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**RESEARCH AND DEVELOPMENT OF PRODUCTION TECHNOLOGY  
SHEET STAMPING PARTS OF COMPLEX SHAPE FOR THE NEEDS OF  
SPACE ENGINEERING**

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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- choice of waveguide filler for implementation of process of bending with obtaining demanded properties;
- research and analysis of existing prefabricated variants of waveguides;
- production of new prefabricated variants.

#### **Scientific novelty of work.**

1. According to the experimental data and calculations there was received the confirmation, that by the traditional ways of bending for relatively small wall thickness it is impossible to get bent waveguide of rectangular alloy AD31 at a 90 degree angle to bend radius ratio  $S / R$  (where  $S$ -thickness wall,  $R$ -bending radius) in the range of  $0,04 \div 0.05$  without changing the wall thickness at its outer radius within tolerance without corrugation formation on its inner radius and on the side wall.

2. New fillers for the process of bending of rectangular section waveguides of an alloy AD31 by an angle of 120 degrees with a wall thickness of 0.65mm were developed.

#### **Practical importance of work.**

1. New installations for bending of waveguides, that allow to implement the bending on angle of 120 degrees, were developed.

2. New prefabricated variants, which in turn have a number of advantages over existing, are offered.

3. Results can be used in space mechanical engineering details production.

#### **Personal contribution of the author.**

All results of research are received in a co-authorship with personal participation of the author, basic of which are as follows: the development of new installations constructions for waveguides bending; selection of fillers for waveguides bending; development of technology of receiving new prefabricated variants.

**Place of the thesis implementation.** Department of Metal Forming of Institute of Nonferrous Metals and Materials of Federal State Autonomous Educational Institution of Higher Professional Education "Siberian Federal University ."

**Place of international internship.** International Academy of Management and Technology «INTAMT» (Dusseldorf, Germany).

**Work approbation.** Basic provisions of the thesis are presented at the following conferences and congresses: annual All-Russian scientific and technical conference of the Siberian Federal University with the international participation "Youth and science" (Krasnoyarsk, 2013); scientific and technical conference of undergraduates "Vocational engineering education: preparation of modern engineering personnel"; All-Russian scientific and practical conference "metallurgy: technologies, management, innovations, quality" (Novokuznetsk, 2013).

**Publications.** Results of the thesis are reflected in three printed works.

**Volume and structure of the dissertation.** The thesis consists of an introduction, three chapters and a conclusion. It contains 80 typewritten pages, 66 figures, 6 tables, bibliography of 26 positions and 1 application.

### **CONTENT OF WORK**

**In introduction** the topicality of the subject is proved and the work purpose is formulated, novelty and practical importance are noted, and also results of the internship are reflected.

**The first chapter** analyzes the range of tubular and rectangular section products received by bending, their field of application, the materials of which they are made, leading manufacturers of bending equipment; the classification of equipment depending on the destination, the basic scheme and bending methods existing nowadays are considered, several variants that are used for waveguides bending are analyzed.

The carried-out analysis of scientific and technical and patent literature allowed to draw the following conclusions:

1. One of the main tendencies of development in the field of bending is bending of thin-walled pipes and profiles, which in turn complicates the bending process.

2. Choice of filler for waveguide tube plays a significant role in the process and has to provide rigidity and at the same time be plastic.

3. Existing methods and equipment for bending allow to bend tubes and profiles only with a wall thickness of 1mm, the material of steel are mainly used. This determines the urgency of the development of new methods and schemes of bending which would enable to carry out bending of more thin samples of various alloys.

4. It is expedient to develop new fillers, that could provide the required properties for bending thin samples.

5. According to the drawn conclusions the following tasks of the thesis were formulated:

**In chapter 2** some installations are presented, which were developed and assembled on Department of Metal Forming for bending profiles of rectangular section, and one of installations allowed to carry out bending of waveguide tube on 120 degrees with the required surface quality (Fig. 2). As a filler lead was used.

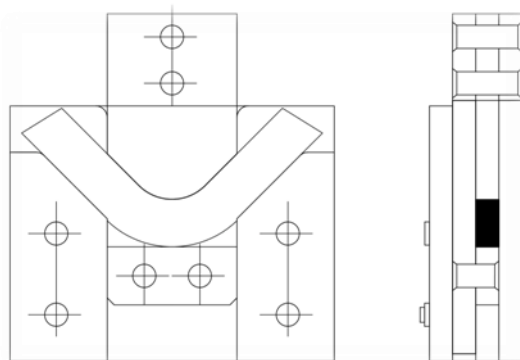


Figure 2- The installation scheme for waveguide bending on 120°

The sample is presented in figure 3:



Figure 3- Sample of waveguide with a bend angle of 120°

Also in the second section the parameters that were obtained by simulation of the bending process in the software package Deform™ 3D were described, which considerably helped at designing the construction and carrying out the process in practice.

There is the calculation, which confirms and proves that the process of obtaining smooth bends at an angle of waveguides 90° by using the bending process is impossible and remains unresolved. Therefore there is necessity of design of prefabricated variant, better in its characteristics than existing.

In the laboratory of Department of Metal Forming two prefabricated variants were developed (Fig. 4 and Figure 5):



Figure 4- Prefabricated variant №1

The second variant is similar in construction to the first one, but differs in manufacturing technology and in fewer welding seams, which in turn improves significantly the distribution of microwaves within the waveguide and reduces the resistance which leads to heating.

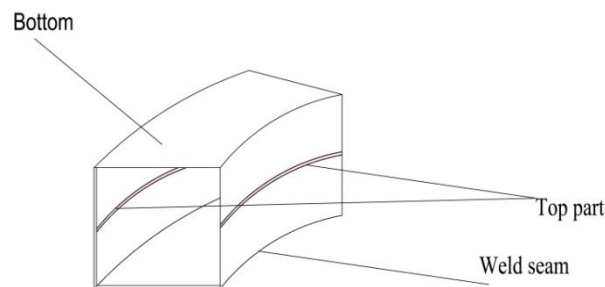


Figure 5- Prefabricated variant №2

Some of advantages of these prefabricated variants are described.

**In conclusion**, the key findings and results as well as recommendations for bending are presented.

## KEY RESULTS AND CONCLUSIONS

1. Installation for waveguides bending, which allows bend on  $120^\circ$ , is developed and collected.

2. Several versions of fillers for waveguides that enable defect-free bending are developed.

3. Existing ways and schemes of thin-walled profiles bending, both in Russia and abroad, are analyzed.

4. The existing technology of manufacturing and design of prefabricated variants of waveguides is analyzed, shortcomings, improvement ways are defined.

5. Two new prefabricated variants are developed, which will have a number of significant advantages over the existing ones.

## CONCLUSION

Thus, the results allow to improve the technology of producing smooth bends of waveguides on an angle  $90^\circ$  (prefabricated variants) and on large angles (using installation for bending that was developed at the Department of Metal Forming).

## BASIC PROVISIONS OF THE THESIS ARE PUBLISHED IN THE FOLLOWING WORKS:

1. **Ivanov A.G.** Research and development of production technology sheet stamping parts of complex shape for the needs of Space Engineering / A.G. Ivanov / 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/s007-014.pdf>

2. **Ivanov A.G.** Research and development of production technology sheet stamping parts of complex shape for the needs of Space Engineering / V.I. Behr , S.B. Sidel'nikov, A.G. Ivanov / Metallurgy : technology, management , innovation, quality : Works XVII Russian scientific and practical conference / ed. E.V. Protopopov ; Sib. Reg. industry. Univ . - Novokuznetsk / SibGIU , 2013 . - 414., fig. p .171-173.

3. **Ivanov A.G.** Research and development of technology of waveguides complex shape bending for the needs of Space Engineering / A.G. Ivanov / Special engineering education - training of modern engineering personnel [electronic resource] : theses of I regional scientific conference of undergraduates, November 19, 2013 / Sib. Fed . Univ ; resp. for perf . E.A. Shipilova . - Electron . text data . (PDF, 14,8 MB). - Krasnoyarsk: SFU , 2013 . - P.35 -39.