \sqrt{b_0}$H; $H = \frac{2}{3} b_0$(14)

Conclusion:

We have used the law of constancy of volume for one particular case, which is widespread in metallurgy and mechanical engineering. Determine the relationship between the board's height and the punch's diameter. Under the conditions of the development of plastic deformations, mainly tensile normal stresses. To present the issue, we considered a slightly different second problem, where a hole with a diameter a 0 ($b_0 > a_0$) is bored as a result of the frictionless impact of a punch with a cone of diameter b 0 and a $b_0 > a_0$slab of constant thickness. The resulting board height is H. Calculate this height based on previous experience. The procedure is the same as in the previous case, with the difference that S,a_0 და b_0The limits of the integrals of are such that the equality holds.

$$\int_{a_0}^{b_0} \sqrt{z} \cdot dz = \int_0^H \sqrt{b_0}\, dz \qquad (15)$$

Hence

$$\frac{2}{3}\left[b_0^{\frac{3}{2}} - a_0^{\frac{3}{2}}\right] = b_0^{\frac{1}{2}} * H \text{ ანუ } H = \frac{2}{3} b_0 \left[1 - \left(\frac{a_0}{b_0}\right)^{\frac{3}{2}}\right] \qquad (16)$$

and the thickness of the board$h_0 = \sqrt{\frac{a_0}{b_0}}$

Now let's find the work of plastic deformation if, $a_0 = 0$and the curve of steel reinforcement is expressed by the law $\sigma = y + p * \varepsilon$. Let's start with the fact that the product of the work done on the plastic deformation of the plate dw, which is spent on the formation of the board, is equal to the product of the volume of the element, which is spent on the plastic deformation of the unit volume on the elongation of the element in the process of simple stretching. i.e. on the $dw = 2\pi s h_0 ds \sigma ds$change of σlogarithmic εstrain $\varepsilon$from$\varepsilon + d\varepsilon$

$$w = 2\pi s h_0 ds \int_0^{\varepsilon} \sigma * ds \quad (17)$$

because $\sigma = y + p * \varepsilon$where y- yield stress and p - modulus of plasticity. The work done on the plastic deformation of the unit volume considering simple stretching is defined as follows

$$\int_0^{\varepsilon} \sigma d\varepsilon = y * \varepsilon + p\frac{\varepsilon^2}{2} \qquad (18)$$

respectively for the entire tile

$$w = \int_0^b 2\pi h_0 \left[y l_n \frac{b_0}{s} + \frac{p}{2}\left(l_n \frac{b_0}{s}\right)^2\right] s * ds \quad (19)$$

But because $s = l_n \frac{b_0}{s}$that's why the final image of the work will be:

$$w = \frac{\pi b_0^2 h_0 y}{2}\left(1 + \frac{p}{2y}\right) \quad (20)$$

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