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## USING OF PROGRAM COMPLEX “DEFORM 2D/3D” IN SCIENTIFIC WORK IN THE DEVELOPMENT OF NEW INNOVATIVE TECHNOLOGIES

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*Abstract.* This article provides information about the software package DEFORM 2D/3D, used for the simulation of metal forming processes. Describes the various models developed by this program.

**Keywords:** computer modeling, metal product industries

### WYKORZYSTANIE PAKIETU OPROGRAMOWANIA «DEFORM 2D/3D» DO PRACY NAUKOWEJ PRZY OPRACOWANIU NOWYCH INNOWACYJNYCH TECHNOLOGII

*Streszczenie.* Artykuł zawiera informacje o pakiecie oprogramowania DEFORM 2D/3D wykorzystywanego do modelowania procesów obróbki ciśnieniowej metali. Opisano realizacje modeli opracowanych z pomocą tego pakietu.

**Słowa kluczowe:** modelowanie komputerowe, przemysł metalowy

#### Introduction

At present simulation of various deformation processes in plastic metal working is very important and this is promoted by several factors.

First of all, simulation makes possible for a researcher to look “inside” the process, assess developing stresses and deformations, to forecast the emergence of defects. Secondly, it allows find optimal parameters of the tool and billet for the best running of the process. And thirdly, modern program simulation complexes give a lot of possibilities for work at times limited only by a user’s imagination. They allow simulate practically any process omitting expensive experiments. For instance, when making dies for some stamping operations it is possible to simulate this die and modifying various geometrical and technological parameters to match their values proceeding from optimal filling of the die cavity. This method of making new parts is now widely used in automotive, aircraft, machine – building and even defense industries. Thus simulation of various deformation processes in plastic metal working is a vital problem.

At the present time, when the computer industry offers a variety of modeling tools, any qualified engineer or technologist should be able not just to model complex objects but simulate them using modern technologies that are implemented in the form of graphical environments and visual modeling packages.

In 1994, in the international conference “Metal Forming Process Simulation Industry” was held the first international testing of settlement programs [2]. Article of 2002 year [1] states quite widespread in industry three-dimensional modeling software and high efficiency of their use. All CAE systems for simulation of metal forming processes can be divided into well-oriented (Ansys) and single-issue (Deform, Qform) [4].

ANSYS/LS-DYNA can simulate almost all of metal forming processes, ranging from a simple hem or rainfall harvesting, finishing deformation multi-layered materials or stamping explosion [6]. At the same time, in contrast to theoretical calculations, where there are significant restrictions on the size and shape of the workpiece, there are virtually no restrictions on these parameters.

The main difficulty in the simulation program ANSYS/LS-DYNA is the presence of a large variety of menus and parameters that require input that requires a high training and understanding of the process and the need for high-performance systems to address them.

QFORM program is a handy tool for the simulation of unsteady processes bulk metal forming in hot, cold and warm [3]. The metal can be in a compact and porous state (metal powders). QFORM allows you to simulate forging (open and closed), free forging, pressing, bending, and electric. Besides program simulates the intermediate operations and processes, natural part of the production chain, such as cooling the workpiece in the air

and tool, punching holes and flash trimming, tilting the workpiece and its positioning under the influence of gravity.

DEFORM - specialized software package designed for process simulation of metal forming, heat treatment and machining, developed by U.S. company Scientific Forming Technologies Corporation (SFTC) [5].

DEFORM can simulate almost all the processes used in metal forming (forging, stamping, rolling, pressing, etc.), as well as the operation of heat treatment (quenching, aging, vacation, etc.) and machining (milling, drilling, etc.).

The advantages DEFORM can include the following:

- Universality, the program allows simulate a wide range of processes used in the production.
- Compatible with most software packages for creating, geometric models and generation of finite element mesh.
- A great opportunity for self- generation of finite element mesh.
- The possibility of using different models of plasticity.
- A large database on the characteristics of materials and forging equipment, as well as ample opportunities for their editing and adding.
- The ability to simulate different conditions of friction between the workpiece and the tool.
- Wide range of modeling various kinds of the tool.
- Simple and intuitive interface.

Program complex DEFORM has a flexible modular structure, allowing the user to select and purchase the best set of modules under the nomenclature of tasks.

#### 1. General information about the simulation of metal forming processes

Modeling of metal forming processes based on the fact that the metal flows in the direction of least resistance [7]. Deformation strength is determined depending on the size of the preform, its shape and material properties of friction. Furthermore, by modeling can determine important parameters such preform as accumulated strain, stress, temperature, direction of the fibers, the possibility of destruction of the workpiece, the wear of the tool.

In autumn 2006 the Department of metal forming in Karaganda State Industrial University (KGIU) was purchased program complex DEFORM 2D/3D. For almost seven years the department staff has done much not only for the study of the known processes such as forging, stamping, rolling, pressing. With this program actively under development and research of new, innovative technological processes, the basic principle of which - it is a high-quality metal with minor changes starting billet size with minimum energy consumption.

## 2. The developed models of metal forming processes

When working in this program by varying different geometrical and technological parameters of the process can be found optimal conditions for reducing deformation force, uniform distribution of accumulated strain and temperature. Also, using this software complex we have ability to see possible occurrence of various defects on the workpiece. Using rational deformation parameters helps to avoid the appearance of these defects.

Thus, the optimal parameters were determined deformation during pressing blanks in matrices of various designs, such as equal channel angular, step and matrix with rollers (Fig. 1) [10].

In addition, using this software has been successfully

developed and put into practice a new way of getting high-quality pieces - combined process “rolling-pressing” (Fig. 2) [9].

Initially, the development of this process to the employees of the department have a problem - in a laboratory experiment, billet stuck in a downward channel matrix, despite the fact that all the geometrical and technological parameters of the process were calculated in advance. In the simulation process with the same parameters as happened jamming of billet (Fig. 3).

The reason for this was the fact that the calculations used by the present value of deformation resistance, which actually corresponds to an isothermal process. In the simulation was chosen nonisothermal type of calculation, so the workpiece during deformation cooled. With this factor and adjusting all other parameters resulting model was successful (Fig. 4).

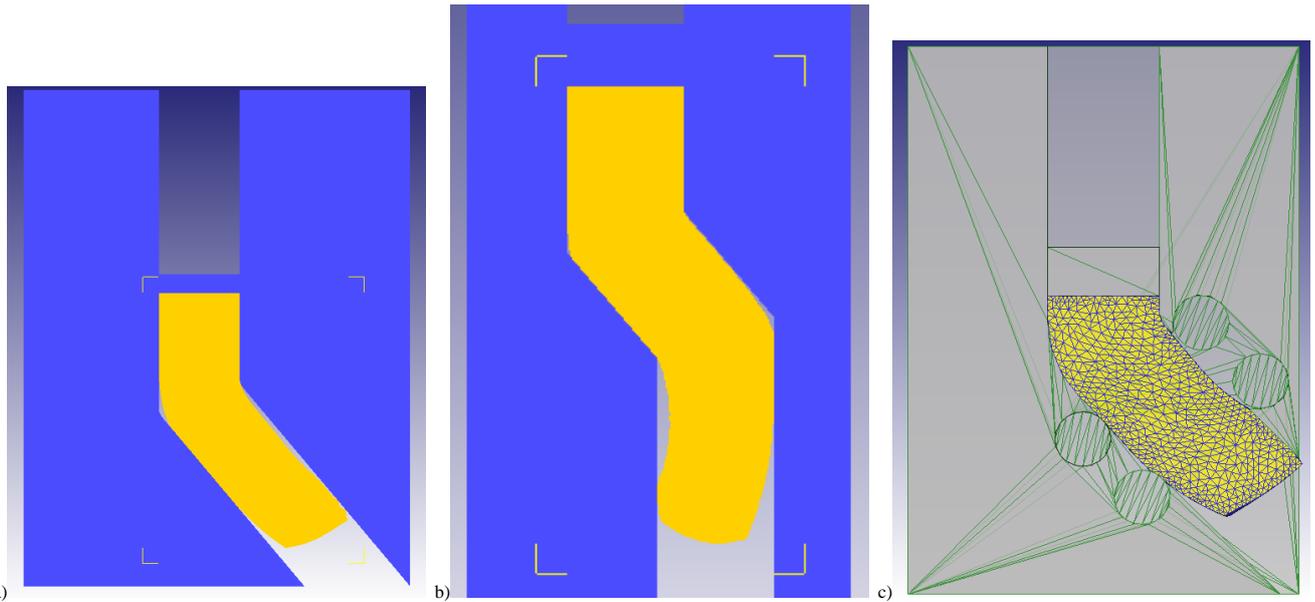


Fig. 1. Pressing of billets in matrices of various designs: a) angular matrix, b) step matrix, c) matrix with rollers

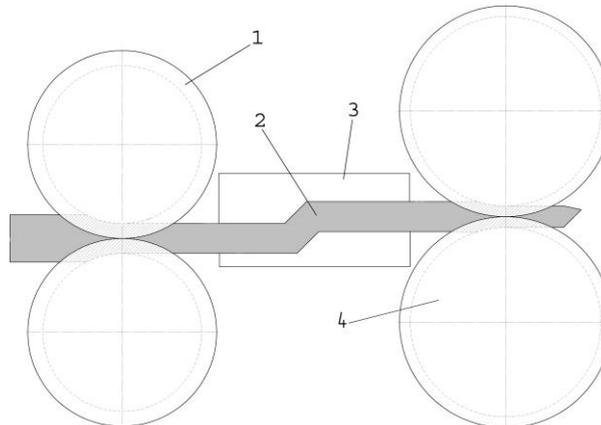


Fig. 2. Combined process “rolling-pressing”: 1 – the first pair of rolls, 2 – initial billet, 3 – equal channel step matrix, 4 – the second pair of rolls

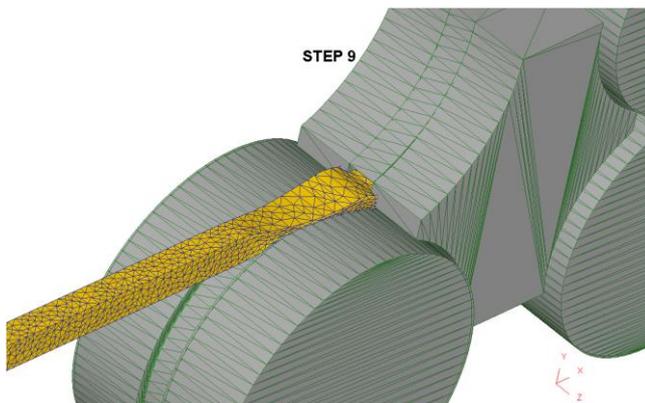


Fig. 3. Pressing out of billet

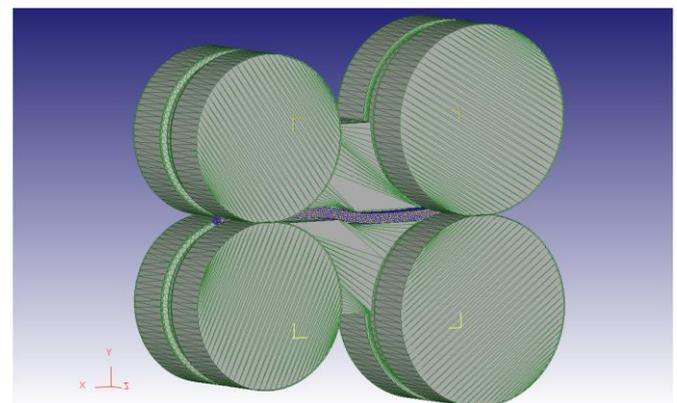


Fig. 4. Successful model of the combined process “rolling-pressing”

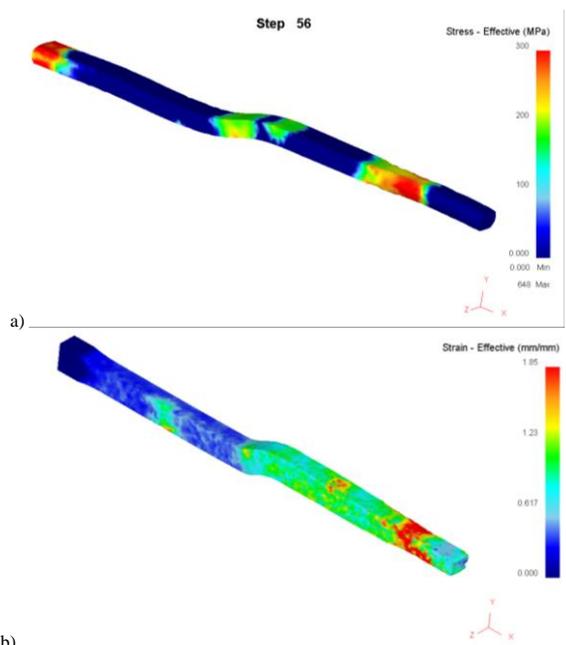


Fig. 5. Investigation of the distribution of SSS: a) study of the stress state, b) study of the strain state

By varying different geometrical and technological parameters of this method of deformation was found their optimal values not only for the possibility of the combined process of “rolling-pressing”, but also for the formation of a favorable distribution of stress-strain state (SSS) in the entire volume workpiece to obtain metal with subultrafine grain structure (Fig. 5) [8].

To validate the simulation was decided by a repeat of the laboratory experiment. For this was made matrix of new design with new geometric dimensions, as well as a new form of the workpieces. As a result, the experiment was successful, all samples were successfully deformed (Fig. 6).

### 3. Conclusion

Beginning with the fifth version, the program DEFORM acquired a modular system that now allows you to use it not only for studying the problems of metal forming, but metal science. For this purpose provided modules Microstructure and Heat Treatment, which were recently purchased by the department in Karaganda state industrial university.

At the moment, many technical colleges and universities have already realized the importance of simulation of metal forming processes in the development process and, therefore, give the issue more attention.

The study of metal forming processes via computer simulation to better understand the specifics of each process metal, explore its features and problems.

Therefore, at the Department of metal forming in Karaganda State Industrial University simulation of metal forming processes were allocated to a separate discipline.

### References

- [1] Anderson R., Richardson A.: Framework to raise value-adding capabilities of members. Forging Technology 11/2002, 4–6.
- [2] Benchmarks Summary and Comparison of Results. International Conference “Metal Forming Process Simulation in Industry” Stuttgart, 1994.
- [3] Biba N.V., Stebunov S.A.: QForm - program designed for technologists. Forging and stamping production. Metal Forming 9/2004, 38–41.
- [4] Chumachenko E.N., Polyakova T.V., Aksenov S.A.: Mathematical modeling of non-linear mechanics. IKI RAS, Moscow 2009.
- [5] Harlamov A., Uvarov A.: DEFORM - software package for the simulation of metal forming processes. CAD and Graphics 6/2003, 27–29.
- [6] Ilyushkin M.V.: Modeling of metal forming processes in the program ANSYS. LS-DYNA. ULSU, Ulyanovsk 2012.
- [7] Storozhev M.V.: Popov E.A.: Theory of Metal Forming. Mechanical Engineering, Moscow 1971.

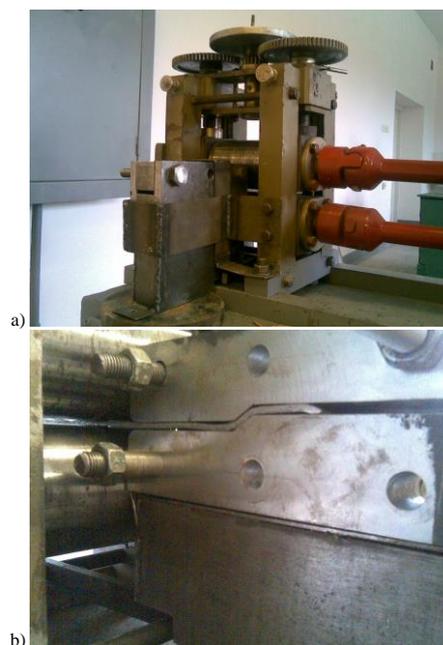


Fig. 6. Laboratory experiment: a) common view of the laboratory equipment, b) workpiece during deformation

- [8] Naizabekov A.B., Lezhnev S.N., Panin E.A. Simulation of the joint ‘rolling-extrusion’ process using equichanneled step die. 17-th International Conference on metallurgy and materials METAL-2008, Ostrava, Czech Republic, 13–15.5.2008. Hradec nad Moravici.

- [9] Naizabekov A.B., Lezhnev S.N., Panin E.A.: Theoretical research of combined process “rolling-pressing” with the use of equal channel echelon matrix. High schools. Ferrous metallurgy 6/2008, 22–26.

- [10] Naizabekov A.B., Nogaev K.A., Lezhnev S.N., Panin E.A.: Investigation of the influence of geometric factors in equal-channel compression on the power parameters of deformation. Technology of production of metals and recycled materials 2/2008, 52–59.

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