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DEFINITION OF THE OBJECTS OF MULTIVARIABLE CONTROL OF TECHNOLOGICAL PROCESS OF SMELTING INDUSTRY ON THE BASIS OF OPTIMIZATION MODEL

Shamil Koshymbaev[1], Zhibek Shegebaeva[1], Waldemar Wójcik[2]
[1]K.I. Satpayev Kazakh National Technical University. Institute of Information and Communication Technologies, [2]Lublin University of Technology, Faculty of Electrical Engineering and Computer Science

Abstract. *This article analyzes work of metallurgical shop as a complex control object. It also includes description of copper complex and synthesizes three-level structure of control system. Technical and economical indexes and also control object are defined in this article.*

Keywords: metallurgical plant, copper, matte, management tasks

DEFINICJA OBIEKTÓW WIELOWYMIAROWEGO STEROWANIA PROCESAMI TECHNOLOGICZNYMI W HUTNICTWIE NA PODSTAWIE MODELU OPTYMALIZACJI

Streszczenie: *W artykule przedstawiono analizę pracy przemysłu metalurgicznego rozpatrywanego jako złożony obiekt sterowania. Opisano kompleks hutniczy i syntetyzowaną trójwarstwową strukturę systemu sterowania. Określono wskaźniki techniczno-ekonomiczne i sformułowano zadania sterowania.*

Słowa kluczowe: zakład metalurgiczny, miedź, matowe szkło, zadanie sterowania

Introduction

Metallurgical shop includes production areas, designed for electric smelting of copper concentrates, matter conversion and fire refining of blister copper.

Raw material input is copper-bearing stock, including granules, recyclable materials and feed-adjusting mixture (limestone and pyritic concentrate). Stock is fed in twin furnaces and melts by the heat, released in slag path. Melted material is divided into matte and waste slag during settling. While accumulation slag is fed from the process are into disposal area and matte is sent to converting area for further recycling.

This process includes removal of sulphur from matter and coverts it into gases as SO_2. Iron is scorified. To create necessary slag adjustment silicious ore(flux metal) is loaded into convertors. Process scheme and interrelation between tasks is shown on Figure 1.

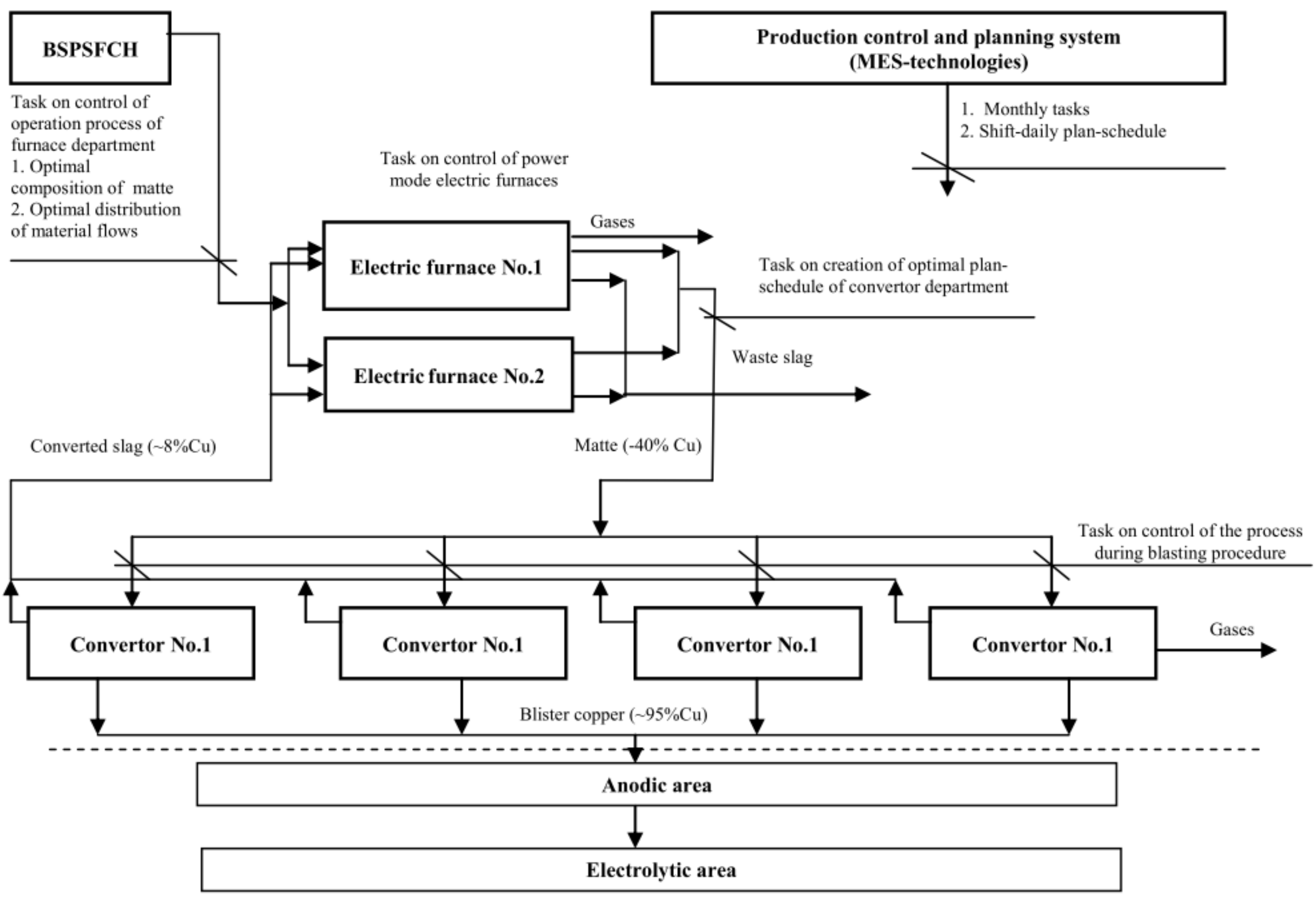

Fig. 1. Process scheme and task interrelation

Converting process refers to the class of discrete-continuous, cyclic, multi-stage processes and is characterized by autogenic operation with heat release. The latter allows additional recycling of cold materials (matte skins). Products of convertor smelting are blister copper, converted slag, released gases and dust. Converted slag is returned back to electric furnaces for copper extraction and gases are fed for production of sulphuric acid after their cleaning from dust [5].

Blister copper is subject to fire refining in anodic furnaces. Solid blister copper, anodic residuals, defective anodes and copper scrap are also loaded into anodic furnace. Process of fire refining refers to the class of discrete-continuous, cyclic, multi-phase processes. Smelting product, refined (anodic) copper is sent to electrolysis department in the form of anodes and anode slag is loaded into converters.

Considered copper-smelting complex is characterized by a number of peculiarities as control object, namely:

a) Discrete-continuous nature of production. Thus manufacturing chain includes discrete, periodic process (converting and fire refining) along with continuous processes (smelt furnaces).
b) Series parallel structure with technological cross (between parallel flows) and reverse relations in the system that complicates coordination of work of adjacent departments and strengthen interconnections between them.
c) Large tonnage, high power consumption and considerable length of production chains, resulting in large dynamic and transport delays. Thus, in accordance with results of studies, delay in terms of stock-matte channel is 6-7 hours and 8-9 hours in terms of stock-slag channel.
d) Broad range and high level of external and internal disturbances that result in random nature of processes and different degrees of uncertainty at different time intervals. It is conditioned by considerable fluctuations in characteristics of feed streams and industrial products, drift of characteristics of process scheme aggregates etc.

1. Decomposition of task

Synthesis of the structure of shop control tasks uses decomposition approach to arrangement of control system structure. Decomposition of general task model, allowing its splitting into several hierarchically interconnected submodels, is realized in accordance with principle of space-time decomposition by multiple areas (aggregates) and multiple time intervals, considering dynamic properties of control objects and frequency characteristics of disturbing effects. Thus we obtain hierarchical multi-level structure of control tasks.

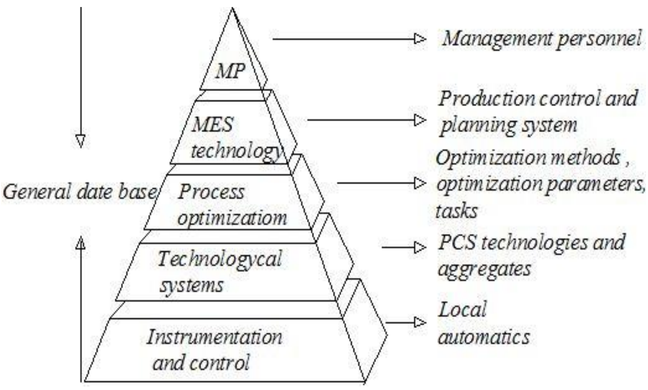

Fig. 2. Levels of control of copper smelting department

The upper level deals with tasks of operational control of copper-smelting complex of metallurgical plant, composed of the following subtasks: distribution of loads between electric furnaces, creation of plan-schedule for converter and anode departments. The main aim of subtasks at this level is specification of daily plan, generated by MES technology system and divided up to aggregate tasks [10].

Results of solution of upper level tasks determine requirements to the second level, i.e. control over separate processes and aggregates (Electric smelting, converting and anodal smelting).

Lower level of control structure is represented by the tasks of stabilization of electric melting condition and control of converting level during blowing [7].

2. Technical and economical nature and definition of control tasks

Metallurgical plant operational control subsystem

Arrangement of rhythmical and coordinated operation of the areas and aggregates of metallurgical plant should be ensured by technological process operational control system that forms and realizes plan-schedule of the plant.

Daily plan-schedule of metallurgical plant defines distribution of loads between electric furnaces, distribution of matte between other converters, beginning and completion of converter melting, distribution of blister copper between separate anodic melting processes, beginning and completion of anodic melting. Plan-schedule should ensure qualitative and quantitative execution of daily plan on production of matte, blister and anodic copper, determined by production planning and control system (MES technologies). The task of plan-schedule is reduced to the task of discrete programming of high dimension. Due to this act there is a need in decomposition of above-mentioned task. As a result of decomposition the solution of the task relating to creation of optimal plan-schedule of metallurgical plant is reduced to solution of the following subtasks:

- Planning of optimal plan-schedule of anodic department, ensuring smooth operation of production area.
- Planning of optimal plan-schedule of converter department, ensuring smooth operation of production area and execution of daily plan on production of blister copper and recycling of cool materials;
- Optimal distribution of material flows between electric furnaces and determination of chemical composition of feed-adjusting mixture, minimizing relative losses of copper in electric furnace department [8].

Electric smelting process control subsystem

Task on control of process conditions of electric smelting, considering specifics of stock preparation area (availability of pile) is split into two tasks, to be solved in different time intervals.

Chemical composition of stock is determined by ratio and chemical composition of material flows, entering electrical furnace (granules, limestone, pyrites etc.). The main role is taken by chemical composition of granules (it accounts for 70-80% of stock weight), which is realized in stockyard through mixing of Zhezkazgan and pyritic concentrates, limestone and other materials. Random fluctuations in composition of granules takes place during production of piles (46 days) and chemical composition of granules considerably deviates (2-4%) from average optimal value, determined for pile, in short intervals of control (shift) [4].

Due to above-mentioned, the task of control of electric welding process condition is split into two tasks, to be solved in different time intervals:

Determination of the optimal composition of pile in time interval of its filling (4-6 days);

Operational (during shift) distribution of lows between furnaces, determining current optimal granular flow, feed-adjustment mixture and its chemical compositions [9].

The task on optimization of chemical composition of pile can be formulated in the following way: to determine chemical composition of pile that minimizes losses of copper with waste slag of electric furnace department, considering limits of qualitative values of smelting products, i.e. matte and slag.

Solve the task on the basis of mathematical model of complex "stock- blister copper" [2].

Task on control of power mode of electric furnace can be formulated in the following way: considering set (current) flow values and chemical composition of stock, determine electrode burial depth (conductivity under electrodes), minimizing rated power consumption at smelting rate limits, losses of copper with waste slag, total capacity of furnace, phase voltage, height of slag and matte baths and also electrode burial depth in melted slag.

3. Converting process control subsystem

Availability of inverse relation of the process through convertor slag considerably effects technical and economical values of production in general. Thus, total copper extraction in metallurgical plant considerably depends on amount of copper in recycled material (converted slag). Concentration of copper in slag mainly depends on concentration of copper in converted mass, siliceous slag and its temperature [1].

Melt temperature during smelting procedure depends on enrichment degree of mass in every blasting and also value of blast rate during blasting procedure. Necessity in obtaining of set volume of copper per melting procedure and coordinated operation of processing units determine need in control (planning of plan-schedule) of sequence of converter blasting procedures with determination of their duration, number and consumption of recycled materials per every blasting procedure.

In accordance of above-mentioned we point out solution of two interrelated tasks: control of the process during blasting and control of converter smelting [3].

Task on control of converting process can be formulated in the following way: basing on current state of the process it is necessary to make decision on continuation or ceasing of blasting procedure. If blasting procedure, determined by process and structural limits, is continued, it is necessary to determine blast and ore flow in current control interval that should be optimal in terms of criteria, considering deviations from set values of blast flow, melt temperature and content of silica in slag. The task on control of converter smelting can be formulated in the following way: to determine plan-schedule of converter smelting that fixes duration of blasting, amount of matte, ore and average blast flow per every blasting procedure that should be optimal in terms of criteria, considering amount of copper in convertor slag, deviations from set values of melt temperature and concentration of silica in slag [6].

4. Conclusion

Tasks on control of metallurgical complex and separate technologies, formulated above, are included into requirements specification of ACS of copper plant JSC "Kazakhmys".

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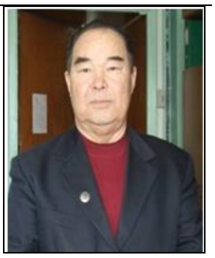
Prof. Shamil Koshymbaevich Koshymbaev



Shamil Koshimbaev is a specialist in field of automation and metallurgical process control. He used to work in capacity of Dean, Chairman of the Automation and Management Department, Vice-Rector of Kazakh Technical University. The main scientific fields include the works in such spheres as: mathematical modeling of process facilities, optimization of controlled objects and synthesis of automated control systems. More than 80 of scientific and guiding papers were published by Mr. Koshimbaev; he is also the holder of patents on scientific inventions. The compact project on TEMPUS-TACIS program involving the creation of Consortium of High Technical Education Establishments of European Union – Kazakhstan was developed due to his participation.

M.Sc. Zhibek B. Shegebayeva
e-mail: jibek_balausa@mail.ru

ZhibekB. Shegebayeva conducts research in the field of electric drives of continuous process lines. She has 11 research publications. She is a first-year doctoral student of the PhD doctor's department of Kazakh National Technical University in "Automation and Control". The theme of her work is "The research and development of the automatic stabilization of the metal tension in coil in the units of hot zinc plating".

Prof. Waldemar Wójcik
e-mail: waldemar.wojcik@pollub.pl

Prof. Waldemar Wójcik - Director of Institute of Electronics and Information Technology at Lublin University of Technology. His research interests include electronics, automatics, advanced control techniques and the optimization of the industrial processes. He is an author or coauthor more than 400 publications.

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