STRESS RELAXATION IN STEEL SUBJECTED TO TENSION-TORSION DEFORMATION

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1. Introduction

An influence of stress on behaviour of engineering constructions depends on relationship between its level and mechanical parameters. When the stress level exceeds the yield point or ultimate tensile stress, then plastic deformation or fracture occurs, respectively. In order to avoid unexpected fracture, a lot of efforts have been done by engineers for careful analysis of stress and its variations due to application of different loading conditions. Such approach enables comparison of mechanical properties considered as a function of stress type and its level. On the other hand, by taking into account operating conditions of various joints one can indicate a controlling of the preloading level as an important issue. Usually, such analysis is carrying out on the basis of stress history evaluation at various time intervals. This enables identification of the exploitation period for which a stress level becomes to be behind admissible limits. In order to predict such situations accurately, a level of relaxation stress should be evaluated. An interesting study concerning the stress relaxation has been performed on the aerospace super alloys [1].

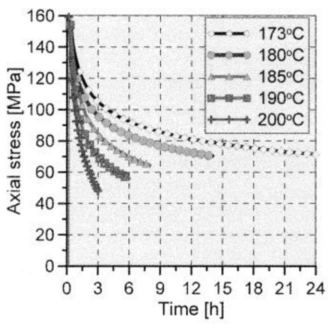

Fig. 1. An influence of temperature on the stress relaxation of the 2XU super alloy [2]

The creep-relaxation behaviour has been compared for three aluminium alloys that have potential for age-forming aerospace components requiring adequate damage properties. It has been shown that the 2XU alloy has the greatest capacity for stress relaxation. It exhibited 30% stress reduction due to 15% increase of temperature. The relaxation behaviour was also tested on the low-alloy 2 ¼ Cr-1 Mo steel, that is extensively used in the steam power industry [2]. Multiple-loading relaxation results were achieved for times to 100 h and for temperatures in the range 450 to 566°C. It was shown that at 510°C and above the plastic flow stress partially recovers during the relaxation process.

In this paper the problem of stress relaxation is considered in the case of complex stress state being combination of constant tension and cyclic torsion. It is shown how the tensile stress under fixed constant strain can be reduced when the torsion cycles are superimposed.

2. Test procedure

All tests were carried out at room temperature on thin-walled tubular specimens (Fig. 2) using servo-hydraulic testing machine. The experimental programme contains two parts. In the first one an influence of a shear strain amplitude of ±0.2, 0.4, 0.8% on the axial stress variations was investigated, Fig. 3. In the second one an influence of frequency (0.005÷0.5Hz) of shear cycles on the axial stress was evaluated under constant shear strain amplitude equal to ±0.2%.

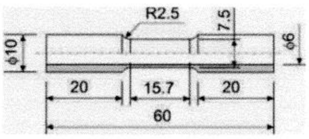

Fig. 2. Thin-walled tubular specimen

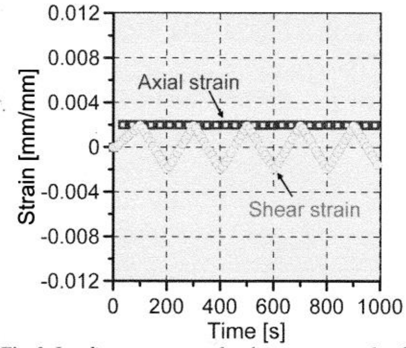

Fig. 3. Loading programme for shear strain amplitude: ±0.2%; frequency 0.005Hz

3. Results and analysis

The results expressing an influence of selected parameters of torsion cycles on the axial stress are illustrated Figs 4 and 5. A reduction of the axial stress due to cyclic torsion can be clearly observed in Fig. 5. The effect becomes to be stronger for higher amounts of the torsion cycles strain amplitude. For the highest strain amplitude considered in this research the axial stress was reduced from 350 MPa to the value lower than 50 MPa. It has to be mentioned, that some local extremes in axial stress signal were obtained. They can be attributed to the variations of cyclic strain signal, i.e. they occur when the strain control signal changes the sign.

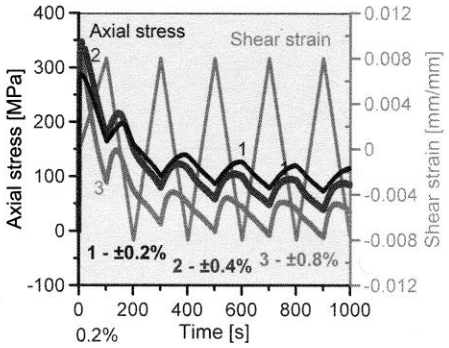

Fig. 4. Variations of axial stress versus time due to shear strain amplitude

An influence of the torsion cycles frequency on the material behaviour in the tensile direction can be evaluated on the basis of diagram shown in Fig. 5. As it is seen, the frequency of cyclic torsion also may have effect on tensile force. One can indicate an essential lowering the axial stress, however, a variation of the frequency of torsion cycles within the range taken into account here did not change the stress significantly. Only, a slight stress decrease was observed with the frequency increase.

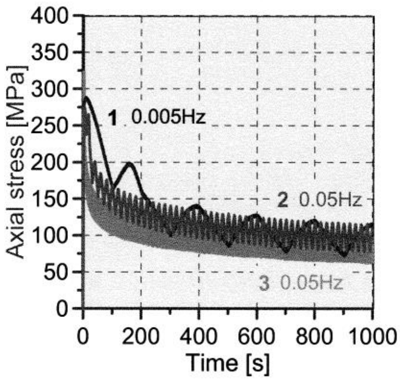

Fig. 5. Variations of axial stress versus time due to shear strain frequency

4. Summary

Assistance of torsion cycles during strain controlled tension keeping constant strain led to the relaxation of axial stress. This effect was dependent on the parameters of the cyclic shear strain. For the higher cyclic torsion strain amplitude the relaxation of axial stress became more significant. In comparison to the stress value at the beginning of test the axial stress reduction was almost equal to 95% for the largest strain amplitude applied. An increase of the frequency from 0.005 to 0.5Hz did not introduce significant difference of the axial stress level.

References

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[2] R.W. Swindeman, R.L. Klueh: Relaxation behaviour of 2 ¼ Cr-1 Mo steel under multiple loading. OAK Ridge National Laboratory, 1977.