Printed as manuscript

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DEVELOPING COMPUTER MODELS AND PROCESS RESEARCH OF HOT FORGING ALUMINUM ALLOYS FOR PERFECTION STAMPING TECHNOLOGY CIRCULAR IN PLAN FORGINGS

Master's Program Metal and Alloys Forming under Pressure

The abstract of the Master's Thesis

Krasnoyarsk 2014

The thesis work is done at the Department of «Metal Forming Under Pressure» Federal State Autonomous Educational Institution of Higher Professional Education «Siberian Federal University»

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GENERAL DESCRIPTION OF THE THESIS WORK.

Significance of the work.

The aluminum deformable alloys are widely used in industry as the structural material, and one of the main ways to obtain blanks for details of these alloys is such kind of metal forming, as hot forging. Thanks to its high plasticity aluminum alloys stamped forgings may have a complex shape with sharp transition sections and such elements as stiffeners, rifts, boards, etc. But complication of the form leads to complication of technology stamping and so getting forging complex shapes requires careful development of technological processes, in which different types of stamps can be used; number of transitions, deformation modes, etc. can be varied. The procedure of the technology development, launch equipment, testing, etc., demand great costs, however, research and experiments in the real manufacturing process have the following shortcomings:

- big energy consumption and risk of getting substandard products;
- impossibility or high cost of parameters changing process in wide range;
- probability of an accident and breakage of equipment, etc.

In connection with the above the use of modeling in the technological processes development of hot forging should be considered significant, as far as it allows to lower costs of this procedure and to make it optimal.

This thesis is carried out within the terms of the cooperation agreement between the Siberian Federal University and OAO Krasnoyarsk Metallurgical Plant.

Subject of the research is development of regimes of hot deformation of volume semi-finished products from aluminum deformable alloys.

The aim of master's thesis is to develop the regimes of aluminum alloys hot processing and to develop a computer software for the support of hot stamped semi-finished products technology production.

Objectives of the research:

– to study the existing technology of hot formed semi-finished products from aluminum alloy АК6 manufacturing for engineering;

– to develop the computer models on the software package DEFORM for the analysis of forming and developing of volumetric semi-finished products of aluminum deformable alloys technological processes production as well as designing stamping tools;

– to develop a computer model algorithm of hot volume stamping forgings of aluminum alloys technological process.

Scientific novelty of this work:

1. On the basis of computerized modeling of hot die circular forging «The lid» from aluminum alloy АК6, performed on the software package DEFORM, there was obtained the dependence of power parameters process on the stamping time and the consistent forming from the blank to finished forgings when punching in closed and open die was shown.

2. The methods were improved and the algorithm for constructing a computer model of hot die forgings of aluminum deformable alloys was conducted.

The practical significance of the thesis:

1. The computer model algorithm for technological process of hot die forgings of aluminum deformable alloys on the software package DEFORM is developed; it corresponds with the normative documents.

2. Optimal parameters hot die forging circular in plan forgings «The lid» from aluminum alloy АК6 were installed.

3. The simulation results have been successfully experimentally tested on a number of forgings in the enterprise OAO Krasnoyarsk Metallurgical Plant.

4. The results obtained in the process of research can be used in metallurgical production when developing the technological processes of hot forging of aluminum deformable alloys and implemented in the educational process for preparation of bachelors and masters in the major 150400 - Metallurgy.

Personal contribution of the author

All results of research were obtained in collaboration and personal involvement of the author, the main of which are as follows: the analysis of the scientific literature; modeling process of hot die forging of aluminum deformable alloys; the development of the computer model algorithm of the technological process of hot die forging of aluminum deformable alloys on the software package DEFORM; processing; systematization and analysis of the results.

Place of performance of the thesis: "Metal Forming Under Pressure" Department of the Institute of Nonferrous Metals and Materials, Federal State Autonomous Educational Institution of Higher Professional Education "Siberian Federal University", OAO Krasnoyarsk Metallurgical Plant.

Place of International internship. International Academy of Management and Technology (INTAMT) (Dusseldorf, Federal Republic of Germany).

Work approbation. Obtained results of dissertation and its separate parts were reported at:

- The International Congress «Non-ferrous metals» (Krasnoyarsk, 2012, 2013);
- All-Russian Scientific Conference Siberian Federal University with international participation «Youth and Science» (Krasnoyarsk, 2013).

Publications:

The results of the thesis are presented in 4 publications.

Volume and structure of the thesis:

The thesis consists of an introduction, three chapters and a conclusion. It contains _____typewritten pages, ___ drawing, __ tables, bibliography of ___ positions and ___ applications.

CONTENTS OF WORK

Introduction substantiates the urgency of the theme and the purpose of work is formulated, the novelty and practical significance are noted.

The first chapter examines principles used for metalworking technologies development, describes the basic methods of modeling used in metal forming processes, sets out the main provisions of Finite Element Methods (FEM), presents an overview of computer programs, describes the technology of hot die forging of aluminum al-

loys, gives the characteristics of faulty forgings, lists the criteria of economic efficiency of the developed technological processes, gives the algorithm for creating a computerized model of hot die forging, provides information about developments using computer modeling for processes of hot die forging of aluminum alloys.

A review of the literature sources showed the relevance of computer modeling application for hot forging aluminum alloys processes. In this most promising use for these purposes such program complexes as QFORM and DEFORM recommended themselves in a good way. But at the same time in most of the examples only fragments of the technological processes of hot die forging are shown and there are no data about computerized modeling of real forming processes , from the beginning to the end with their detailed analysis, that would make certain adjustments in these processes and serve as a landmark in the subsequent technological processes for such forgings. The following tasks were to be solved:

1. to make the analysis of the present technological process of an aluminum alloy hot die forging.

2. to develop a computerized modeling of the chosen technological process.

3. to examine the character of the flow, the stress-strain state of the metal blank and energy-force parameters process of hot forging.

4. to prepare recommendations to correct the present technological process.

The second chapter presents the characteristics of the test material: aluminum deformable alloy AK6, including chemical composition, appointment, application, technological, mechanical and rheological properties, kinds of heat treatment and requirements, requirements to semi-finished products of alloy; gives a description of the manufacturing process analog; describes the methodology of computer simulation technological process of hot forging aluminum alloys using the computer program SolidWorks and DEFORM-3D; shows the step by step sequence for constructing the computer technology of hot forging.

The third chapter represents the computerized modeling process of hot forging, which type is «The lid», from aluminum alloy AK6.

The development of computer modeling started with the creation of block diagrams of the modeling process of hot circular forging (fig. 1).

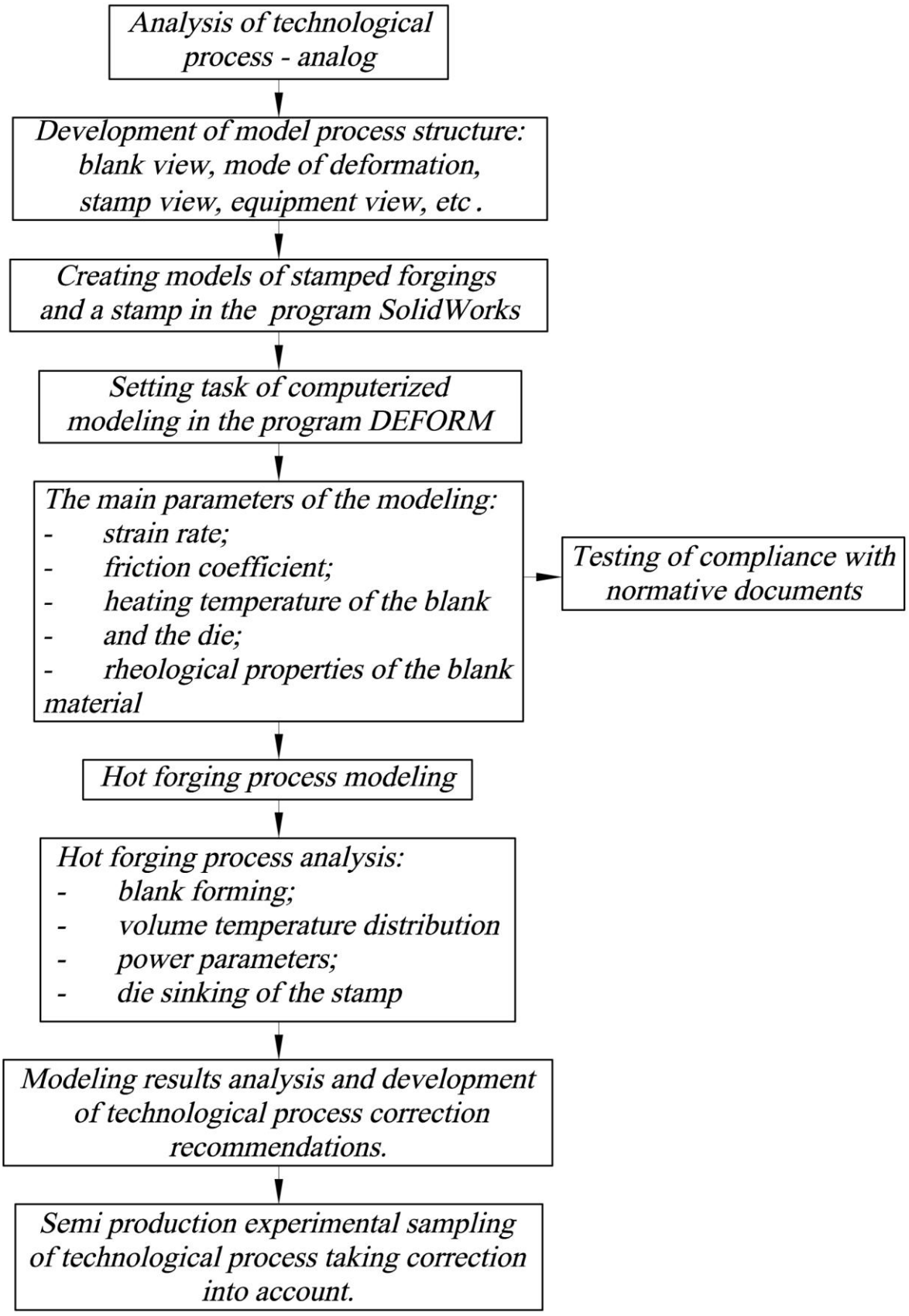

Figure 1 – Block diagram of the aluminum alloys hot forging modeling process

The research started with the analysis of stamping forgings *«The lid»* technological process. Then on the basis of the drawing die forging with the help of *SolidWorks* a three-dimensional model of the forging and stamps was created; then it was downloaded into the program *DEFORM-3D* and the calculation started. This virtual experiment was conducted for both open and closed die.

Technological processes modeling allowed to follow the process of blank forming and to show the temperature distribution directly inside the blank for open (fig. 2) and closed (fig. 3) stamping.

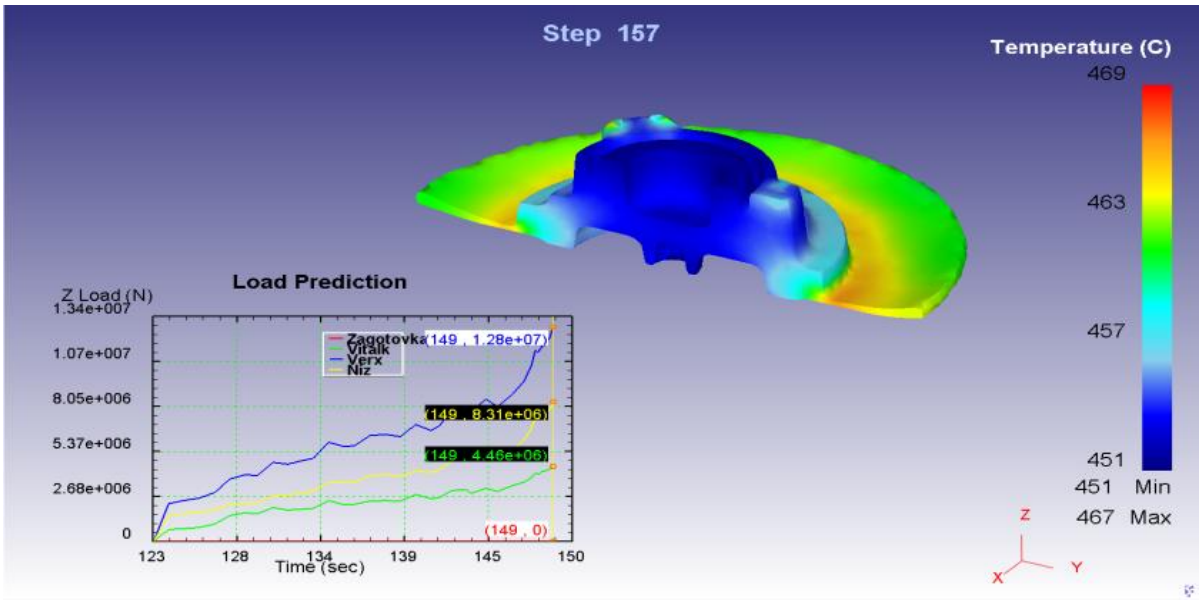

Figure 2 – The model of blank forming during open stamping

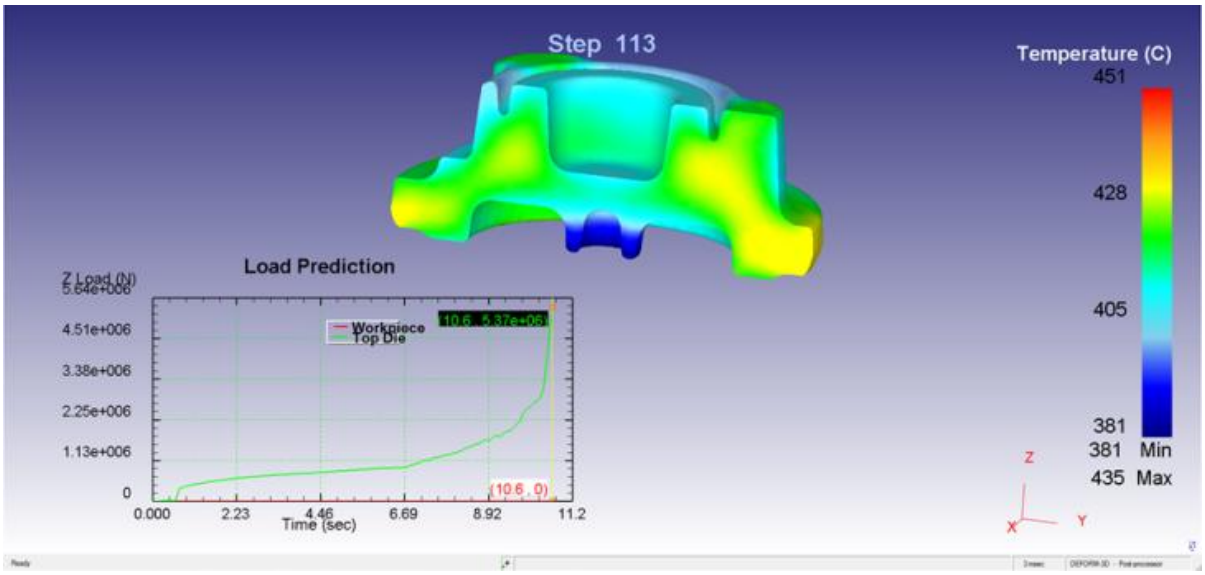

Figure 3 – The model of blank forming during closed stamping

To studying the metal flow character during stamping (fig. 4) the forming process was combined with the depending on time force graph stamping.

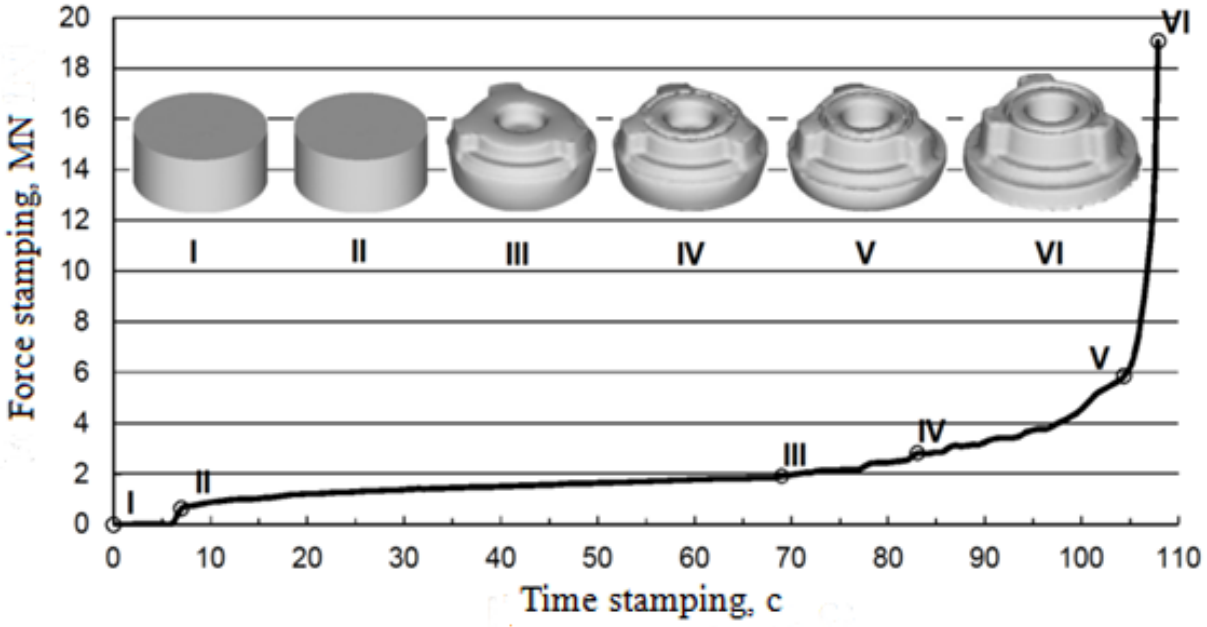

Figure 4 - Changing of the stamping force and blank forms during stamping modeling in a closed die

The modeling process showed that during stamping in a closed die the complete forging design cannot be achieved, in particular, there remain unfilled lugs on the forgings' surface. The stamping force increases and it can result in the destruction of the die.

For comparison and analysis the modeling process was also carried out in an open die (fig. 5).

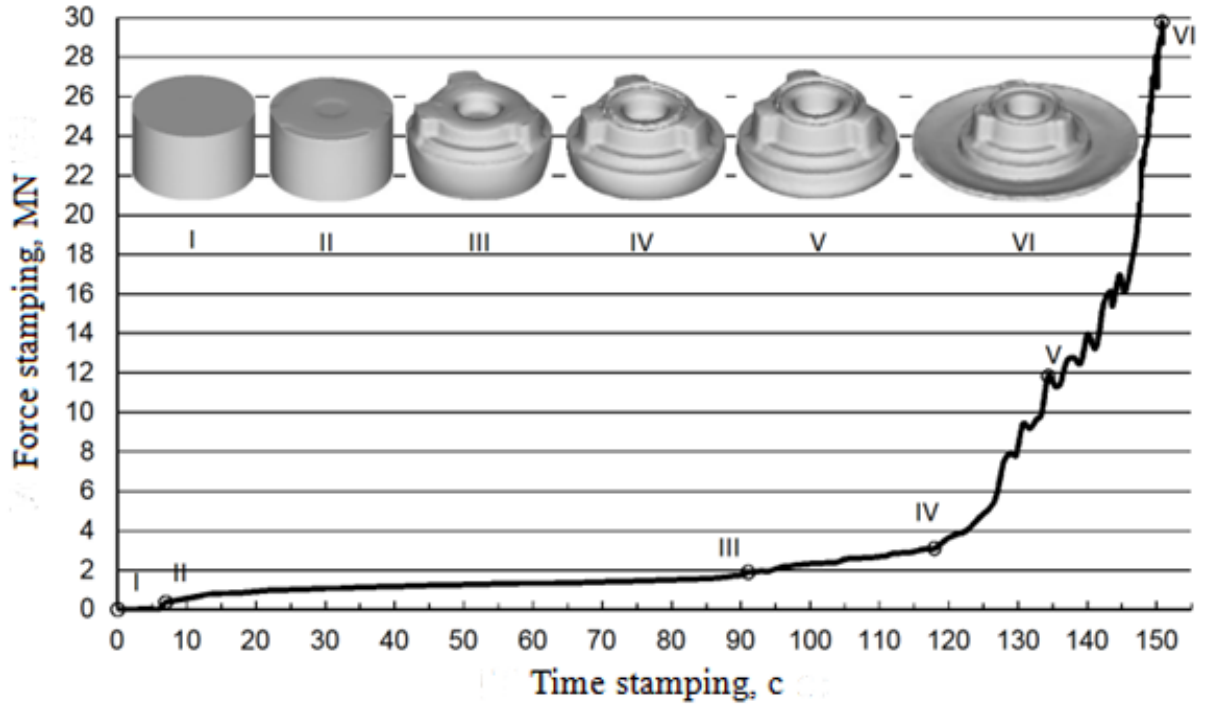

Figure 5 - Changing of the stamping force and blank forms during stamping modeling in an open die

The analysis of the chart and blank changing showed that the final forging design, including small relief elements, occurred before forming in the stamping time interval of 135 – 150 c (fig. 5).

According to the modeling results the recommendations for the present technological process correction were given.

Conclusion presents the main developments and results.

MAIN RESULTS AND CONCLUSIONS

The analysis of the work led to the following conclusions:

1. The computerized modeling in the program DEFORM is advisable to use for studying forming at hot forging of aluminum alloys, during both the technological process and for the corrections of the present process, because it allows to follow the step-by-step die sinking; to assess the power parameters of the process, the temperature distribution in the blank; and to escape faulty forgings.

2. In the studied technological process of hot forging from aluminum alloy АК6 the operation of shortening should be excluded; the stamping process should be conducted in one press; the nominal stamping press force should be lowed to 50 MN.

3. Corrections of the technological process of stamping forgings «The lid» can be conducted unchanged using die tooling.

The improved hot forging technological process has successfully been tested at the enterprise OAO Krasnoyarsk Metallurgical Plant.

MAIN PROVISIONS OF DISSERTATION PUBLISHED IN THE FOLLOWING

1. **Astrashabov, I. O.** The use of computerized modeling at development technological processof aluminum alloys stamping using the superplasticity effect / I.L.Konstantinov, U.V.Gorohov // Non-ferrous metals-2012: Compilation of scientific papers. – Krasnoyarsk: Verso, 2012. – C.850 – 853.

2. **Astrashabov, I. O.** The use of computerized modeling at the development of hot volumetric stamping aluminum alloys technology. / I.L.Konstantinov, I.U.Gubanov, N.A.Belan // Non-ferrous metal-2013: Compilation of scientific papers. – Krasnoyarsk: Verso, 2013. – C. 610 – 611.

3. **Astrashabov, I. O.** Computerized modeling processes of aluminum alloys hot forging. // N.A.Belan, D.V. Klemenkova // The source book of the IX All-Russian scientific and technical conference of students and young scientists “Youth and Science”,/ SFU ; (PDF, 14,8 Мб). - Krasnoyarsk, 2013. – C.58 – 61.

4. «Accepted for publication in 2014 » **Astrashabov, I. O.** Modeling the process of hot volumetric forgings from aluminum alloy АК6// I.L.Konstantinov, I.U.Gubanov, S.B.Sidelnikov, N.A.Belan. Proceedings of Higher Education «// Non-ferrous metallurgy», 2015, №1.