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FUZZY MODEL OF THE COMPUTER INTEGRATED DECISION SUPPORT AND MANAGEMENT SYSTEM IN MINERAL PROCESSING

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Abstract: During the research on the subject of computer integrated systems for decision making and management support in mineral processing based on fuzzy logic, realized at the Department of Applied Computing and System Engineering of the Faculty of Mining and Geology, University of Belgrade, for the needs of doctoral thesis of the first author, and wider demands of the mineral industry, the incompleteness of the developed and contemporary computer integrated systems fuzzy models was noticed. The paper presents an original model with the seven staged hierarchical monitoring-management structure, in which the shortcomings of the models utilized today were eliminated.

Keywords: Fuzzy logic, fuzzy technology, computer integrated systems, decision support, monitoring, management, process control.

1. INTRODUCTION

Our researches and knowledge related to the computer integrated systems for decision support and management in mineral processing based on fuzzy logic shows that the developments in this area are expanding, especially the ones based on the segmented functional levels of development research, introduction and application of the fuzzy technology in mineral processing processes [1, 3, 7, 16].

It is noticeable that main topics in engineering - creative and research attention on the management application of these technologies lie in the functional sections of the real system [4, 6, 8, 9]. The advanced approaches in fuzzy control, intelligent processing and data analysis and information, and decision making support based on fuzzy philosophy in mineral processing are related to applications in the extended time (by managing the quality of mineral resources - homogenization), or to applications in the real time (by controlling the processes of comminuting and classification of mineral resources, physical and flotation - based coal cleaning, and partially managing the flotation processes in a general sense) [10, 11]. Although it is stated in many papers and publications that fuzzy technology is adaptive and easily applicable in different areas, and that application possibilities are vast, we think, due to insufficient theoretical processing and complexity of the real processes, that from the mining and mineral processing point of view, this area is just opening [12-15].

The initiative to place fuzzy logic at the foundation of the computer integrated system for decision making and management support in mineral processing is not solely a consequence of knowing the mineral processing operations, and distinguishing its "fuzzy nature", but is also a result of knowledge that the full efficacy and efficiency of the system for decision making and management support in mineral processing is harder to achieve by conventional means.

The real processes and classes of data for management of mineral processing diverge in case - wise, or, better to say, plant-wise. This is understandable, having in mind that mineral processing plants are designed and built according to actual working conditions, functional, environmental and production demands. Therefore, physical, logical and functional topology differences exist between plants. At first sight, this fact is creating an impression of unfeasible unique mineral processing model establishment.

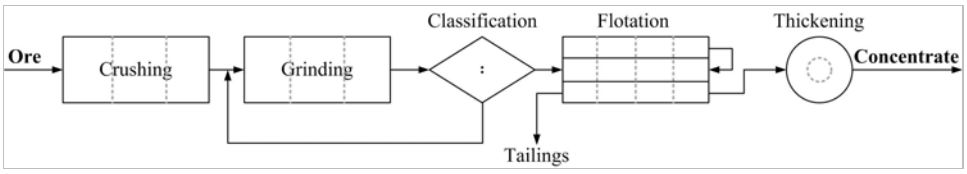

Figure 1: A conceptual schematic of the general multiphase structured model of the mineral processing process

However system approach and mineral processing complexes are considered as a whole, consisting of functionally joined sections (subsystems), enable setting up of general multiphase structured model, such as the one shown in Figure 1. The model is appropriate for analysis and reviewing of information - management flows, and setting the concept and model development, such as the fuzzy model of the computer integrated system for support to decision making and management in mineral processing.

2. GRAPH OF THE MINERAL PROCESSING PROCESSES MONITORING - MANAGEMENT FLOW

Taking the general multiphase structure model presented in Figure 1 as the starting point, together with the process flows, an oriented graph of the process of mineral processing is determined. The oriented graph in Figure 2 presents a set of activities, events, and mutual connectivity of the mineral processing operations. Graph nodes describe events, while branches describe activities. The event described by a node takes place when all the activities described by branches entering the node are completed.

Any activity described by a branch exiting from the node cannot start before all the activities whose branches are ending in a node ends.

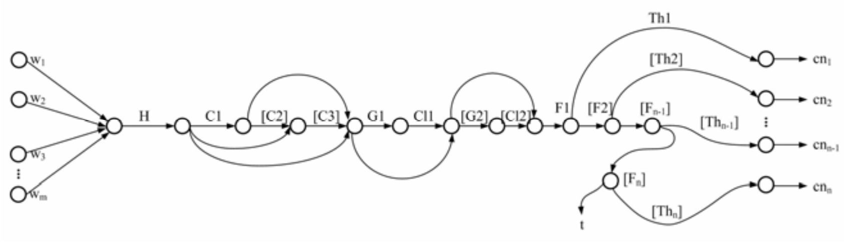

Figure 2: Oriented graph of the mineral processing process
Activities: H – homogenization, C – crushing, G – grinding,
Cl – classification, F – flotation, Th – thickening

Every decision making process, including the real time decision making during the control of the mineral processing operations assumes possession of information on events and processes in the management system. Figure 3 describes the oriented graph of the monitoring - management flows of the mineral processing operations. The graph is depicting the fact that monitoring - management flows depend on the organizational structure, hierarchical topology, and the functional connections in the system. The graph shows that the architecture of the management - monitoring structure is a pyramidal type, which means that there are firm monitoring - management connections from the process (measurement - actuator) level to the level of monitoring, management and feedback corrective actions on the process, if necessary. Mineral processing operations are basically belonging to the risk processes class, due to its nature, complexity, changeability of external influences and operational safety measure needs. This also explains the pyramidal organizational structure and monitoring - management flows.

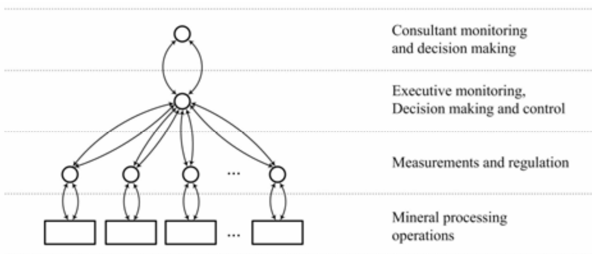

Figure 3: Oriented graph of the mineral processing
monitoring - management flows in mineral processing

For the mineral processing, and we can argue, for the mining production systems in general, the pyramidal hierarchy is a typical organizational and a surveillance -management form.

3. FUZZY MODEL

Having in mind the subsystem functional structure, technical, technological and safety demands of the real systems from the aspects of monitoring and management, as well as the above presented, we can assert that the monitoring - management operations in the mineral processing are centralised with selective ability to pass to hierarchically higher levels. From this, we can conclude the following:

FIRST CONCLUSION: on the need of pyramidal layered architecture of the computer integrated system for decision making and management support in mineral processing

The production systems, such as mineral processing systems, with demanding information - management flows and changeable internal and external influential factors, (often difficult to predict), very sensitive from the aspect of decision making and management, demand an efficient integrated computer supported monitoring and management systems. From this, we can conclude the following:

SECOND CONCLUSION: on the need of fuzzy logic implementation in the monitoring - management structure of the mineral processing system.

Effectivity and efficiency of the monitoring - management systems for mineral processing, under assumption that all the integrative, technical, technological and organizational conditions are met, imply the fuzzyfication of all the layers of the hierarchical logical structure. From this, we can conclude the following:

THIRD CONCLUSION: on the need of fuzzyfication of vertical introduction of fuzzy logic, i.e. by levels (layers) of the monitoring -management structure of the mineral processing system.

Our analyses and research shows that computer integrated systems for decision making and management support in mineral processing should be hierarchically set up as a seven staged layered structures (FOURTH CONCLUSION), which should ensure:

1. Ability for expansion and easy adaptability for changes in the real system;
2. Increase in performance of the monitoring - management system;
3. Ability to process fuzzy data;
4. System variability, ability to operate and scalability;
5. Control logic realization;
6. Transfer of data from the real process toward the command sight and selectively toward higher hierarchical levels;
7. Processing, interpretation and presentation of data in real time;
8. Archiving data and information;
9. Data filtration and selective distribution;
10. Feedback actions on the real systems components;
11. Availability of the additional information (in extended time).

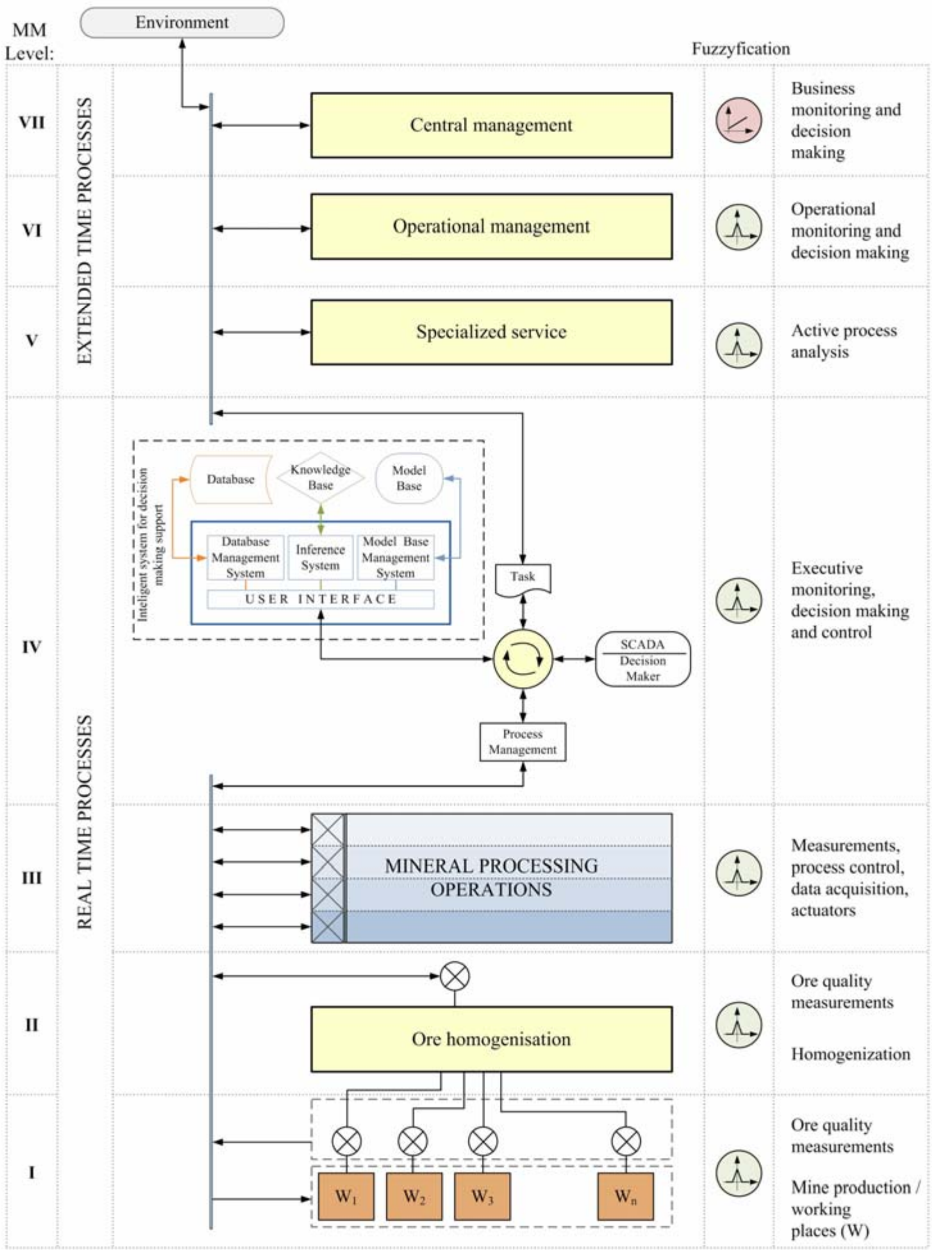

Figure 4: Model of the computer integrated system for decision making and management support [5].

Based on the conclusion presented, and conditions set up, an original fuzzy model of the computer integrated system for decision making and management support in mineral processing is developed and presented in Figure 4.

The model substantially differs in concept from the models developed so far (e.g. Flintoff model [2]. The model integrates seven fuzzyfied monitoring management levels: ore production (workplaces/mines); homogenization; production process of the mineral processing plant, executive monitoring, decision making and management; active process analysis; operational monitoring and management, business monitoring and decision making.

The introduction of the fuzzy inference system within the model implies the defuzzyfication. The purpose of defuzzyfication is conversion of fuzzy inference into the crisp, real (numeric) value, which is particularly important with feedback control action on the process (over actuator), since the control signal being sent to the control object must be a determined discrete value. Hence, by fuzzyfication and defuzzyfication, a part of the data from the real process is being turned from the outer (non - fuzzy) form to the inner (fuzzy) form and vice versa. For the purpose of introduction of the proposed fuzzy model of mineral processing control, an appropriate control algorithm is necessary. The algorithm presents the arranged set of fuzzy instructions that is, when executed, providing the approximate solution of the problem in focus. The fuzzyfication of the model layers is fully justified, due to the complexity of the real system, lack of precise mathematical description of the real system, process dynamics, variability in process characteristics and external influences in time and a consequent non - linearity control in general. The seven - staged fuzzyfied layered structure of the model suggested creates conditions for:

1. Optimum guidance of the mineral processing operations (at the system and the subsystem level);
2. Efficient corrective reaction on possible disturbances in the real system;
3. Increase in work efficiency at the subsystem and system level;
4. Easier harmonization of subsystem operation;
5. Efficiency of prognostics and condition diagnostics, process trends and disturbances;
6. Efficient control of the operating costs;
7. Easier accomplishment of numerous environmental demands etc.

4. CONCLUSIONS

Our very own experience in design, development and establishment of the similar monitoring management systems in mining and mineral processing are in line with the experiences of other researches worldwide and shows that the application in practice is successful with useful effects that are proven, and justified in substantial investment return, maintenance and system innovation costs.

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