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SIMULATION MODEL OF METALLURGICAL PRODUCTION MANAGEMENT

This article is focused to the problems of the metallurgical production process intensification. The aim is the explaining of simulation model which presents metallurgical production management system adequated to new requirements. The knowledge of a dynamic behavior and features of metallurgical production system and its management are needed to this model creation. Characteristics which determine the dynamics of metallurgical production process are characterized. Simulation model is structured as functional blocks and their linkages with regard to organizational and temporal hierarchy of their actions. The creation of presented simulation model is based on theoretical findings of regulation, hierarchical systems and optimization.

Key words: metallurgical production, model, simulation, functional block

INTRODUCTION

Also in metallurgical production there is growing pressure to increase labor productivity, time and performance utilization of equipment, staff economy, relative savings of physical work, determination of optimum parameters of workplaces in the connection to economic decisions' criteria (cost optimization, expenses, profit etc.). This article presents a model that can contribute to meeting these increasing demands.

Model considerations presented in this article relate to metallurgical production process with parallel linkage of workplaces. This means that it is possible to realize metallurgical production at two or more workplaces. For example, it may be the production of a group of wires: screw wire, hard wire, rope, polished, annealed wire, etc.

To create such a management system it is necessary to have a knowledge of a dynamic behaviour and characteristics of metallurgical production system and its management. Under the term of dynamic behavior it is considered reactions, i.e. with what changes of output levels in time does the metallurgical production system react to changes of the values of its inputs, while the dynamic behavior of the system is dependent on its dynamic characteristics [1]. One of the possibilities how to solve the problematic of analysis and creation of systems with required dynamic behavior is its exploration with the use of simulation models [2].

This approach was used for the analysis and projection of dynamic behavior of metallurgical production system. It could not be overlooked the principles of lo-

gistics and the principles of feedback control [3]. Formed simulation model was elaborated based on theoretical findings of regulation, hierarchical systems, empiric research, optimization and it was systematically tested by software.

EXPERIMENTAL PART

When forming dynamic characteristics of the metallurgical production process including its modeling projection, the following characteristics are considered:

a) functional characteristics of elements, which form the process' dynamics of the production process and are presented by special functions of sub-blocks and blocks

b) structure of its linkage and behavior, i.e. its dynamic characteristics which are determined by the character of transformation of the value change of its inputs to its outputs.

Functional blocks, its sub-blocks and its linkage are functionally determined in a way that it is possible to, by the modeling of its application, express criteria condition for evaluation of effectiveness of existing dynamic characteristics of the metallurgical production process, analyze it and execute simulation evaluation of the impact of its changes.

Criteria condition for evaluation of required level of dynamic process' characteristics of metallurgical production process is possible to write in formula:

$$Q_{pT}^{\max}(T-\tau) = Q_{pT}(T-\tau) + \sum_{t=0}^{t=\tau} \Delta Q(t) \qquad (1)$$

Where:

$Q_{pT}^{\max}(T-\tau)$ – maximum amount of production, which is possible to produce in time $(T-\tau)$ while respecting necessary or limiting conditions of workplace

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such as: productivity of equipment, level of requirements for safety conditions at a workplace, admissible level of cost effectiveness of workplace operation, etc.

$Q_{pT}(T-\tau)$ – required amount of production, which should be produced in time $(T-\tau)$

$\sum_{t=0}^{t=\tau} \Delta Q(t)$ – sum of undesirable regulation deviations in the fulfillment of required amount of production in the time interval $t = 0$ to $t = \tau$

$(T-\tau)$ – time when it should come to balancing of arised deviation at the latest

τ – time, in which it comes to finding out the amount of incepted deviation from time $t = 0$.

Criteria condition is determined from the empiric operation management of metallurgical organizations and deviation management method.

SIMULATION MODEL STRUCTURE

The base of simulation model structure is formed on the basis of regulation circumference. In addition to use of theoretical knowledge especially from regulatory theory, simulation model was designed as a system using the practical experience of operations in metallurgical workplaces. These workplaces were in steel companies MSD, a.s. respectively ZDB Group, a.s. in Karvina and Ostrava in the Czech Republic. The function and applicability of the model for metallurgical production in practice has been consulted with competent managers of these companies.

Individual functional blocks of the model labeled "OD", "OUT", "IS", "SHI", "SHII", and "US" and its functional linkage and behavior in given hierarchical structure (functional, time and organizational decomposition) are set in the analogy of process management with a feedback, on which base it can be able to test the level of required dynamic characteristics of metallurgical production process.

Time decomposition is based on the fact that partial subsystems of a given system are activated in different time levels. In the case of simulation model, meaning that the model's blocks and sub-blocks are activated during shifts, in shifts and within the framework of given period (e.g. month) for fulfillment of the production tasks given by market. By internal shifts are activated the activities of blocks "IS", "SH I", "SH II" and "OUT", possibly block "OD" and in the framework of time level the period is activated the activity of blocks "SH II" and "OD".

Organizational decomposition is realized considering organization structure of its creation purpose. In a case of the model it is a structure of parallel linkage of workplaces from the view of its possible production representation and its grouping into hierarchically higher controlling and organization levels.

From the view of functional decomposition, the system is decomposed into four levels, namely:

– *stabilizing* with balancing undesirable deviation – activity of "IS";
– *optimizing* of controlling quantity – activity of block "OD";
– *adaptation* of regulation process, including optimization of newly arised condition – activity of block "OD";
– *self-organizing* – system's structure change, if it is not able to fulfill target behavior with given limitations (it is not applied in the model).

Functional block "OD"

This block is modeling optimal determination of controlling quantity, such as market required amount of production (T$^{(i)}$) from individual workplaces for the time periods while respecting conditions determining maximum of possible dynamics of production at the workplace considering the limitation of its possible operation: technological, safety and transportation. Simultaneously both, the minimum of operation's cost effectiveness at the workplace and fulfillment of required level of production qualitative parameters are respected.

Functional block "OUT"

This block is modeling the outcome of criteria condition required dynamic characteristics of production process, i.e. such situation in evaluating the possibility to fulfill tasks at the workplace, when the given time for the whole period is fully used for production together with maximal possible production dynamics in the shift.

Functional block "OUT" is model's "signalization" of a state of operation, which warns of a situation that it does not have to come to the fulfillment of required task in the production for a given period and that it is necessary to think about transfer of tasks among workplaces (if it is possible).

Functional block "US"

This block is modeling systems of unproductive states (failure/malfunction) in the production process in workplaces on the base of its generating by the usage of random number system or deterministic implementation into process of its simulation, when the unproductive states make a system, which is a relative system in the connection to real time of shift, both from the view of time duration and inception moment of these unproductive states. In model it comes to generating a group of unproductive states expressed by time of inception, time duration and characteristics of its influence on production process in the sense that it is state of stopping or limiting production at a workplace.

Functional blocks "IS", "SH I" and "SH II"

They model dynamics of fulfillment task progress in production from the view of time hierarchy, namely: internal shifts (block IS), shift (block SH I) and shift with the linkage to determined period (block SH II) for individual workplaces. The outcome of blocks "SH I" and "SH II" is the determination of controlling quantity (expected production) for time level of shift and internal shift and its possible change.

Blocks "IS", "SH I" and "SH II" model regulating and regulated system according to the analogy of regulation circumference. More detailed characteristics of purpose functions and linkage of individual blocks in simulation model are mentioned when describing the behavior of simulation model in another article. Linkage of model's individual blocks is shown in Figure 1.
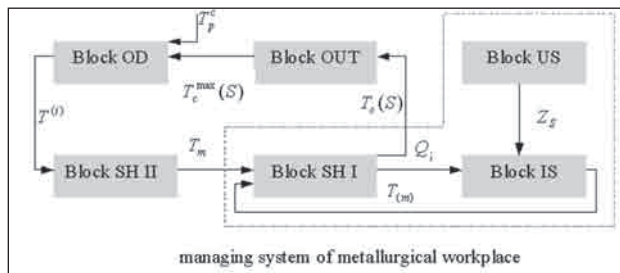

Figure 1 Simulation model structure

Legend of individual quantities used in Figure 1 is following:

T_p^c – market required production amount (demand) from workplace for given period

$T^{(i)}$ – by calculation determined optimal amount of required production for i-th workplace for given period (t. period $^{-1}$)

T_m – required production amount from workplace per shift (shift expectation)

$T_c^{max}(S)$ – maximum amount of production from workplace given by simulation for given period (t period^{-1})

$T_{(m)}$ – shift expectation of workplace production after having done the correction as the consequence of undesirable deviation inception in production (t. sm^{-1})

T_cS – determined production amount from workplaces, given by simulation, after finishing S-th shift from the period beginning (for given time) (t. time^{-1})

Z_S – unproductive state with maximum amount of its influence in workplace towards lowering possible production from workplace (t. min^{-1}).

As fundamental input quantities, when change of their level will, in the process of simulation, influence the level of process dynamics of possible workplace task fulfillment in given period, are considered following quantities: amount of workplace shifts in given period, effectiveness of controlling influence, capacity limitation of production from workplace with the consideration to applied technological system, limitation in safety and manipulation, productive time in shift for production by production equipment, amount of reserves in workplace productive activity and in the amount of productive time in shift, required revenue from utility products from refining process, cost effectiveness of operation and occurrence frequency of so called unproductive states in workplace, information delay and delays in possible realization of given measures in workplace operation.

DISCUSSION

It can be argued that the model can be applied to:

– *simulate* the course of metallurgical mass production and results in the process of production for different dynamic characteristics of workplaces operations;

– *determine* in advance the situations and times when it would not come to fulfillment of workplaces' tasks with the necessity to adapt the whole process of metallurgical production which is lying in the redistribution of required workplace's production tasks with the possibility to fulfill these tasks within the organization or reorganization of workplace structure;

– *devide* the distribution of required production to individual workplaces with regards to determined objective criteria and considered limiting conditions of metallurgical production process;

– *create* a database of production results achieved for certain technologies operated in certain conditions and objective requirements on the metallurgical production process within different time, hierarchical levels with the possibility to its utilization for strategic, tactic and operative production management.

CONCLUSION

Dynamics' simulation model of metallurgical production process at given hierarchical organization level is possible to use in both the process of preparation of this production and also during the process of realization, i.e. within the framework of operative production management and this way contribute to its efficiency.

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