PRINCIPLES OF THE DESIGN OF A SYSTEM FOR AUTOMATING BLAST FURNACES

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Blast-furnace No. 2, with a useful volume of 1033 m$^3$, has been in operation at the Chusovoi Metallurgical Plant since a class I overhaul in 1983, i.e., a new overhaul of the same class will be needed in the coming years. A substantial amount of reconstruction is being planned as part of that overhaul. The existing level of automation of the furnace is one reason for its inconsistent performance indices and the uneven quality of the pig iron it produces.

Taking into account the capabilities of the plant as a whole and the periods of time allotted to the reconstruction of the furnace, planners have set the goal of creating an automation system which can be efficiently installed and operated. The system should also be designed so as to improve existing smelting practices, while ensuring that all operations are performed safely and that the equipment operates more reliably. In attempting to solve these problems, the planners proceeded on the basis of the following preconditions:

1. The indices which characterize blast-furnace smelting depend on the coordinated operation of the hot-blast line, stove block, and stockhouse, on the prescribed changing regime, and on stabilization of the thermal state of the furnace.

2. It is best if the automation system as a whole is realized in the form of information-related control subsystems based on relatively simple but reliable programmable controllers (such as the “SEMATIK SS,” “VAKS 300,” etc.). These devices make it possible to collect and process a large volume of raw data, operate the furnace in accordance with prescribed programs, and — most importantly — transmit information between different objects in the automation system. Duplicates of the controllers and of certain measuring instruments in the system should be provided to enhance system reliability.

3. Programmable controllers, including those which contain the so-called intelligent devices, are suited only for stabilizing individual parameters and for programmed control of process operations (such as the furnace changing regime, switching of the stoves, etc.). The more complex problems of diagnosis, prediction, and control of the smelting regime require the expertise of the process engineers and blast-furnace operators. The development of methods which can solve this problem and are based on the use of information technologies and expert systems constitutes a new area of research in control theory — informatics (information technology) [1] and variantics [2, 3].

4. New methods developed to solve the given problem were not considered in the design of the automatic process control systems that were installed on certain large blast furnaces. System designers also made several other serious errors of omission in developing the mathematical application software for the upper level of such systems (for example, no provision was made for evaluating and improving the reliability of the initial data, the control algorithms were based on mathematical models that are poorly suited for the given application, no “furnace-operator-computer system” interface was developed, etc.). As a result, those complicated and expensive control systems do not satisfy the requirements that must be met before the methods now used to control blast-furnace smelting can be improved.

5. It is proposed that the “Smelter Adviser” expert system be used to solve problems encountered in the real-time control of blast furnace operation. The knowledge base of the system is founded on specific technical instructions, with additional recommendations being made to the smelter-experts (the supervisors of the blast-furnace shop and the plant laboratory). To implement the new smelting method, it is necessary that all of the information on process indices which is needed by the technologist-expert be shown on the screen of the monitor installed on the furnace control panel.

6. In the smelting methods used presently, process engineers make decisions based on analysis of the dynamics of the changes in the main process parameters and their own observations of the smelting products and the operation of the tuyeres and...

Fig. 1. Structure of the system recommended for the efficient automation of the 1033-m³ blast furnace at the Chusovoi Metallurgical Plant: HL) hot-blast line; SB) stove block; GDC) gas- and dust-cleaning system; SV) “SNORT” valve; CS – HL; CS – SB; CS – TS; CS – CR; CS – CP) subsystems that control the hot-blast line, the charging regime, and charge preparation with the use of programmable microcontrollers.

hearth. In order to formalize this approach to evaluating the condition of the complex production process, it is proposed that use be made of the concepts “variants of deviations of variables from their norms” and “distinguishing signs of individual variants.” Those signs are needed to identify the given variant. Each variant, characterized by deviations of the initial values and operating conditions from their respective norms and by changes in the control actions, is ascribed certain numerical indices. This makes it possible to analyze large files of data with the use of computer technology.

7. The technologist-expert identifies the above variants by querying the computer program, the questions being shown on the screen of the monitor. The screen also shows curves or other graphical aids depicting the variables being analyzed and the conditions chosen for evaluating their deviation from the norm. The numerical indices of the variants chosen by the technologist-expert are entered into the computer.

8. This new method of describing the complex process of smelting, based on discrete estimates of changes in the indices of the process, makes it possible to treat blast-furnace smelting as a multivariant information-material system. Study of this system has shown that its state can be evaluated by using as many as 90 variants of deviations of the initial data from their respective norms and roughly 18 variants of deviations in operating conditions. In addition, there are more than 30 sets of control actions that can be used to control the smelting process. Thus, a multifaceted approach can be used to analyze the course of the smelting operation based on selection of the most reliable solutions from the many possible variants. The use of such an approach should be considered in developing any information technology.

Taking the above preconditions into account, we recommend that the 1033-m³ blast furnace at the Chusovoi plant be equipped with an efficient automation system (Fig. 1) based on the use of reliable programmable microcontrollers and the new