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IDENTIFICATION OF MATERIAL PARAMETERS BY FEM

STANOVENÍ MATERIÁLOVÝCH PARAMETRŮ POMOCÍ MKP

Abstract

The article describes identifications of material parameters from set of experiments. Five experiments were analyzed - hollow cylindrical specimen was loaded by tensile axis force, torsion moment and their combinations. The homogeneous and isotropic material (steel) was assumed.

Abstrakt

Článek popisuje stanovení materiálových parametrů pomocí MKP. Jedná se o analýzu pěti experimentů –dutý válcový vzorek byl zatěžován tahovou osovou silou, krouticím momentem a jejich kombinacemi. Byl uvažován homogenní a isotropní materiál (ocel).

1 INTRODUCTION

Identification of material parameters from the experiment data is the main part of experimental analysis. The increased power of computers makes possible to use the Finite Element Method (FEM) for material parameters identification. The basic procedure is described e.g. in [1], [2]. In this procedure is used the probability algorithm (basic on correlation between the data and the data dispersion).

2 EXPERIMENTS

The universal testing machine (see [3], [4]) on Department of Mechanics of Materials was used for making of the experiments (see [6]). The hollow cylindrical specimen (Fig. 1) was used in experiments. The specimen loads are described in Tab.1. The applications of loads in experiments were controlled by the deformation (linear increased displacement, distortion).

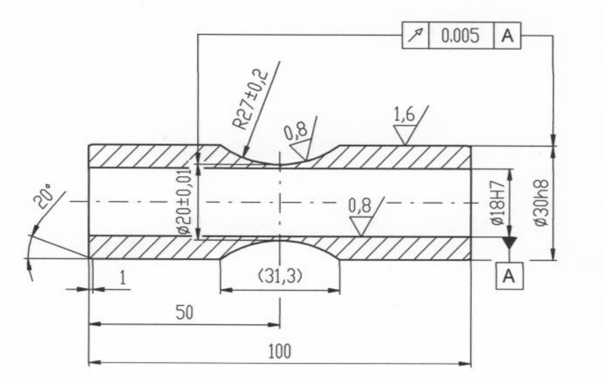

Fig. 1 Cylindrical specimen

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Tab. 1 Application of loads

Type:	Torque *Mk*	Axial Force *F*	Twisting angle φ [rad]	Elongation y [mm]
Tension	Measured	Measured	*0*	*1.67*
Torsion	Measured	Measured	*1.484*	*0*
Combin_1	Measured	Measured	$y\times(5\times\pi/180)/0.25$	*1.36*
Combin_2	Measured	Measured	$y\times(5\times\pi/180)/0.1$	*0.86*
Combin_3	Measured	Measured	$-y\times(5\times\pi/180)/0.1$	*-1.98*

3 ALGORITHM

The basic algorithm is described by Fig.2 (in more detail see [2]).

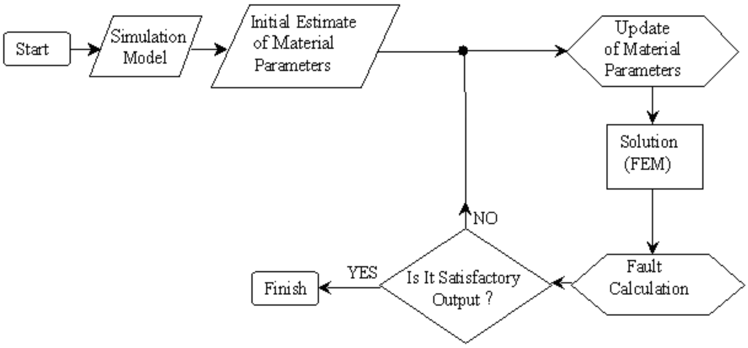

Fig. 2 Basic algorithm

The constitutive equation of material is represented by Ramberg-Osgood's approximation (1). The initial value of approximation was acquired from simplified analytical solution (e.g. [5]).

$$\varepsilon = \frac{\sigma}{C1} + \left(\frac{\sigma}{C2}\right)^{\frac{1}{C3}} \tag{1}$$

The computation of fault function [%] is given by equation (2).

$$Fault = \frac{\sum_j \left|\left(Mk_j^{Exp} - Mk_j^{FEM}\right)\cdot\left(\varphi_j - \varphi_{j-1}\right)\right| + \sum_k \left|\left(F_k^{Exp} - F_k^{FEM}\right)\cdot\left(y_k - y_{k-1}\right)\right|}{\sum_j \left|Mk_j^{Exp}\cdot\left(\varphi_j - \varphi_{j-1}\right)\right| + \sum_k \left|F_k^{Exp}\cdot\left(y_k - y_{k-1}\right)\right|}\cdot 100, \tag{2}$$

FE analysis was performed using software ANSYS v.11.0, (multilinear isotropic material model, rate independent). The new material parameters estimated by the probability algorithm - based on the data correlation and the data dispersion (experimental data + FEA data = fault, material parameters).

4 RESULTS

The material parameters (*C*1, *C*2, *C*3 see equation (1)), with the faults find by probability algorithm, are displayed on Tab. 2. Fifty computational cycles were performed for the solution of each experiment (finding of parameters). The probability algorithm gives different results in each simulation.

Comparing of the FE results and experiments are shown on Fig. 3.

Tab. 2 Material parameters

Type:	*C*1 [MPa]	*C*2 [MPa]	*C*3 [1]	*Fault* [%]
Tension	199428	759	0.2009	1.26
Combin_1	193501	713	0.2005	4.70
Combin_2	195653	681	0.2162	4.26
Torsion	194241	662	0.2044	6.52
Combin_3	190482	603	0.2075	5.75

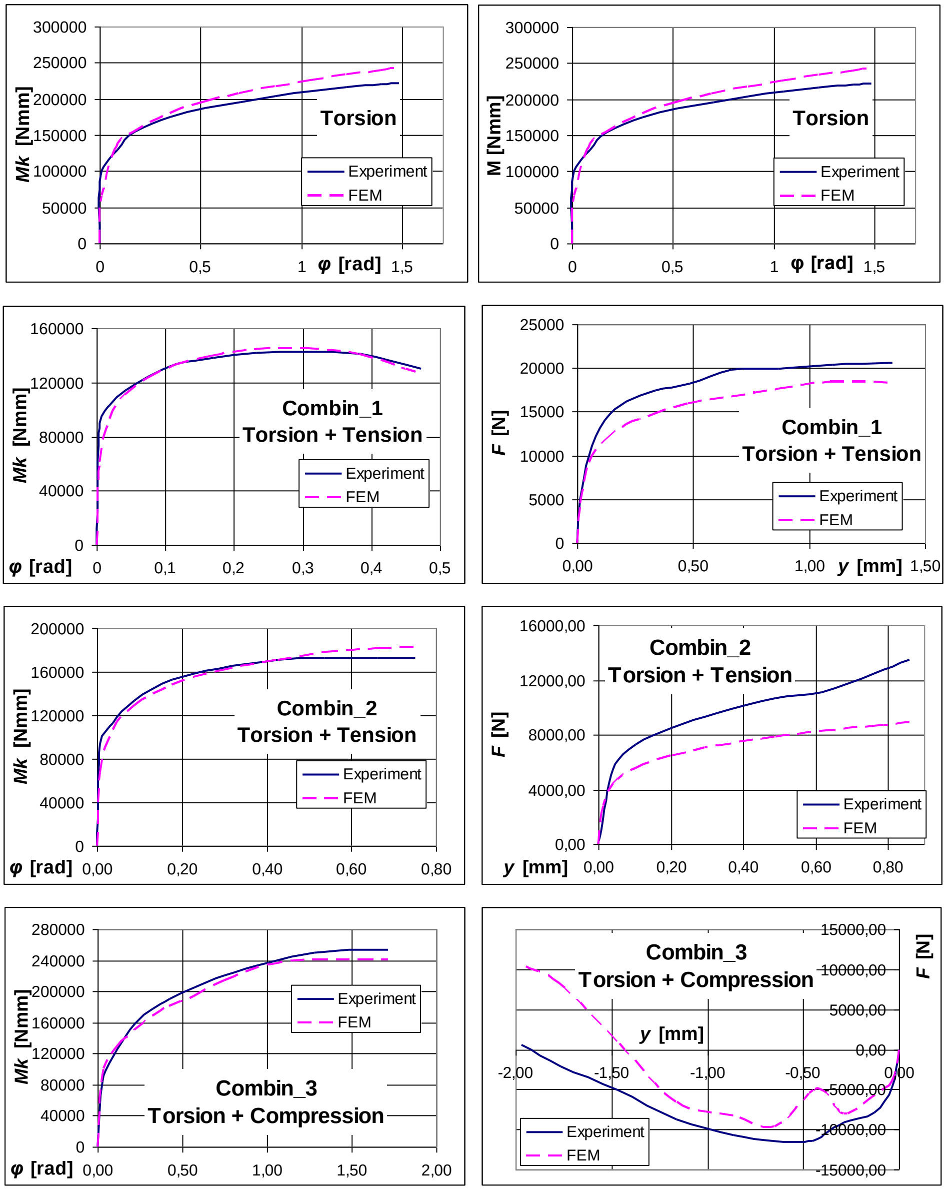

Fig. 3 Comparison of results from FE analyses and experiments

5 DATA INTERPRETATION

From the comparing of the results (see Tab.2, Fig.5) are evident interesting results. The decreasing of the parameter C2 is causing the decreasing of the axial stress in the specimen (curve move to the right). It is evident that the selected material model (multilinear isotropic) is not able correctly described the behavior of tested material. However, the results also depend on the shape of specimens.

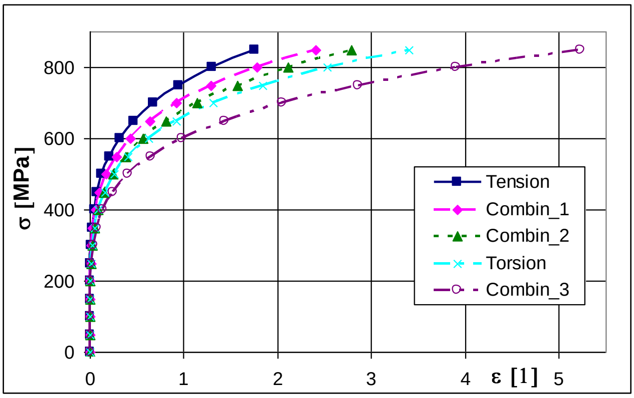

Fig. 5 Results

6 CONCLUSION

The article describes identification of material parameters (3 parameters) under condition of isotropic material (ANSYS - MISO material model). The above results indicate that the material shows different behavior for different types of loading.

The next step of the analysis will be the identification of parameters for anisotropic material (e.g. ANSYS-Hill´s anisotropy – unknown 9 parameters).

REFERENCES

[1] AQUINO, W., BRIGHAM, J. C. Self-Learning Finite Elements for Inverse Estimation of Thermal Constitutive Models. In: *International Journal of Heat and Mass.* Transfer 49, 2006. s. 2466-2478.

[2] ROJÍČEK, J. *Statické hypotézy pevnosti,* Static Strength Theories. Ostrava, 2007, Disertační práce, VŠB-TU OSTRAVA, FS, kat. pružnosti a pevnosti, (Czech).

[3] FUSEK, M. *Univerzální zkušební stroj*, Universal testing machine. Ostrava, 2007, Disertační práce, VŠB-TU OSTRAVA, FS, kat. pružnosti a pevnosti, (Czech).

[4] FOJTÍK, F. 2005. *Návrh způsobu upínání zkušebních vzorků (VZOREK 2 č. v. 4 – Zz – 157) na zkušebním stroji SCHENCK typ PWXN*, Závěrečná zpráva Workshop fakulty strojní 2005, VŠB – TU Ostrava, FS, Ostrava, 2005. 16.února 2005. s. 25. ISBN 80-248-0750-5, (Czech).

[5] FUXA, J. 2000. Analytické řešení napěťově-deformačního stavu při zkoušce krutem. In: *Výpočtová mechanika 2000.* Západočeská univerzita v Plzni, Fakulta aplikovaných věd, Katedra mechaniky, 2000. 30.10-1.11.2000, Nečtiny. 8 s, (Czech).

[6] FRYDRÝŠEK, K., HALAMA, R., FUXA, J. 2005, Nízkocyklová únava a torzní test. In *Aplikovaná mechanika 2005.* Hrotovice, 29.3-1.4.2005. s.19-20, ISBN 80-214-2373-0, (Czech).

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