DYNAMIC AXIAL CRUSHING OF FLAWED THIN-WALLED SQUARE SECTION TUBES

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1. INTRODUCTION

In the case of thin-walled members subjected to axial compression, which act as energy absorbers, a substantial issue is such a design, which promotes a progressive buckling mechanism, stimulating the highest energy absorption capacity. One of the possible design solutions is the application of a trigger (notch or dent), which releases the most desirable crushing mechanism. There are numerous published results of research concerning energy absorption of thin-walled tubes [1, 2], however, very few deal with tubular structures with dents or other flaws. In [3] the authors studied the behavior of tubular columns with dents, but these flaws were treated as imperfections coming from damage. The static analysis of axially compressed square section tube with dents in the corners is presented in [4].

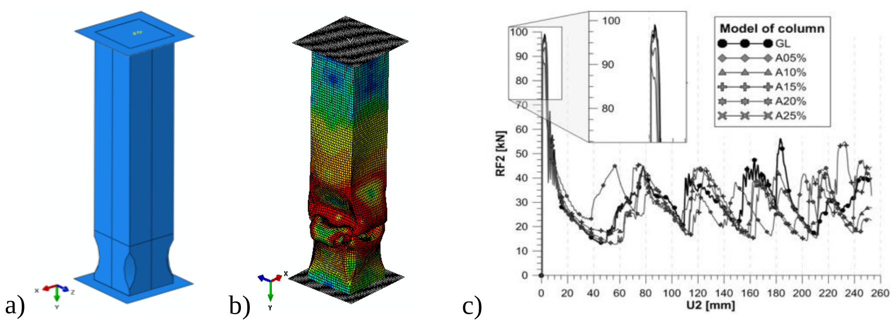

Fig. 1. Subject of analysis: a) - theoretical model (A15%), b) - numerical model - failure pattern, c) - comparative load-shortening diagram

2. SUBJECT OF RESEARCH

The subject of investigation was a thin-walled square section aluminum tube with four indentations in the corners. The tubes of dimensions 70x2 and height l = 335 mm, were made of aluminum alloy EN AW6060-T6 (R_e = 175 MPa, R_m = 250 MPa, ν = 0.33). This material exhibits linear hardening during plastic flow (E = 70GPa, E_t = 937,5MPa). The process of modeling of the column with dents was realized with the Catia v5 software package in the Generative Shape Design module. The dent's geometry was characterized by the main radius R = 50 mm. The depth of the dent was 2.5; 5; 7.5: 10, 12.5 mm, what is 5; 10; 15; 20; 25 % of its diagonal of cross- section. Dents were made at the bottom of the column (Fig. 1a). The models were designated by the symbols from A05% to A25%, where the number stands for the relative depth of the dent. The column with smooth walls was designated as GL.

3. NUMERICAL ANALYSIS - PARAMETRIC STUDY

A parametric study into an optimal dents situation and geometry with respect to the energy absorption capacity of tubes was performed on the basis of FE simulations. FE explicit analysis was carried out using ABAQUS 6.13 code. An impact of energy E = 10 kJ was assumed. A bi-linear material model was applied. As the preliminary results of the parametric study have showed that the best energy absorption indicators for examined columns, namely EA - energy absorption, MCF - mean crushing force, CLE - mean to ultimate crushing force ratio were obtained for columns A20%, the further analysis was performed for these columns, with different distance of a dent from the bottom end, 5,10,15 and 20 [mm]. The columns were indicated as B20_05 to B20_20, respectively. Energy absorption indicators for those columns are shown in Table 1.

Table 1. Energy absorption indicators for columns type B

	Model of column			
Parameter	GL	B20_05	B20_15	B20_20
EA [J]	6748.91	6327.37	6271.96	8274.59
MCF [kJ/mm]	31.27	29.30	29.04	38.34
CLE [%]	31.58	33.09	32.21	42.34

As shown in the Table 1 the energy indicators increase rapidly for column B20. The research presented in the paper is a part of a wider project. Further investigation will be continued into an experimental validation of theoretical results and more detailed parametric study into an optimal situation and dimensions of dents. Also an optimization using a technique of metamodels is planned.

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