Experimental and Numerical Investigation of Ductile Fracture of Elements With Notches Under Elevated Temperature

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ABSTRACT

The paper presents the experimental and numerical results of ductile fracture of axisymmetric specimens with different circumferential notches under elevated temperature. EN-AW 2024 aluminum alloy was subjected to investigation. Specimens were subjected to uniaxial monotonic loads under temperature 20°C, 100°C, 200°C and 300°C. In order to this, the MTS 651 environmental chamber and the Messtician ME46 video extensometer were used. The relations between tensile force and elongation of the measuring base for different temperature have been obtained for specimens witch notches. It has been pointed out that the effect of elevated temperature is a decrease in the material properties, including its hardening. It was noticed that the increasing of temperature even to 300 °C does not cause significant differences in the shape and location of the fracture surface. Also attention is drawn to the influence of the notch shape and the set temperature on the value of the critical force and the maximum displacement of the measuring base. The results of fractographic observation of fracture surfaces carried out in order to determine the effect of elevated temperature.

The results of the numerical modelling of axisymmetric specimens with circumferential notches shown the stress and strain fields in whole specimens with notches. Non-linear calculations were made using an axisymmetric finite element mesh model built of four-node elements with a bilinear shape function. The material's hardening curve, obtained using the hybrid (experimental - numerical) method, was applied. Special attention was paid to influence on distributions of stresses and plastic strains under uniaxial loading, elevated temperature and notch radius. It has been shown that the location of maximum stresses and plastic deformations depends only on the notch radius where their value depends both on the notch radius and on the temperature.

Based on experimental and numerical results, new ductile fracture criterion for notched specimens taking into account elevated temperature and uniaxial loading was proposed. In this criterion assumed that the fracture initiation occurs when the normal stress on this physical plane reaches the critical value, depending on the isotropic damage state variable ω, generated by plastic flow of the material (depending on the temperature). This criterion assumes that the normal component of the stress vector on the critical plane is responsible for fracture. The critical value of this stress dependent on the variable of the damage state induced by the material's plastic flow and on temperature. In the considered loading case, this variable depends on the values of maximum (or equivalent) plastic strains and temperature.

REFERENCES

[1] Derpeński Ł., Seweryn A., Bartoszewicz J., Ductile fracture of specimens with notches made of EN-AW 2024 aluminum alloy under elevated temperature, Part I-experimental research, (2018), (submitted to *TAFM*)

[2] Derpeński Ł., Seweryn A., Ductile fracture of specimens with notches made of EN-AW 2024 aluminum alloy under elevated temperature, Part II-numerical calculation, (2018), (submitted to *TAFM*)