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RESEARCH AND DESIGNING OF COMBINED CASTING, ROLLING-EXTRUDING PROCESS FOR PRODUCING ROD FROM AVE ALLOY AND FEASIBILITY STUDY

Master's Program Metal and Alloys Treatment under Pressure

The abstract of the Master's Thesis

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

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Background.

Aluminum production and its downstream products are the key factor of development of Russian economy it determines the development of Krasnoyarsk Region, and of Siberian Region in general. In 2016 in Russia was produced about 4 million tons of aluminum, where one of the most consuming industries was electrical-power industry. In the last years the average consumption has reached 29% compared to the world production, which consumes only 8-13% of rod from aluminum electrotechnical alloys. However, 80% of aluminum produced in Russia is exported which meant limited possibilities to treat it by domestic's companies.

Nowadays 90% of wire rod produce on casting and rolling aggregates (CRA) which have been used since 1970. This equipment has low resistant characteristic of rolls and frames of the rolling mill and allows to produce only pure aluminum of A5E and A7E grades. In Russia, only 2 out of 7 aggregates can produce wire rod from AVE alloy.

Moreover, Russian cable plants produce mostly for the domestic market due to the high requirements of cable producers. As a result, national plants have no possibilities to hedge risks of changing currency rate and price rate for primary materials.

Subject of research.

The subject of research is researching and projecting of combine casting, rolling-extruding process for producing rod from AVE alloy and feasibility study.

Objective of thesis.

The objective of thesis is to improve production technology of electrotechnical rod from AVE alloy using combined treatment methods and feasibility study.

To achieve the objective the following problems are solved:

- Choose the most energy efficient production technology of rod from aluminum alloys by analyzing the different methods of rod production;
- Check the feasibility of combined treatment process of AVE alloy under given heat-speed and deformation parameters;

- Research the rheological properties of AVE alloy depending on grade and speed of deformation and heat of treatment;
- Develop the metallographic analysis of structure and properties of AVE rod produced by different methods of combined treatment;
- Realize the feasibility study of the production processes of rod from AVE alloy by CRA and CCRE methods.

Scientific novelty of thesis:

- The rheological properties of AVE alloy produced by CCRE method were received;
- The experimental parameters of feasibility of realization CCR process during producing rod from AVE alloy were confirmed;
- The valuation model of technical-and-economic efficiency of rod from AVE alloy production was developed.

Practical significance of thesis:

1. It was experimentally proved that the combination of hardness and plasticity parameters of rod from AVE alloy produced by CCRE method allow to produce the maximum reduction due cold drawing without broken wire.
2. The analytical derivation of the feasibility of CCR process realization during producing rod from AVE alloy was confirmed.
3. By using the valuation model of technical-and-economic efficiency of rod from AVE alloy production the benefits of using CCRE equipment for industrial production was proved.

Personal contribution of the author:

- Participation in modeling of CCRE process, testing of samples for rheological properties determination;
- Developing of valuation model of technical-and-economic efficiency of rod from AVE alloy production;
- Developing of comparative feasibility study.

Place of the thesis implementation: Department of «Metal Treatment Under Pressure» Federal State Autonomous Educational Institution of High Professional Education «Siberian Federal University».

Thesis approval: The general provisions of thesis are presented at the following conferences and congresses: International congress «Non-ferrous metals and minerals» (Krasnoyarsk, 2016), All-Russian scientific and technical conference of the Siberian Federal University «Prospekt Svobodny» (Krasnoyarsk 2016-2017), International research-to-practice conference of Magnitogorsk State Technical University (Magnitogorsk, 2016), XVII International scientific and technical Ural school-seminar of metal scientists-young scientists (Ekaterinburg, 2016).

Publication: Results of thesis are reflected in five printed works.

Content of thesis

In background the relevance of subject and objective is formulated, the practical and novelty of thesis are noted.

In first chapter by analyzing technical literature and cable market is stated that CCRE equipment does not require a lot of space, it allows to treat metal with high deformation level in one processing cycle and rapidly move from one size of wire rod to another. As a result, costs are reduced and possibilities to treat electrotechnical alloys are extended. However, the extending of this method requires a complex of experimental studies, evaluation of its technical and economic indicators and implementation in the production process.

In second chapter the results of the torsion test of wire rod samples from AVE with 9mm cross section produced by CCRE at 320 and 450 °C (fig.1-2) is presented. The pattern of rheological properties changing corresponds to general views of metal treatment under pressure theory. In case of increasing reduction and speed of the deformation resistant does not change and temperature influences on the deformation resistant. When temperature is high deformation resistant is low and vice versa.

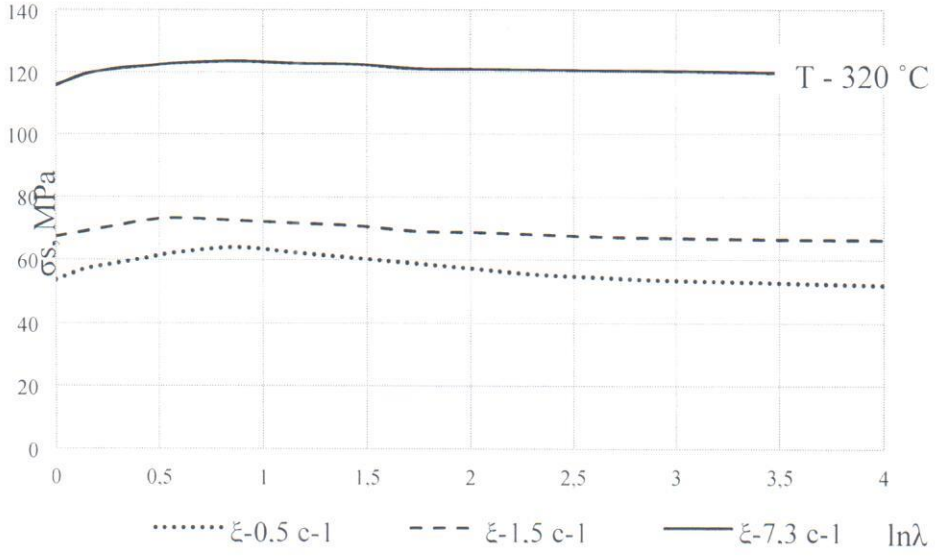

Figure 1 – Dependency diagram of deformation resistant from logarithm of reduction at 320 °C

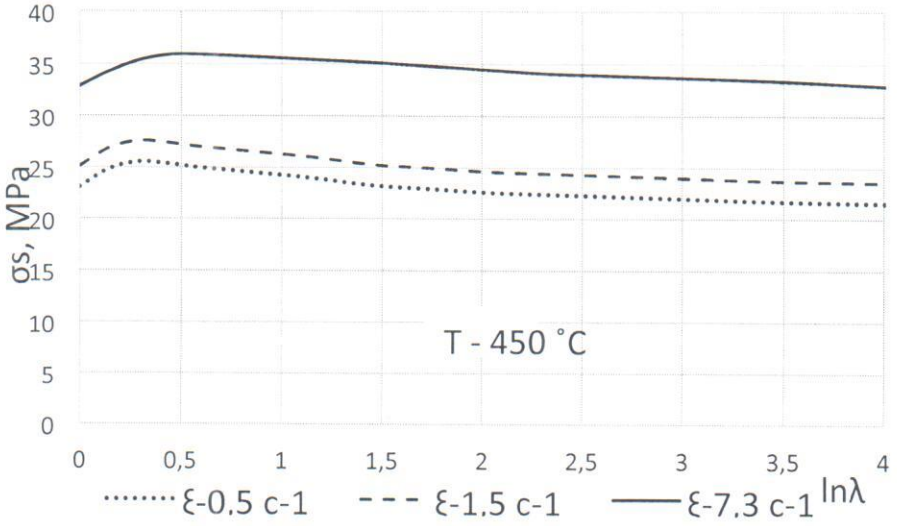

Figure 2 – Dependency diagram of deformation resistant from logarithm of reduction at 450 °C

Table 1 – Mechanical properties of rod samples from AVE alloy

Technological process, standards	Rupture strengh, Mpa	Flow limit, Mpa	Extention, %	Microhardness, kgf/mm^2
CRA	252	112	17	69,48
CCRE	139	105	24	39,8
GOST	118-132	-	12	-
ASTM	103-138	-	10	-

Therefore, research shows that using CCRE method for producing rod from AVE alloy allows to obtain a necessary combination of hardness and plasticity.

As far as rod is a semi-finished product which is used for continuous wire-drawing this fact makes no doubts that CCRE method is appropriate. In this case high plasticity with well hardness is allow to produce the maximum reduction due cold drawing without broken wire.

In third chapter the results of comparative analysis are shown below on table 2.

Table 2 – Comparative analysis of processes for producing rod from aluminum alloys by combined treatment processes

Requirement	CRA	CCRE
Continuance	Is provided	Is provided
Rolling equipment	15-20 and more stands	One stand
Equipment ~~size on the~~ length	50-70 meters	10-15 meters
Energy ratio	Group driving 15-20 rolling stands and equipment for casting	Individual drivng of 1 rolling stand
Flexibility of changing from one profile to another one	Is viable only when production volumes are huge	Is providing quick change of extruding tool
Recovery	80-90%	90-95%
Possibility of alumnium alloys treatment	Only AVE	All wrought alloys including low plasticity alloys
High productivity	from 2,5 to 8 tons per hour	from 2,5 to 8 tons per hour

Feasibility indicators of wire rod production on casting-rolling aggregators (CRA) and CCRE determine by a number of parameters, which are necessary to be taken into account when calculating a prime cost of product. For calculating a production cost of wire rod made of an AVE alloy: USD exchange rate was 67.14 rubles; LME aluminum was 1538 USD / ton. By analyzing the structure of the production cost of the wire rod from AVE alloy on CRA it was found that 24% consist indirect costs, thus reducing production costs is possible by increasing production volumes. Consequently, the analysis of technical and economic indicators of CRA and CCRE processes revealed that the production cost of 1 ton of wire rod from AVE alloy by CCRE is 26% lower than using CRA process.

By calculating net profit and payout it was found that net profit of CCRE process 2,5, 4 and 8 is higher at the first year in 4%, 3% and 2% than a net profit of CRA 2,5, 4 and 8 correspondingly. Payout of each project starts from year of commercialization of product.

Therefore, technologies of CCRE for rod from AVE alloy production is more profitable considering both high economics ratios and reduction energy and labor content.

In conclusion, the key findings and results are presented.

Conclusion

The using of combined casting, rolling and extruding method for producing rod from AVE alloy is the most preferable in comparison with CRA, which allow to achieve the highest economic indicators and reduce the energy consumption and labor intensity of the process, and as a consequence environmental friendliness.

General provisions of thesis are published in the following printed works:

1. **Kleimenova Yu.Yu.,** Technical and economic analysis of the ABE aluminum alloy rod production process at the combined casting-rolling and casting-rolling-extruding facilities. // Collection of abstracts of the reports of the Eighth International Congress of Non-Ferrous Metals and Minerals, 2016

2. **Kleimenova Yu.Yu.,** Investigation of the structure and properties of a rod form aluminum alloy AVE, produced by combined treatment methods. // Ural school of young metal scientists: Collection and reports of the XVII International Scientific and Technical Ural school-seminar of metal scientists-young scientists, 2016

3. **Kleimenova Yu.Yu.,** Analysis of the production of rod from AVE alloy on casting-rolling equipment and an estimation of its cost price. // Collection of the international conference of students, graduate students and young scientists "Prospekt Svobodny - 2016", 2016

4. **Kleimenova Yu.Yu.,** Technical and economic analysis of the production of rod from AVE alloy using various processes of combined treatment. // Innovative processes of metal treatment: Materials of the 2 nd International research-to-practice conference/ Ed. M.V. Chukina. Magnitogorsk: Publishing house Magnitogorsk. State. Tech. G.I. Nosov, 2016, pp. 23-24.

5. **Kleimenova Yu.Yu.,** Comparative technical and economic analysis of the new metallurgical technology of combined treatment of aluminum alloys AVE. // Collection of the international conference of students, graduate students and young scientists "Prospekt Svobodny - 2017", 2017