THE COMPUTER SIMULATION OF SOME METAL FORMING PROCESSES – NUMERICAL EXPERIMENT BASED ON FEM AND MFS

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1. Introduction

This work concerns the processes of research and solving problems of metal forming. To investigate the new process or introduce the novelty into existing technology the research in situ is necessary. But, since the computer simulations became more accessible and available, the investigations start with computational simulations, show the way of innovation of the technologies. And the results of the performed computer simulations are used for improvement of the procedures. Of course, the proposed solutions, given by simulations, are verified and validated by research in situ, in real conditions.

In this paper, two types of numerical methods are used for computer simulations of chosen processes of metal forming. First of used methods is Finite Element Method. The commercial computer program will be applied for solving some metal forming problems. The second type of used numerical procedure is based on meshfree method (i. e. Method of Fundamental Solutions MFS [3]). Both FEM and MFS will be compared, their advantages and disadvantages will be pointed. .

2. Problem description

Metal forming is a general term for a large group, that includes a wide variety of manufacturing processes. The chosen problems of metal forming will be mathematically modeled by general equations of plasticity theory with proper boundary conditions [2, 3]. To compare the both methods the 2D, 3D, axisymmetric 3D problems will be considered. The numerical experiment will be done for bodies of different geometrics, material characteristics.

3. Description of the numerical procedures

3.1. The Finite Element Method

The FEM has been proposed by Zienkiewicz [4], and became very popular at the end of XX century. The first step of this method is an introduction of mesh defined on the domain of the problem. The domain is divided into small, "finite" elements and basis functions are chosen and calculated for each element. Than the mathematical model is applied for each element of the mesh. Than all of finite element problems are combined in one mathematical problem in matrix form. And this mathematical problem in numerically solved. The solutions is obtained in the form of a function which has derivatives of order dependent of used basis functions. It is very simplified version of FEM characteristics, but is enough to compare with MFS.

3.2. The Method of Fundamental Solutions

The MFS was proposed by Kupradze and Aleksidze [1]. The method is analytically-numerical one. The analytical part of the MFS is to find a special function called fundamental solution, which is unique one for the differential operator appeared in the governing equation of mathematical model. These functions are known in literature for some, very common differential equations. The next step on the procedure based on MFS is to discrete boundary of the domain. By this way the dimension of the problem is reduced by 1. The boundary conditions are applied for getting mathematical problem. Solution of this problem has a form of analytical function which possesses derivatives form first to infinite order.

4. Numerical experiment

The numerical experiment is performed to show good points of each of both numerical methods. The FEM and MFS give as a results differentiable functions. It allows to perform analysis based not only on raw results, but also do for example strength analysis.

As a brief example of applying numerical method the simulation of metal forming the upsetting process of cylindrical sample is shown. Problem has been modeled as axisymmetric one. Figures 1-3 show the results of computations. The equivalent stresses are presented on Fig. 1. The Fig. 2 contains the plot of the equivalent plastic strains. The analysis of the obtained results has been done and the vectors of material flow are plotted in Fig. 3.

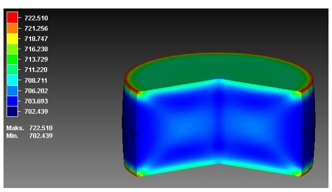

Fig. 1: Equivalent plastic stresses of a cylinder during upsetting.

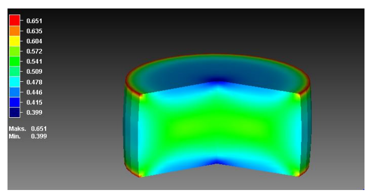

Fig. 2: Equivalent plastic strains of a cylinder during upsetting.

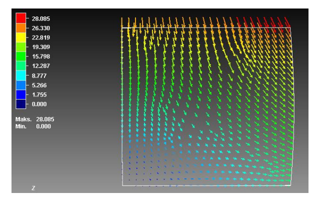

Fig. 3: Vectors of material flow of a cylinder during upsetting.

So, we can observe the results of numerical simulations and do the analysis of this results. In full paper the comparision of two used methods will be presented. Moreover, the simulations will be performed to different metal forming processes to show the justification of numerical procedure selection. It will check if there is any influence of process parameters, material characteristics on the choice of the numerical method.

References

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