DETERMINATION OF ARTIFICIAL DFFECTS IN MATERIAL UNDER MONOTONIC TENSION BY THE USE OF FEM AND DIC METHODS

TADEUSZ SZYMCZAK [1], ZBIGNIEW L. KOWALEWSKI[2], ADAM BRODECKI[1]

[1] Motor Transport Institute, Centre for Material Testing, Jagiellońska 80, 03-301 Warsaw, Poland. e-mail: tadeusz.szymczak@its.waw.pl; adam.brodecki@its.waw.pl

[2] Institute of Fundamental Technological Research, Department for Strength Materials, Pawińskiego 5B, 02-106 Warsaw, Poland. e-mail: zkowalew@ippt.pan.pl

1. Introduction

A lot of research groups works [1 ÷ 4] are focused on determination of artificial defects influence on material properties in experimental [1, 2] and numerical [3, 4] investigations. Mathematical calculations enable determination of the stress concentration factor and maximum stress at a tip of notch on the basis of forces and displacement capturing during experiments. These results are not sufficient because they enable describing material behaviour under uniaxial stress state. More complex analysis can be obtained by the use of modern technique such as Digital Image Correlation (DIC) for example. This method enables assessment of strain/stress state components variation in 2D or 3D coordinate systems.
The main aim of the paper was to evaluate an influence of holes simulating defects on material behaviour up to fracture.

2. Experimental procedure

The flat specimen was designed to have three holes having diameter equal to 1.5, 3.0 and 5 mm, Fig. 1.
The experimental procedure contained two stages, numerical and experimental. In the first part of the procedure for determination of the Huber – Mises – Hencky effective stress ditstribution the Abaqus programme was employed. The specimen was modelled as 3D solid body having a full-elastic tensile characteristic. The Poisson ratio value taken into calculations was equal 0.3. The specimen body was divided into 507 300 Hex elements having dimension equal 0.3 mm.
The experimental investigation was performed by the use of the 8802 Instron servo-hydraulic testing machine and DIC system called Aramis 4M. The DIC system was applied to determine variations of the HMH strain/stress from beginning of the test until the specimen fracture.

3. Results

In order to determine a role of holes diameter, the HMH effective stress distribution in 3D coordinate system from FEM calculations was considered, Fig. 1.

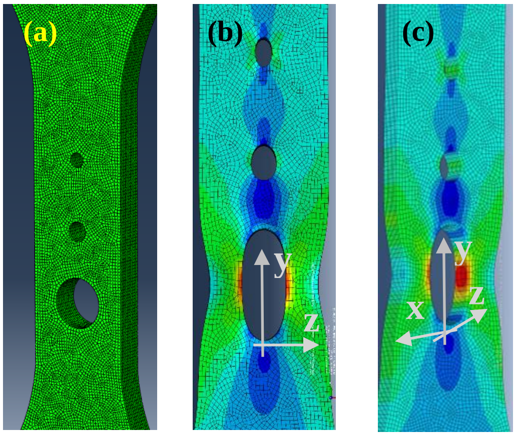

Fig. 1. Specimen with holes: (a) the geometry; the HMH stress distribution on: (b) 0YZ and (c) axonometric view.

The results presented on the 0YZ plane show significant differences in the stress distribution due to application of the round holes, Fig. 1b. Differences in stress distribution was achieved for the HMH effective stress distribution presented on the 0XY plane in Fig. 1c. In this case a hole effect is expressed also by differences between zones of the maximum stress. The largest area of the stress, expressing the crack occurrence, was obtained for the biggest magnitudes of the diameter considered. Moreover, one can notice that a diameter decrease caused variations of the stress level. It was expressed by reduction of the maximum stress zone area and its value, Fig. 1b, c.

The effect of the hole diameter on the stress level was also evaluated on the basis of calculation performed using the equation recommended for perforated specimens [4]. As it is presented in Fig. 2a the stress concentration factor (SCF) decreases linearly. An opposite tendency can be observed for maximum stress variation, Fig. 2a. The largest value of this parameter was obtained for the biggest diameter considered. These effects are consistent with the results obtained by means of FEM analysis, Fig. 1 b, c.

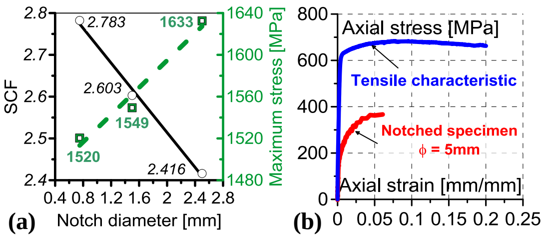

__Fig. 2.__ Variations of: (a) stress concentration factor and maximum stress; (b), stress-strain curves for tested specimens

Comparison of the tensile curves determined in experiment for specimens without and with holes enables to identify their essential differences. It is expressed by 70% drop of the yield point and ductility observed for test performed on the specimen with holes, Fig. 2b.

The HMH strain distribution obtained from test under monotonic tension on the multi-hole specimens is shown in Fig. 3a, b. An effect of the holes is reflected by variations of the strain isolines. At the beginning of tension represented by 43th stage, the biggest hole is appeared as significant stress/strain concentrators.

Further tension led to the stress/strain increase for the biggest hole, and finally to the specimen fracture (Fig. 3b, c).

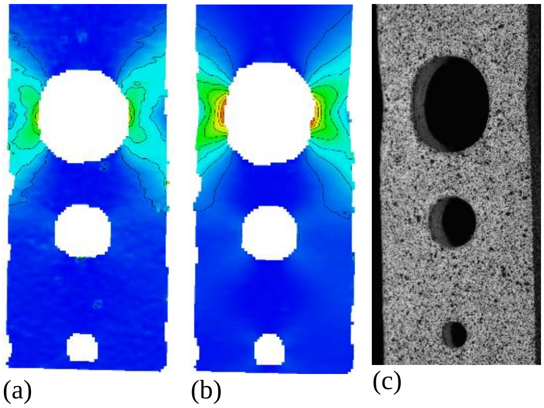

__Fig. 3.__ Results of DIC analysis: (a) and (b) the HMH strain at 43th and 61th stages, respectively; (c) specimen view at 61th stage.

4. Remarks

An increase of hole diameter leads to the linear decrease of the stress concentration factor and linear increase of maximum stress. The main difference in the shape of the tensile curve for the specimen with holes with respect to that without them takes place in the yield point and ductility.

References

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