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DYNAMIC BEHAVIOUR OF MATERIALS AND ITS APPLICATIONS IN INDUSTRIAL PROCESSEs

PROGRAMME and ABSTRACTS

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ENERGY-BASED MULTISURFACE LIMIT CRITERIA IN APPLICATION FOR MODELLING AND SIMULATION OF METAL FORMING PROCESSES

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1. Introduction

Metallic materials are usually used in engineering applications in the as received state. In such a case, developing in in the course of manufacturing processes texture induces anisotropy of mechanical properties and produces often the so-called strength differential effect (SDE).The precise description of elastic properties and formulation of limit criterion requires application of the formalism used typically for anisotropic solids. It is a complex and difficult task related with proper experimental characterisation of all material parameters. In some cases, however, a simple model of isotropic solid revealing possible strength differential effect and certain correction for the limit strength in shear can be proposed. It is in accord with the observation that developing texture influences mostly shear strength of metallic solids.

2. The main objective

The aim of this work is to apply the energy-based hypothesis proposed by Burzyński [1] to formulate a multisurface limit criterion. The resulting limit surface inherits corners, which are not convenient for applications in numerical analysis of complex deformation processes. Therefore, certain smooth out procedure is proposed. As a result a smooth limit surface is obtained, which can be applied in plasticity and viscoplasticity models implemented in finite element calculations of metal forming processes. The idea of the procedure for a hypothetical material characterised with the yield limits for tension and compression tests and the parameter describing the deviation of the yield strength in shear from the predicted one from Huber-Mises criterion:
$\sigma_Y^T = 1.0,\ \sigma_Y^C = 1.1,\ \lambda = 0.7,$ where

$$\lambda = \frac{\sigma_Y^C\ \sigma_Y^T}{(2\tau^S)^2} - 1$$

is depicted in Fig. 1, where the resulting interior of three limit curves shows the elastic range with corners according to Burzyński yield condition while in Fig 2 the resulting smooth yield limit curve is presented. The yield limit is described by the following equation:

$$\Phi = \sigma_1^2 - R_B \sigma_1 \sigma_2 + \sigma_2^2 + (\sigma_Y^C - \sigma_Y^T)\sigma_1 + (\sigma_Y^C - \sigma_Y^T)\sigma_2 - \sigma_Y^C \sigma_Y^T = 0$$

where R_B is the material constant determined by the yield strength in tension, compression and shear tests.

The discussed yield condition was compared with the special case of the known criterion for anisotropic materials proposed by Hill in 1948 specified for transversally isotropic solids. As an example the results of numerical simulation of deep drawing process of metal sheet are discussed.

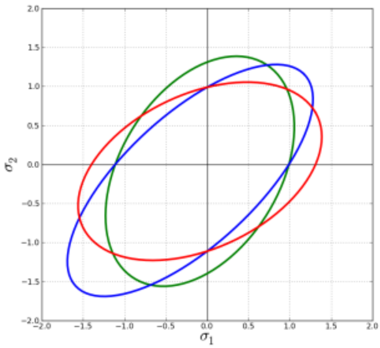

Fig. 1. The Burzyński yield condition depicted for plane state of stress.

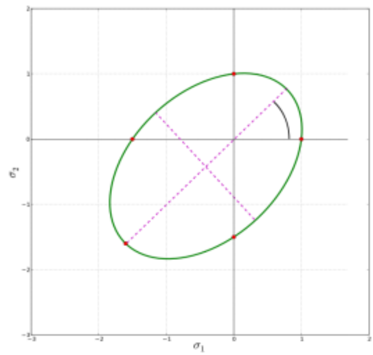

Fig. 2. The resulting smooth limit curve

3. References

[1] W. Burzyński, (2009). Selected passages from Włodzimierz Burzyński's doctoral dissertation Study on Material Effort Hypotheses, *ENGINEERING TRANSACTIONS*, 57, 185-215, 2009; published originally in Polish: Studium nad hipotezami wytężenia, Nakładem Akademii Nauk Technicznych, 1-192, Lwów, 1928; also: Włodzimierz Burzyński, Dzieła Wybrane, tom I, 67-258, PWN, Warszawa, 1982.