

Dissertation Review Form -for members of the Dissertation Commission-

Please write a review of the dissertation taking the following criteria into account, where appropriate:

- General remarks
- The significance and status of the dissertation in the field
- The sufficiency and quality of the material
- The adequacy of the methods used
- The validity of results
- The logic of the dissertation's structure
- The knowledge and use of literature in the field
- The project's contribution to the research area
- The author's input into the achievement of the dissertation results
- Language
- The shortcomings of the manuscript

Name of the PhD Candidate : Mr Sai Krishna Padamata
Planned Date of Graduation : September, year: 2020

Title of the Dissertation: « Electrolysis of cryolite-alumina melts and suspensions with oxygen evolving electrodes»

Would you please elaborate upon your review with reference to the above mentioned criteria in the box below. Please add extra pages if needed

General remarks

Mr. Sai Krishna Padamata's dissertation "Electrolysis of cryolite-alumina melts and suspensions with oxygen evolving electrodes" focuses on the problem of creating a technology for aluminum electrolysis using oxygen evolving inert anodes that is relevant for the modern aluminum industry. The introduction of the inert anode technology will solve a whole range of environmental and economic issues. In particular, it will reduce the "carbon footprint" by replacing carbon anodes with inert ones, as well as reduce CAPEX and OPEX in the production of aluminum.

The significance and status of the dissertation in the field

The development of an inert anode for aluminum electrolysis has been carried out for several decades in various countries of the world. Research areas are quite extensive – this applies both to the material of the inert anode (ceramics, cermets, alloys), and the choice of conditions for electrolysis: the composition of the electrolyte, temperature, current, voltage, cell design, etc.

The research direction of metal-alloy inert anodes based on aluminum bronzes in low-melting potassium electrolytes and suspensions proposed in the dissertation is relatively new and promising for understanding processes, determining dependencies and selecting optimal conditions for high-efficiency aluminum electrolysis.

The sufficiency and quality of the material

The dissertation is a complete scientific research consisting of several directions:

- study of the kinetics of electrode (anode and cathode) processes in a system consisting of an inert anode (Cu-Al alloy), a tungsten cathode wetted with aluminum, in low-melting electrolytes KF-AlF₃-Al₂O₃ and suspensions depending on the composition of the electrolyte (CR), temperature, and the alumina particles volume fraction in the suspension;*
- investigation of the dissolution kinetics and sedimentation velocity of dispersed alumina particles in low-temperature melts and suspensions of the KF-AlF₃-Al₂O₃ system depending on the melt composition (CR), temperature, properties of alumina and the alumina particles volume fraction in the suspension;*
- investigation of processes at the anode-electrolyte interface during electrolysis, assessment of the applicability of the metal inert anode 90Cu-10Al for the electrolysis of low-melting potassium electrolytes (by analyzing the purity of produced aluminum, current efficiency and voltage stability).*

Based on the research and experimental data obtained in the dissertation, a complex multi-factor analysis of the system under study "Cu-Al anode / KF-AlF₃-Al₂O₃ / W cathode" in the process of electrolysis was carried out.

The logic of the dissertation's structure

The dissertation has the following clear structure and logic of presentation of the material:

- the available scientific background,*
- fundamental electrochemical and physical-chemical studies to determine the parameters of electrolysis on inert anodes,*
- electrolysis test with subsequent analysis of the results*

The knowledge and use of literature in the field

In the dissertation, the author shows deep knowledge of the literature on the topic of research of an inert anode, the kinetics of electrode processes, physical and chemical studies of the properties of melts and suspensions, as well as the kinetics of dissolution of alumina. In all sections of the dissertation, the author actively uses references. In total, the author used 124 references.

The adequacy of the methods used

In his experimental research, the author applied several modern methods for the study of electrochemical electrode processes, dissolution and mass transfer processes, as well as for microstructural studies, determining the phase and element composition of the inert anode material.

In particular, the author used methods of chronopotentiometry, stationary state polarization, and cyclic voltammetry to study the kinetics of electrode processes. The author also used methods of electrochemical impedance spectroscopy (EIS) and linear sweep voltammetry method (LSV) to study the kinetics of dissolution and sedimentation of alumina. The author used scanning electron microscopy (SEM) with energy-dispersive x-ray spectroscopy (EDX) and x-ray diffraction analysis methods (XRD) to conduct microstructure studies and to determine phase and element analysis.

All the methods used by the author are adequate and sufficient to achieve the set research goals.

The validity of results

The high level of validity of the results obtained is determined by the reasonableness of theoretical concepts and the use of modern automated research methods, and there is no doubt.

The project's contribution to the research area

The results presented in the dissertation are undoubtedly scientific novelty and will expand the understanding of the electrode processes occurring in low-melting potassium electrolytes and suspensions on metal-alloy inert anodes, as well as the processes of dissolution and sedimentation of alumina in cryolite-alumina melts.

In particular, the influence of the composition of alumina and of the alumina particles volume fraction in the suspension on the kinetics of electrode processes on an inert Cu-Al anode in KF-AlF₃ melts and suspensions was first studied using stationary and non-stationary polarization methods. The phase composition and the process of formation of the oxide layer in the process of electrolysis at the "anode-electrolyte" boundary in low-melting KF-AlF₃ melts and suspensions are studied.

Also in the dissertation, for the first time, the kinetics of alumina dissolution in a low-melting KF-AlF₃ melt and the sedimentation velocity of dispersed alumina particles in the suspension and the influence of temperature, granulometric and phase composition of alumina, and the volume fraction of alumina particles in the suspension on these processes using modern electrochemical methods EIS and LSV were studied.

The author's input into the achievement of the dissertation results

It should be noted the author's great personal input to achieving the results of the dissertation. This is confirmed by a large number of scientific articles on the topic of the dissertation published by the author (5 articles were published).

Language

The dissertation is written in clear, competent language. The process descriptions and conclusions are clear and understandable.

The shortcomings of the manuscript

The following shortcomings of the dissertation can be noted:

- the estimation of error in determining experimental results is not given;*
- during the electrolysis test (section 5), a 50% increase in the cell voltage occurs within 18 hours. In this case, it is not clear why this occurs to a greater extent– due to oxidation of the anode current leads or due to passivation of the boundary layer of the inert anode itself?*

- in accordance with the research logic, in the final part of the work, it would be advisable to perform an electrolysis test on an inert Cu-Al anode not only in a KF-AlF₃-Al₂O₃ melt, but also in a suspension under selected optimal conditions and compare the results obtained.

As a result, the content of the dissertation fully meets all the necessary requirements. and the author Mr. Sai Krishna Padamata deserves to be awarded the PhD SibFU degree in Metallurgy of Non-Ferrous Metals.

Anton Frolov

Name of the Dissertation Commission Member :

Chair / Function :

May 29, 2020

Date :

Signature : *

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