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**RESEARCH AND DEVELOPMENT OF STAMPING TECHNOLOGY FOR
ELECTROTECHNICAL DETAILS OF COPPER AND ITS ALLOYS**

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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Doctor of Engineering,
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Sergey. B. Sidelnikov

GENERAL DESCRIPTION OF THE THESIS

Significance of the work. Currently, the Russian space program is actively developed; specialized machines of strategic purposes as well as civic devices such as navigation satellites are being constructed. Satellites are solar-powered that's why solar panels should turn periodically and absorb solar energy. For this purpose a system for turning solar panel was worked out. This system uses such an element as a collecting ring, providing electrical communication, commands and signals between the rotating solar panels and the spacecraft, both during rotation and in a stopped state. Its fixation is implemented by means of the mechanical contact with both sides. Among other things, the collecting elements should have resilient properties, and therefore they are made from alloy BrB2 because this material has high level strength and elastic properties. The requirements for their production are very complex.

Subject of the research is development of stamping technology for electrotechnical details and assessment of the structure and mechanical properties of the samples.

The aim of master's thesis is to increase a metal use coefficient; to reduce the number of defects; to form structure and to increase wear resistance.

There are several **tasks** to reach it:

- to create new technology for obtaining collecting rings blanks from alloy BrB2 with given size and properties.
- to develop stamping equipment

Scientific novelty of this work:

1. A new technology for production of semi-finished alloy BrB2 was created, which resulted in utilization rate of metal increasing by several times.
2. The result of the cold sheet stamping ensured crushing structure product that will undoubtedly have a positive impact on the mechanical properties of the parts.

Practical significance of the work:

1. New technology for collecting elements has been developed.
2. A new approach to the product manufacturing reduces costs on the process of production and improve mechanical properties as well.
3. The research results show that at high speeds it is necessary to use an intermediate heat treatment, which reduces the chance of breaking the sample.
4. The results are used in space engineering industry.

Personal contribution of the author:

All research results were obtained in collaboration with the personal involvement of the author, the main ones are: development of die tooling; processing and analysis of studies of the semi-finished items from BrB2 properties; experimental studies of samples of beryllium alloys.

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

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

Work approbation:

Obtained results of the thesis and its separate parts were reported at:

- The annual International Congress «Non-Ferrous Metals" (Krasnoyarsk, 2013.);
- Annual All-Russia Scientific Conference of Siberian Federal University with international participation "Youth and Science" (Krasnoyarsk, 2013, 2014.).

Publications: The results of the thesis are presented in 5 publications, one of which was published in a journal included in the list of recommended publications by the higher certifying commission.

Volume and structure of the thesis:

The dissertation consists of an introduction, two chapters and a conclusion. It contains _____ typewritten pages, _____ drawing, _____ tables, bibliography of _____ positions and _____ applications.

CONTENTS OF WORK

Introduction. The urgency of the topic was grounded and the purpose of the work was formulated, noting its novelty and practical significance.

The first chapter deals with the characteristic features of the material from which the semi-finished product is manufactured; its mechanical and physical properties. Also there given the industry where this material is used as details for critical applications, thanks to a number of specific properties. The methods for obtaining semi-finished collecting elements with given properties have been analyzed.

The analysis of scientific, technical and patent literature allowed to make the following conclusions:

1. Beryllium bronze is a unique material for electronics and electrical engineering.
2. Semi-finished products made from beryllium bronze are very useful for such promising industries as: computer equipment, modem and mobile communications, oil and gas.
3. Manufacturers of beryllium bronze supply the customer with a wide range of semi-finished products with the mechanical properties achieved by both plastic deformation and by various types of heat treatment, but there's a probability of anisotropy properties presence.
4. Cold sheet stamping method will ensure full implementation of the requirements given by the customer.

Tasks of the thesis work were formulated based on the findings.

The second chapter provides a methodology to determine the degree of deformation on transitions and method for making rings, that is stamping. As a result, a hollow article (glass) with an open top with the required (or close to the set) size was obtained. The transitions in the drawing without thinning and with thinning were calculated, semi-finished sizing in transitions were defined, the diameter of flat blank

was calculated, and the equipment was chosen. Calculations have shown that for such a product six transitions drawing are needed, and it requires at least one operation of the intermediate heat treatment.

To determine the feasibility of this technological scheme stamping equipment was designed and tested. Fig. 1 shows drawings of universal exhaust stamp for details set size, and Figure 2 shows detailing of one of the transitions drawing.

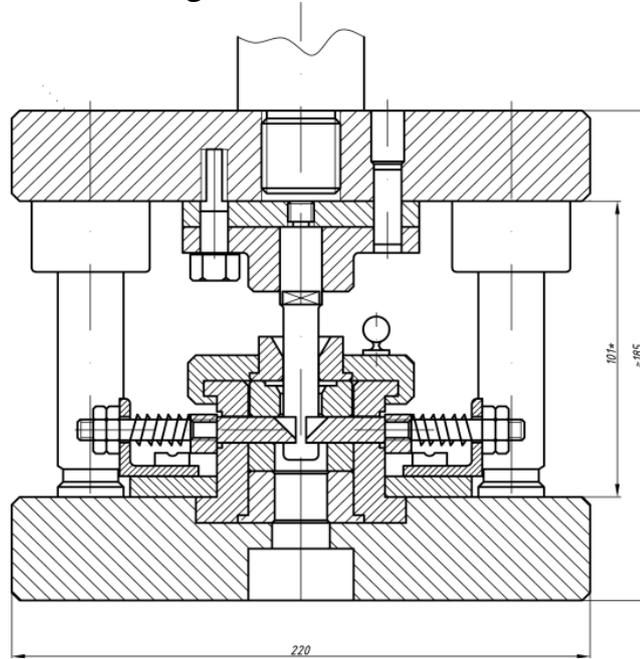


Figure 1 - Schematic exhaust stamp

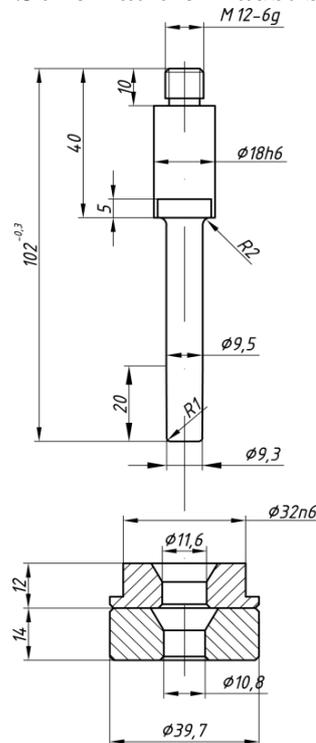


Figure 2 - One of the variants of the working tool for semi-finished products with outer diameter of 10.8 mm

The studies of the strain rate effect on the precipitation process are also presented as well as the study of the obtained samples microstructure.

Four transition drawings were made at a rate of 5 mm / s and the resulting sample was subjected to metallographic analysis. Research has shown that at high speed grains are crushed more intensively but due to the material hardening after the fourth transition there happens a breakdown and, therefore, it is necessary to use an intermediate heat treatment (quenching). Quenching allows you to remove the residual stresses after deformation and normalize the structure, it is advisable to apply quenching after the third transition. Grain size and hardness of the third transition is: $12,4 \pm 2,4$ micrometers and 314 ± 19 HV, and after hardening and final drawing it is: $17,3 \pm 5,4$ micrometers and 268 ± 5 HV. The obtained semi-finished product was subjected to aging and its hardness was 427 ± 4 HV. Figure 3 shows the structure of the sample.



Figure 3 - Microstructure of sample after sixth drawing with increasing x500

In conclusion the main conclusions and results are presented.

MAIN RESULTS AND CONCLUSIONS:

1. The new technology for collecting equipment allowing to lower the complexity of manufacturing rings was developed.
2. Thanks to new technology the number of menders has significantly decreased, while metal utilization factor (MUF) increased tenfold.
3. The structure was studied and wear resistance of details was increased.
4. The structure of semi-finished and the strain rate dependence were studied.

CONCLUSION

The developed cold sheet stamping technology allows to receive details at less cost, which fully meets given requirements.

**MAIN PROVISIONS OF THESIS ARE
PUBLISHED IN THE FOLLOWING:**

1. Wagner, AV Development of die tooling to produce blanks for slip-rings made of beryllium bronze / A.V.Vagner, A.N.Korobkin // Youth and Science: Sat materials IX All-Russian conference with international participation, devoted 385 anniversary of the founding of the city of Krasnoyarsk [electronic resource]. - Krasnoyarsk, 2013. Access mode: <http://conf.sfu-kras.ru/sites/mn2013/thesis/s007/s007-028.pdf>

2. Wagner, AV technology and design tool for slip-rings for special purposes / S.B.Sidelnikov, V.I.Ber, T.A.Orelkina, AN Korobkin, A.V.Vagner // Non-ferrous metals 2013: Coll. Nauchn. articles. - Krasnoyarsk: Verso, 2013. - S. 612 - 613

3. Wagner, AV Development of technological schemes of slip-rings made of beryllium bronze with methods stamping / S.B.Sidelnikov, V.I.Ber, T.A.Orelkina, A.N.Korobkin, AV . Wagner // Proceedings of the MSTU "MAMI". Scientific peer-reviewed journal. Series 2. Engineering technology and materials. - M., MSTU "MAMI», № 2 (16), 2013, v.2. - Pp. 45 - 48. (recommended publications by the higher certifying commission.)

4. Wagner, AV Development of new technology for electrical purposes stamping blanks of copper alloys / A.V.Vagner // Special engineering education - training of modern engineering personnel [electronic resource]: I theses regional scientific conference undergraduates November 19, 2013 year / Sib. a fed. Univ; Num. for MY. EA Shipilova. - Electron. text data. (PDF, 14,8 MB). - Krasnoyarsk: SFU, 2013. - P.25 - 28

5. Wagner, AV Investigation of influence of strain rate on the technological parameters of drawing blanks from beryllium bronze / A.V.Vagner // Youth and Science: All-Russian conference with international participation [electronic resource]. - Krasnoyarsk Sib.feder.un-t, 2014