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IDENTIFICATION OF PARAMETERS FOR MODELS OF DUCTILE DAMAGE

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Abstract: *This paper introduces the description of effective method of calibration of a material plasticity. This problem is solved in the project „Identification parameters of ductile damage materials for nuclear facilities“. The research focuses on the phenomenological material models and identification of their parameters. The calibration of the material parameter is based on the evaluation of the experimental samples series and FE simulations that are calculated in Abaqus 6.10 software.*

Keywords: ***Plasticity, calibration, FEM, Johnson-Cook, ductile damage***

1. Introduction

Because of the growing demands on safety, reliability and longer lifetime period of nuclear facilities components it is necessary to use material data in a numerical simulation that considers the ductile damage. The plastic strain represents one of the most crucial parts in the process of ductile damage. The ductile fracture occurs after all the plasticity reserve is consumed. If the damage additionally affects plastic behavior of the material then we can talk about the so called tied continual damage model. Von Mises plastic model and the isotropic hardening were used in this project. In this case it is necessary to calibrate dependence of actual yield stress on accumulated intensity of the plastic strain $\sigma_Y^{True}(\varepsilon_{\ln}^{pl})$.

2. Method of plastic model calibration

The basic experimental ground for finding this dependence mostly uses the uniaxial tensile test on smooth samples. If the strain is distributed equally it is possible to calculate true stresses and logarithmic strains from the condition of the material constant volume. With this method we can determine $\sigma_Y^{True}(\varepsilon_{\ln}^{pl})$ until the sample is locally strangled. In this paper the function of $\sigma_Y^{True}(\varepsilon_{\ln}^{pl})$ has two parts. The first one, which is valid until the plastic strangling, is formed by values of true stresses and plastic strains that were computed directly from the experimental data. The second part of the dependence $\sigma_Y^{True}(\varepsilon_{\ln}^{pl})$is replaced by convenient approximate function, which is chosen to meet the condition of tangential connection in the place of plastic strain during the strangling. The parameters of the approximation function are identified by iterative process. Therefore an optimizing script in Python was developed, which is started directly in the Abaqus software. The calibration is based on a simplex algorithm of local optimization. This algorithm makes effective optimization of several parameters in the same time. For more parameters The calculation time and the uncertainty of the optimization process increase with the growing number of parameters therefore we try to describe a model with the lowest number of parameters as possible.

In practice Johnson-Cook plasticity model is often used. During the approximation of a plastic part of the tensile curve by Johnson-Cook's model we can´t expect exactly the same results as when using the FE simulation and experiments. But it is reasonable to demand that at least the maximal reached loading force and the extension would correspond. The condition of the accordance between the experiment and the material model in the place of strangling enables us to describe the parameters *A, B* in dependence on the chosen exponent *n*.

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$$A(n) = \frac{\sigma_{Y.neck}^{True}\left(n - \varepsilon_{\ln.neck}^{pl}\right)}{n} \qquad B(n) = \frac{\sigma_{Y.neck}^{True}\left(\varepsilon_{\ln.neck}^{pl}\right)^{1-n}}{n} \tag{1}$$

The method described in this paper shows in a very effective manner the way how to approximate plastic response of material using this model.

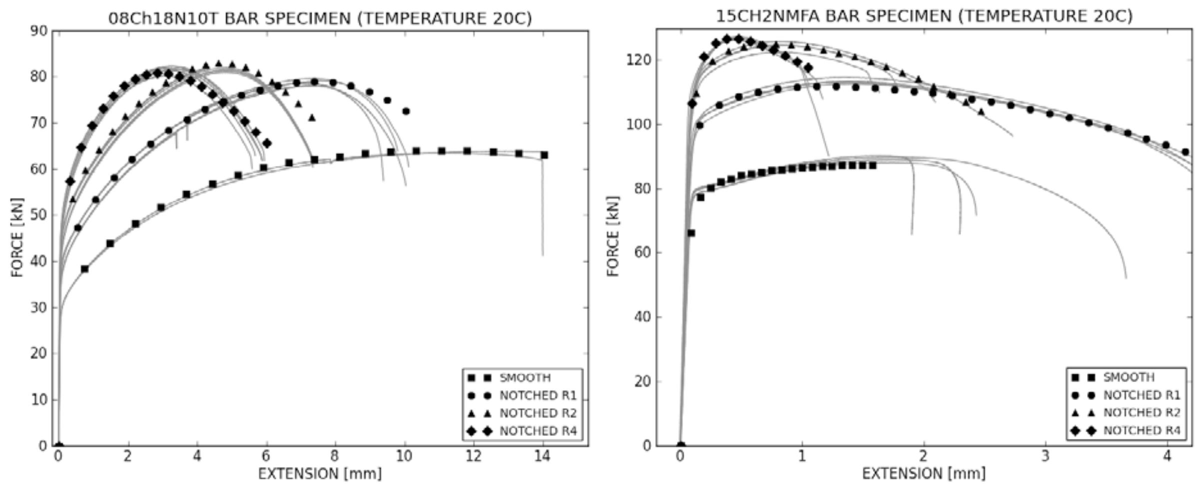

Fig.1: Comparison of the FE simulation of tensile samples with experiments

3. Conclusion

This paper describes the method of the calibration of the plastic part of a curve that performs an important aspect of ductile damage models. Basically two different ways of approximation of the dependence on actual yield stress and accumulated intensity of the plastic strain were defined and an effective method for their identification was designed. This described technique is based on theoretical knowledge of the plastic material behavior and hence substantially reduces demands of the calibration. Identification of the independent parameters of the models is processed iteratively using an optimizing script that was developed as a part of this project. The calibration is largely corresponding with the experimental results as we can see in the *Fig. 1*. Currently the calibration of the plasticity models in dependence on the strain-rate is being designed and processed. Our future work in the field of plasticity will be focused on the plasticity models that consider the third invariant of the deviation stress tensor and hydrostatic pressure.

References

Ling, Y. (1996) Uniaxial True Stress-Strain after Necking. *AMP Journal of Technology Vol. 5*

Abaqus Online Documentation: Version 6.10

Havner, K.S. (2004) On the onset of necking in the tensile test. *International Journal of Plasticity 20 965-978*

Bridgman, P. W. Studies in Large Plastic Flow and Fracture. *Cambridge, Harvard University Press, 1956*

Gurson, A.L. Continuum theory of ductile rupture by void nucleation and growth. *Journal of Engineering Materials and Technology 1977, vol. 99*

Johnson, G. R., Cook, W. H. Fracture characteristics of three metals subjected to various strains, strain rates, temperatures and pressures. *Engineering Fracture Mechanics, 1985, vol. 21*