AN INFLUENCE OF CYCLIC TORSION PARAMETERS ON TENSILE CHARACTERISTIC VARIATION

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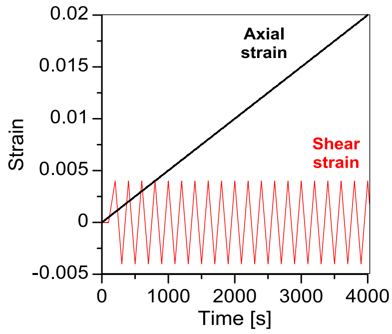
1. Introduction

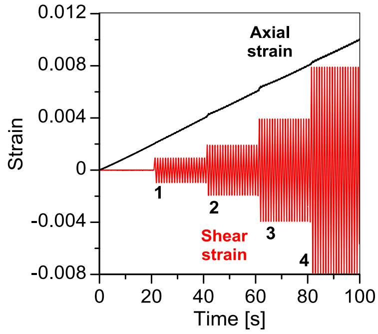
Investigations of various materials under biaxial stress state have recently attracted an interest of either scientific or engineering communities [1-5]. The reasons of that result from: progress in new materials technology, development of numerical methods, improvement of metal forming processes and application of experimental solutions for precise determination of the engineering elements lifetime. Among many metal forming techniques one test can distinguished the KOBO method [3] as that giving a chance to prolong working period of some responsible elements due to an essential reduction of acting forces. For example, the method was successfully used in forging of bevel gears manufactured from structural steel [3]. In this case more than a fourfold reduction of the forging force was achieved in comparison with the force required using the conventional method. Cyclic rotation was also used to modify the extrusion process of lead bars [5]. The average load under these conditions was also significantly reduced, up to 25%, in comparison to the simple extrusion process with no die rotation. This feature plays a great role in modifications of technological processes, but does not result significantly on variations of the stress-strain relationship that are negligible in terms of modelling of material behaviour. Therefore, the main part of the paper is focused on investigating of an influence of torsion cycles parameters, such as: strain amplitude and frequency, on the tensile curve being determined simultaneously.

2. Material and test details

The 13HMF steel (notation according to Polish Standards), widely used in the power engineering industry has been chosen for investigations. The conventional mechanical parameters of this steel in the as-received state, such as: Young's modulus (E=199GPa), proportional limit ($R_{0.05}$=482MPa), yield point ($R_{0.2}$=523MPa) and ultimate tensile strength (R_m=653MPa) were determined on the basis of the standard tension test results.



(a)



(b)

Fig. 1: Loading programme consisting of monotonic tension and torsion-reverse-torsion cycles: (a) constant strain amplitude ±0.4%; (b) variable strain amplitude: (1) ±0.1%, (2) ±0.2%, (3) ±0.4%, (4) ±0.8%

The loading programme was controlled by two signals, i.e. axial strain monotonically increased, and shear strain varying cyclically at constant (Fig. 1a) or variable amplitude (four blocks of cycles, Fig. 1b). In the case of torsion cycles with the step increasing strain amplitude a frequency was constant (1Hz), while an amplitude varied from ±0.1% to ±0.8% Fig. 1b. In the second part of the programme the frequency varied from 0.005Hz to 0.5Hz while the amplitude kept constant value equal to ±0.4%, Fig. 1a.

3. Experimental results and discussion

An analysis of data for loading path shown in Fig. 1b, exhibited a gradual decrease of axial stress with the increase of cyclic shear strain amplitude, Fig. 2. The effect was very strong and dependent on the amplitude of torsion cycles. In the case of the highest cyclic strain amplitude applied the axial stress reduction, measured with respect to the tensile characteristic (0) obtained without the torsion cycles assistance, achieved almost the level of 600MPa (stage 4).

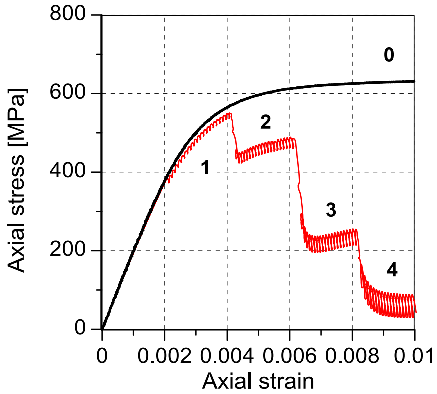


Fig. 2: Comparison of the standard tensile characteristic (0) to the axial stress responses into the loading path shown in Fig. 1b

The loading programme in Fig. 1a also influenced the axial stress, Fig. 3, however a reduction of the tensile stress was not so large as that during the loading containing the step increasing cyclic strain amplitude, Fig. 2. A drop of the tensile stress became greater with an increase of the frequency. It was equal to 500MPa for the highest frequency considered.

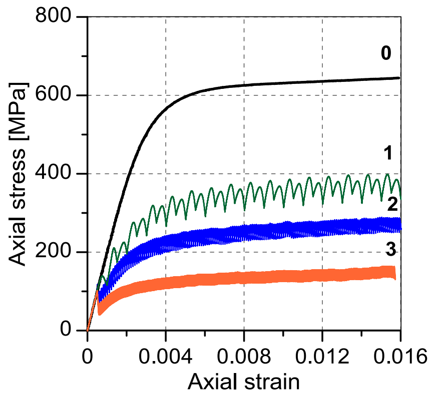


Fig. 3: Effect of cyclic torsion frequency on the tensile characteristic (0). Numbers denote frequency magnitude: 1-0.005Hz, 2-0.05Hz, 3-0.5Hz

An analysis of data shown in Figs. 2, 3 enables to observe a greater stress sensitivity of the material into the strain amplitude variations than those caused by the frequency within the range of values considered in the programme. It indicates that the cyclic strain amplitude may change acting forces in technological processes more effectively than the frequency variation does.

4. Remarks

- The torsion–reverse–torsion cycles conducted in the perpendicular direction with respect to the simultaneous monotonic tension lead to an essential axial force reduction independently of the values of strain amplitude and frequency.
- The loading path containing torsion cycles with step increasing strain amplitude can be treated as the effective solution for a quick determination of an optimal value of cyclic strain amplitude for significant reduction of forces taking place during selected metal forming processes.

5. Acknowledgements

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6. References

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