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MODELLING OF DUCTILE FRACTURE FOR SUB-SIZED THREE-POINT-BEND GEOMETRY

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Abstract: *The contribution deals with the simulation of R-curve using complete Gurson model of ductile fracture. The R-curve was experimentally determined for a Eurofer97 steel on sub-sized three-point-bend geometry in previous study. To apply complete Gurson model the parameters describing the voids´ behaviour and characteristic length parameter need to be determined. Comparing experimental and simulated R-curve the ductile tearing was not successfully achieved. Insufficient calibrated parameters as a result non-uniqueness problem of single specimen method were found.*

Keywords: ***complete Gurson model, single specimen approach, Eurofer97, R-curve***

1. Introduction

Apart from getting be familiar with the Gurson model, the possibility to derive the Gurson parameters from smooth tensile specimens was verified. The identified parameters were used for simulation of R-curves which were measured by single and multispecimen method using sub-sized three-point-bend specimen type of KLST by Dlouhý et al. (2011) in previous study.

For determination of the Gurson parameters the single specimen approach was applied. This methodology involves the description of ductility of the material from smooth tensile test (trace load-elongation or load-diameter reduction). When ductility of the material is known, the optimal nucleation parameters (f_0, f_n), which give the best fit to the experimental results, can be obtained.

2. Identification of Gurson model parameters

To choose which nucleation model should be applied, metallographic study of micro-void nucleation mechanism was performed. The broken parts of tensile specimens were longitudinally cut and specimens were prepared by standard metallographic processes. The specimens were then studied using scanning electron microscopy and quantification of voids fraction was performed by image analysis. The examination revealed that voids nucleate just in the neck region and no voids were observed in uniformly deformed part of specimen. This fact exclude the cluster nucleation model as a possible description of void nucleation mechanism and leaving its value f_0=0. The value of void volume fraction from region near to the fracture surface 0.011 was chosen as f_c. The value of void volume fraction f_F and the values of parameters describing void growth q_1 and q_2 were chosen as recommended in literature (Ødegård et al., 2000; Dutta et al., 2008) thus 0.15, 1.5 and 1.0, respectively. The statistical nucleation model was applied by choosing recommended values of ε_n=0.3, s_n=0.1 (Ødegård et al., 2000) and parameter f_n was fitted to experimentally determined trace load-elongation. The results of tensile tests were used from study (Dlouhý et al., 2011). Only smooth tensile specimen results as a load vs. elongation were available. The axisymmetric model of tensile

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specimen was created consisted using ABAQUS 6.11 software. It was found that f_n=0.001 gives good fit to the experimental data. By obtaining parameter f_n the process of their identification has finished.

The 3D models of the tested KLST specimens were built according to (Dlouhý et al., 2011). From comparison of experimental and simulated curves the mesh with element size 22 μm fits the best to the results. Based on that element size characteristic length parameter l_c=22 μm was obtained.

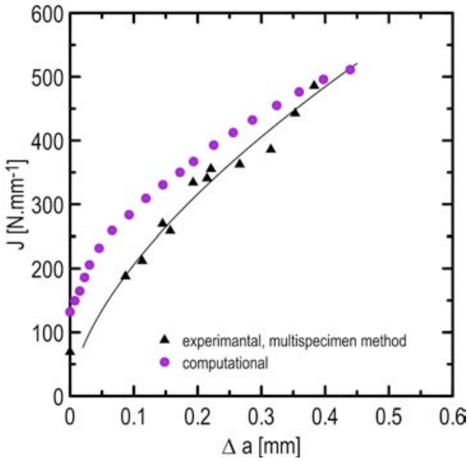

Fig. 1: Computed and experimentally determined R-curves.

3. Results

The values of J-integral were determined from load-displacement curve according to the standard determination like for fracture mechanics test. The ductile tearing at different deflection was determined by counting the elements, where void volume fraction reached value of f_F. Comparison of experimental and computed R-curves is shown in Fig. 1. The simulated R-curve fits with experimental one within its upper parts. However, the J-initiation values and values of J-integral up to about 0.2 mm of crack extension are considerably overestimated. That is not problem of values of J-integral counted from load-displacement curve but of crack extension. The crack propagation up to 0.2 mm is slow because model behaviour is too stiff. It could be changed just by parameters of Gurson model. Thus it seems to be that the parameters were not successfully identified. In fact it is disadvantage of single specimen approach of nucleation parameter identification, which is non-uniqueness problem.

4. Conclusions

In this study the process of identification of complete Gurson model parameters was carried out. The parameters describing the voids´ behaviour and characteristic length parameter need to be determined. Difficulty was encountered while computing R-curve of fracture specimens using identified parameters in agreement with the experimental data. Insufficient calibrated parameters as a result non-uniqueness problem of single specimen method were found. Non-uniqueness problem can be resolved by using multispecimen approach. The possibility of multispecimen approach of nucleation parameters identification and also performance of Gurson model for Eurofer97 steel will be studied further.

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