QUALITATIVE EVALUATION OF STRUCTURAL DEGRADATION AND MECHANICAL PROPERTIES BY MEANS OF BARKHAUSEN AND MAGNETOACOUSTIC EMISSION

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1. Introduction

It has been found that magnetic Barkhausen emission (MBE) is significantly sensitive to material damage [1]. MBE is the result of the irreversible movement of magnetic domain walls during a magnetisation cycle [2]. Domain walls are pinned by microstructural barriers and released abruptly in the changing magnetic field [3]. Among many kinds of microstructural barriers breaking domain wall movement the grain boundaries, precipitates, dislocations [2] and voids [4] can be distinguished. The movements of magnetic domains 90º generate the acoustic waves in materials having non-zero magnetostriction. This effect is known as magnetoacoustic emission (MAE) [5]. This research is an attempt for finding of a modern method based on measurements of these physical phenomena which allows to assess the stage of exploitation and basic mechanical properties of the creeped material.

2. Experimental Results

The tested material was 13HMF steel. The microstructure of the material in the as-received state is presented in Fig. 1: the material consists mainly of ferrite and carbides.

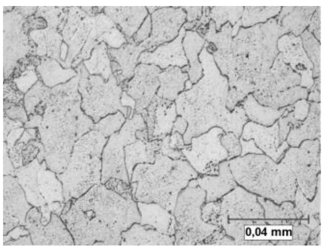

Fig. 1: The microstructure of the 13HMF steel, etched state (2% HNO_3 + etlhyl alcohol), light microscope, magnification 500×

The specimens of the steel were subjected to the creep (180MPa, 500ºC). The process was interrupted for a range of the selected time periods in order to achieve specimens with increasing level of strain. Next, magnetic measurements, static tensile test and microscopic investigation were carried out.

A decrease of the normalized MBE and MAE integrals ($Int(U_b)_{norm}$, $Int(U_a)_{norm}$) can be observed in Figs. 2-3.

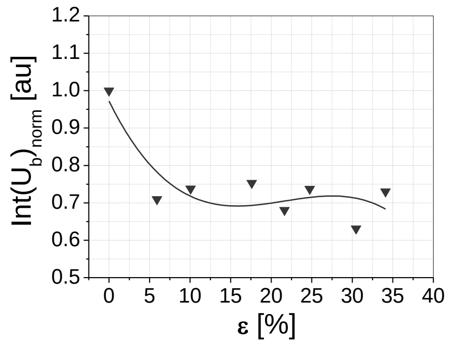

Fig. 2: Integral of half-period voltage signal of the MBE versus pre-strain for the 13HMF steel

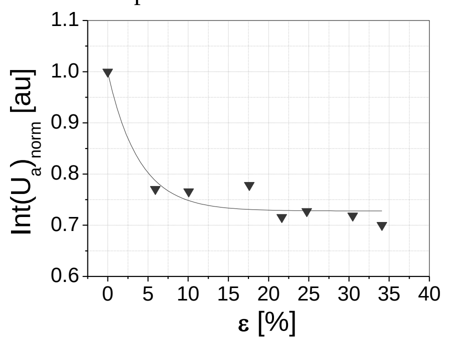

Fig. 3: Integral of half-period voltage signal of the MAE versus pre-strain for the 13HMF steel

Figure 4 presents the MBE envelopes obtained for the 13HMF for three exemplary strain levels. It is well seen that the shape (height and width) of the maximum varies for deformed specimens.

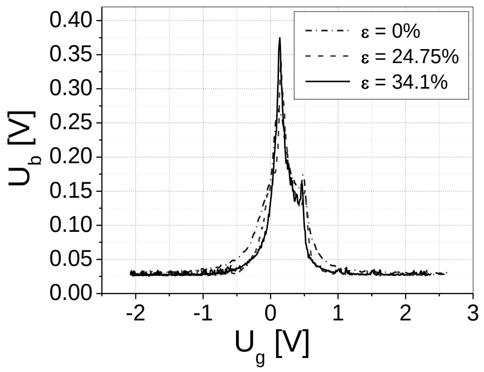

Fig. 4: Envelopes of MBE intensity as a function of increasing generator voltage for specimens of the 13HMF steel after creep

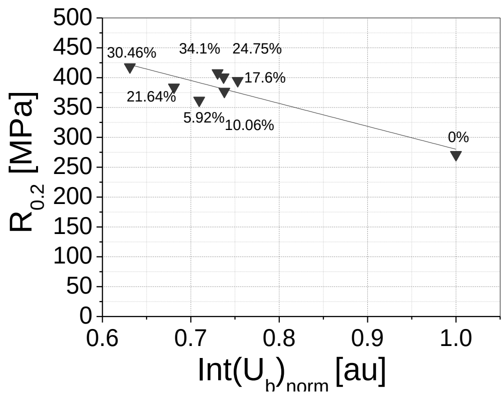

Fig. 5: Variation of yield point of the 13HMF steel versus integral over half-period voltage signal of the MBE: $Int(U_b)_{norm}$; numbers in the figure denote the level of prior creep deformation

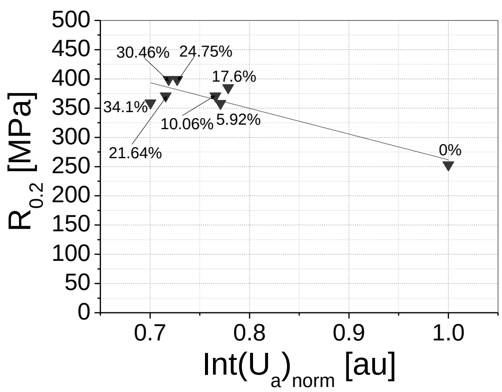

Fig. 6: Variation of yield point of the 13HMF steel versus integral over half-period voltage signal of the MAE: $Int(U_a)_{norm}$; numbers in the figure denote the level of prior creep deformation

The relationship between yield point ($R_{0.2}$) and integrals over half-period voltage signal of the MBE $Int(U_b)_{norm}$ and MAE $Int(U_a)_{norm}$ is presented in Figs. 5-6. The results show that the $Int(U_a)_{norm}$ can be a good qualitatively indicator of yield point of the creeped 13HMF steel.

3. Acknowledgements

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4. References

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