I INTERNATIONAL CONFERENCE
KRASNOYARSK, RUSSIA
30 July 2020

CAMSTECH
International Conference on Advances in Material Science and Technology

Science and Technology City Hall
KRASNOYARSK, RUSSIA

«International Conference on Advances in Material Science and Technology - CAMSTech-2020»

«Features of the effects of oriented plastic deformation in rectangular bars»

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Problem statement

- The plastic process is the same size and sign of deformation of each element of the section-stretching or compression. The effect remaining after unloading is mainly reduced to changes in elastic resistance thresholds and, in particular, to the so-called deformation hardening. If the plastic process causes uneven deformation of different sections of the cross-section (bending, torsion, drawing), then in addition to changing the elastic resistance thresholds, residual stresses occur in the products.
- The effect of changes in elastic resistance thresholds is that in cases when products are subjected to loads in the same directions as previous plastic deformations, the elastic resistance boundaries expand. In opposite directions, the borders are narrowed due to the Bauschinger effect.
- Thus, it is necessary to speak with some caution about the hardening caused by plastic deforation, keeping in mind the role of directions.
- The ambiguity of results in predicting strength is caused not only by changes in directions. No less important is the size of deformations. It is known that every plastic process causes different deformations of structural elements (blocks, grains, crystals). This is explained by their arbitrary orientation in relation to the influencing forces, and consequently, the presence of various reserves for safe actions.
- Some elements of structures exhaust reserves in the initial stages of loading, causing early appearance of foci of destruction. With increasing deformities, the number of foci increases and can reach dangerous development.

Solution methods

- Since, along with the subtraction of stresses near the surface, they are summed for points in the depth of the section, the overall picture of stress ratios in different zones becomes much more complex than is often recognized. Therefore, the idea of the greatest tension of the surface layers of curved and twisted rods cannot be automatically transferred to products that have undergone preliminary plastic deformations. Here we should also mention an important condition for the feasibility of the predicted results. If the effects of the plastic process are determined for the specified or found values of deformation, then in subsequent loads such deformations should not be exceeded.
- This is due to the inevitable redistribution of stresses during increased deformation, as a result of which new parameters of the plastic process can only be determined from repeated calculations. The same category of restrictions should include temperature effects that lead to decreases in the potentials of the accumulated strain energy, and therefore to redistributions of residual stresses in cross sections.
- The construction of common analytical dependencies for calculating various elements of strength calculations is in many ways similar to the corresponding dependencies for the elastic region. In calculation systems, stresses or deformations are used as arguments, and the dependencies themselves include material constants and cross-section dimensions in addition to arguments.
- If we assume that strength calculations can be justified only at such values of deformations that do not lose the stability of the materials1, then it is possible to significantly simplify the calculation formulas for one-dimensional problems and at the same time give them a greater generality.
- Simplification can be achieved if all parameters, including elastic constants, whose numerical values do not change with the development of plastic deformation within the boundaries of the stability of materials, can be compiled into independent constant complexes that determine the dimensions of the calculated values and their absolute values under extreme elastic loading.

Conclusions

Results, implementation

Considering the question of the limits of practical applicability of the inferred dependencies, it should be emphasized that, since they must take into account changes in elastic resistance thresholds, therefore, the deformations within which such changes are observed serve as a physical constraint.

For structural elements of machines and devices, deformations near the boundary of neck formation are not allowed, therefore, the applicability of formulas beyond this limit is completely excluded.

The numerical values of allowable deformations at the limit, of course, must be different, since different materials at the time of formation of the necks or at the time of the appearance of other signs characterizing the beginning of the buckling of materials able to undergo uneven deformation, which are called uniform.

For softer materials, in particular austenitic steels and aluminum alloys, uniform deformations can reach tens of percent, so all formulas cannot meet narrow restrictions.

For harder or high-strength steel grades, the elastic modulus values, on the contrary, can be limited to fractions of one percent, and therefore the limits of applicability of all formulas should be relatively small allowable deformations.

Therefore, the restrictions imposed are related to the features of the loading curves, so they are easily established in each case from the information about the properties of materials.

Thus, this paper does not consider the issues of plastic flow and therefore excludes the extension of formulas to such technological processes as bending, stamping, landing and other operations, the purpose of which is to change shapes, and the means, in particular, is bending, performed, however, far beyond the limits of uniform deformations.

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