Tensile stress variation due to stepwise increase of cyclic torsion amplitude

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ABSTRACT

In order to elaborate more efficient technological processes enabling a lifetime prolongation of some elements of devices and machines a lot of scientific efforts are focused on searching of the optimal loading combinations. As it has been found by Korbel and Bochniak [1, 2], a significant reduction of tensile or compressive forces in technological processes is possible using twisting moment simultaneously applied. They proposed the so-called KOBO method and successfully applied it to extrusion, forging or rolling processes. Up to now the method was checked for large deformations, what required a lot of energy. Since the available results of the method validation in the range of small deformations are not sufficiently represented, an experimental programme limiting maximal strain level below 1% (Fig. 1) was elaborated. The strain controlled loading programme enables observation of stress/strain components variation as a function of time (Figs 1 and 2).

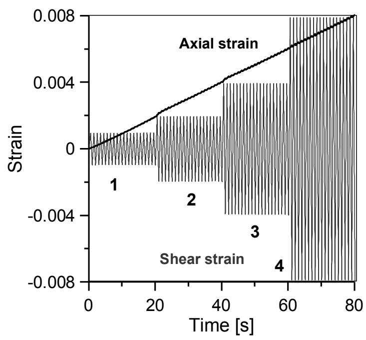

Figure 1. Loading programme. Numbers denote amplitudes of cyclic shear strain: (1) ±0.1%, (2) ±0.2%, (3) ±0.4%, (4) ±0.8%.

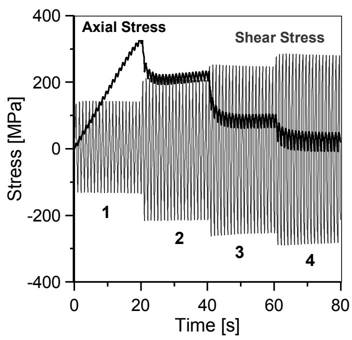

Figure 2. Variations of axial and shear stress components as a function of time.

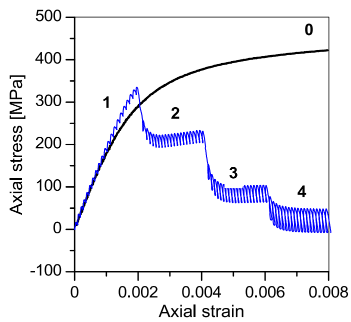

Figure 3. Comparison of tensile curves determined without (0) and with (1, 2, 3, 4) assistance of torsion cycles.

The loading programme (for the 10H2M steel) contained four subsequent blocks of cyclic shear deformation assisted by tension. As it is illustrated in Fig. 2, the axial stress increases at the beginning of the test (first cyclic strain amplitude). However, for higher cyclic strain amplitudes, its lowering is clearly manifested. Figure 3 shows comparison of tensile characteristics in the case of activated and inactivated torsion cycles. It is seen, that while the torsion cycles were applied a gradual decrease of axial stress can be observed. The maximum drop of it was almost equal to 400 MPa for the highest cyclic strain amplitude used in the programme. The effect of similar order was also achieved for this material tested under monotonic tension and torsion-reverse-torsion cycles of constant strain amplitude (0.8%), Fig. 4. It means that prior cyclic loading history does not influence a magnitude of the tensile stress drop. A reduction of axial stress due to application of cyclic loading by means of reversible torsion was also observed for other materials, i.e. the P91 steel and M1E copper (Fig. 5) [3].

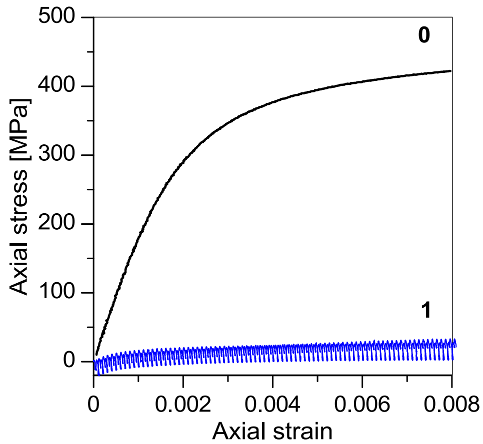

Figure 4. Comparison of tensile characteristics:
(0) - curve from standard tensile test;
(1) - curve obtained in assistance of torsion cycles for the strain amplitude of ±0.8%.

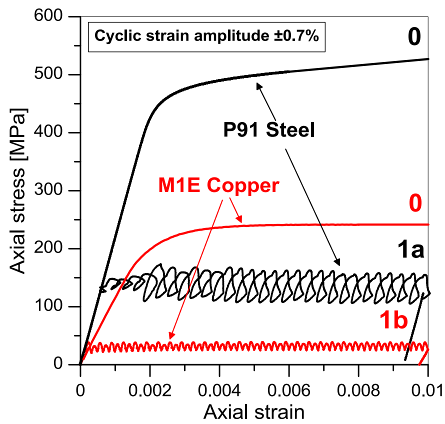

Figure 5. Variation of tensile curves, obtained without (0) and with assistance (1a, 1b) of cyclic torsion for the strain amplitude of ±0.7%.

References

[1] A. Korbel, L. Szyndler, The new solutions in the domain of metal forming – contribution of the Polish engineering idea, Met. Form., 21, 3: 203–216, 2010.

[2] W. Bochniak, A. Brzostowicz, Fabrication of fine-grained flat products by continuous KoBo methods, Arch. Metall. Mater., 55, 2: 587–600, 2010.

[3] Z.L. Kowalewski, T. Szymczak, Modification of simple deformation processes of metallic materials by means of cyclic loading, Mater. Res. Innov., 2011, 15, 1, 73–76.