STRUCTURAL AND MECHANICAL PROPERTIES ESTIMATED BY MEANS OF ULTRASONIC TECHNIQUE

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1. Introduction

Evaluation of structural degradation and mechanical properties still seems to be an attractive direction of investigations due to unsolved problems related to safety of different construction elements, installations or machine devices. Among many non-destructive techniques of damage assessments the ultrasonic method is used at different branches of industry. However, it has to be mentioned, that the conventional ultrasonic parameters (e.g. attenuation coefficient, wave velocity) suffer on some limits in application. The attenuation coefficient allows to detect material damage in a late creep stage when voids are created [1] and its application in industrial conditions is difficult due to surface roughness and local material heterogeneity. In the case of wave velocity, in addition to the above mentioned factors also the non-uniform thickness of elements tested may disturb its measurements. Taking into account these facts, the acoustic birefringence was proposed [2] as the alternative ultrasonic parameter enabling assessments of structural degradation. Its measurement is based on the wave velocity difference between two shear waves polarized in the mutually perpendicular directions [1]. Variations of the acoustic birefringence coefficient are attributed to the material texture (preferred grain orientation) and even small, oriented voids resulted from creep [3]. According to previous investigations [2, 3] the acoustic birefringence seems to be more sensitive to damage development than the attenuation coefficient and wave velocity. Among advantages in measurements of this parameter one can indicate a high speed, low price and simplicity in use at the industrial conditions. It can be measured on unknown thickness elements, its value is temperature independent, and measurements can be made with a single shear SH wave transducer.

2. Experimental procedure

The specimens manufactured from power engineering steels were subjected to creep under tensile conditions. The creep tests were interrupted for a range of the selected time periods in order to achieve specimens with an increasing level of strain. After each loading process the specimens were tested using ultrasonic technique and then the qualitative observations and quantitative metallographic assessment of specimens were carried out by means of light microscope (Olympus PMG3) coupled on-line with image analyser (CLEMEX), (Fig. 1a,b). The quantitative image analysis was carried out at the same areas (6,11 mm^2) of each specimen; close to the fracture (about 0-1mm) and far away from it up to several millimetres using systematic area scanning. The measurements were interrupted when the differences between successive quantitative results were not observed. The observations of fractures by means of scanning electron microscopy (SEM - JEOL 6360 LA) were also carried out.

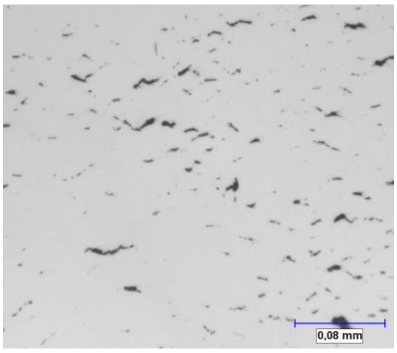

Fig. 1a. Specimen prestrained up to ε = 6,51%, non-etched state, conventional light, magn. 200×.

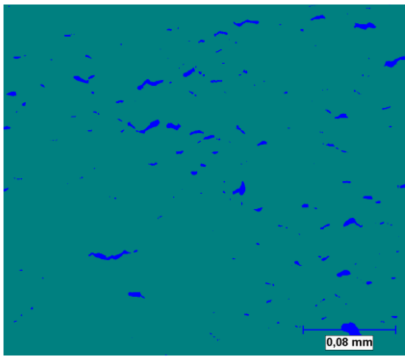

Fig. 1b. The same image, prepared to quantitative analysis.

3. Results

The representative results for the 40HNMA are presented in Figs. 2-3.

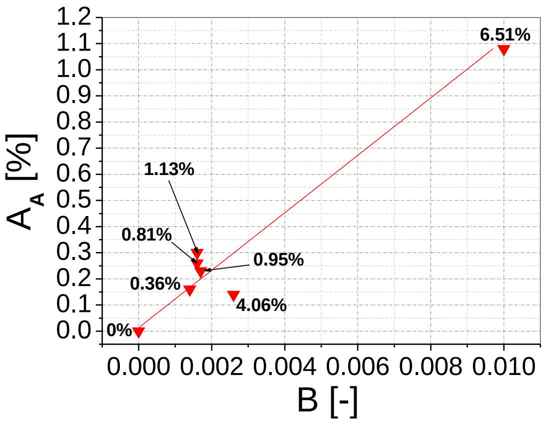

Fig. 2. Relationships between volume fraction of voids from area about 1mm from the fracture and acoustic birefringence.

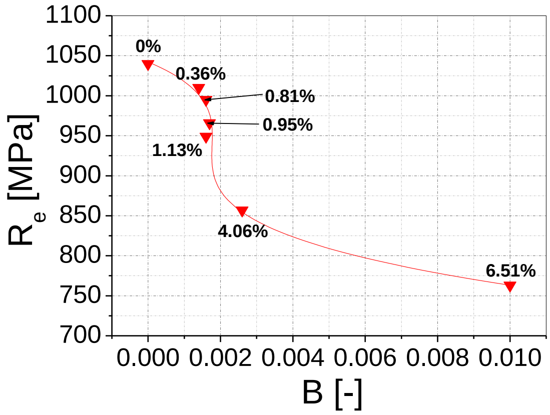

Fig. 3. Relationships between yield point and acoustic birefringence of the 40HNMA steel.

4. Conclusions

It is shown that the relationships between acoustic birefringence and selected destructive parameters (stereological and mechanical) can be determined for the 40HNMA steel. They seem to be applicable for elaboration of a new promising method for early stage detection of material degradation.

5. References

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