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ROLLING PROCESS DECISION MAKING SUPPORT SYSTEM

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Abstract. Here one of the new efficient approaches to solving problems of intelligent support of making decisions of a cooperate enterprise scale is analyzed, bearing in mind that the enterprise is oriented towards integration of two interconnected information technologies: a technology of constructing information storages and a technology of intelligent data analysis. A new conception of the role of informating-controlling systems in controlling and operating pipe manufacturing process is suggested. It broadens a traditional view over information systems just as if it were only an instrument of a computer data analysis.

Key words: information system**,** data analysis, information storages.

Nowadays, the informating-controlling systems alongside with expert-logical systems are considered essential instruments of the theory and practice of manufacturing. At the same time, the sphere of the informating-controlling systems is very deep, varied and wide, it requires knowledge and an active using of the results of different sections of computer-information preparation, mathematics, system

analysis, statistics, engineering process of manufacturing. In fact, nowadays, this sphere pertains to the fundamental basis of technological research of the product and of efficiency of the manufacturing in whole.

During all the development period of the direction and especially in the recent years, its extreme importance for the product's quality improving and working efficiency increasing has been pointed out. That is why, as the informating-controlling systems were developing, they were getting associated in a single system of the engineering process and manufacturing control.

A lot of works are devoted to the problem of research, elaboration and plantation of the computer systems in metallurgy. So, in [1, p. 147] the role of the computer control systems in cast iron production is accentuated. In [2, p. 361] it is shown that the computer control systems allow to realize not only a current fusion control, but also to conduct an analysis of the technological situations with giving recommendations as to controlling the blast-furnace process in whole. In [3, p. 70] it is noted that the software environment for conducting a calculating analysis of the most important sides of the blast-furnace process and for conducting an automated search for the optimal conditions of fusion in basic modes of the blast furnace's performance

In this article, one of the efficient approaches to solving problems of intelligent support of making decisions of a cooperate enterprise scale is analyzed, bearing in mind, that the enterprise is oriented towards integration of two interconnected information technologies: the technology of constructing information storages and the technology of intelligent data analysis. Additionally, in our opinion, the information systems, correspondent mathematical models and processes of their construction, verification and interpretation are the irreplaceable link in the triad "raw product-engineering process-end product" , and they are called to provide integrity of the engineering process and manufacturing. Besides, prospects of a further development of informating-controlling systems, both in pipe manufacturing and in some related researches supporting this direction are examined.

Setting the problem. Upgrading of technics and technologies and a continuos

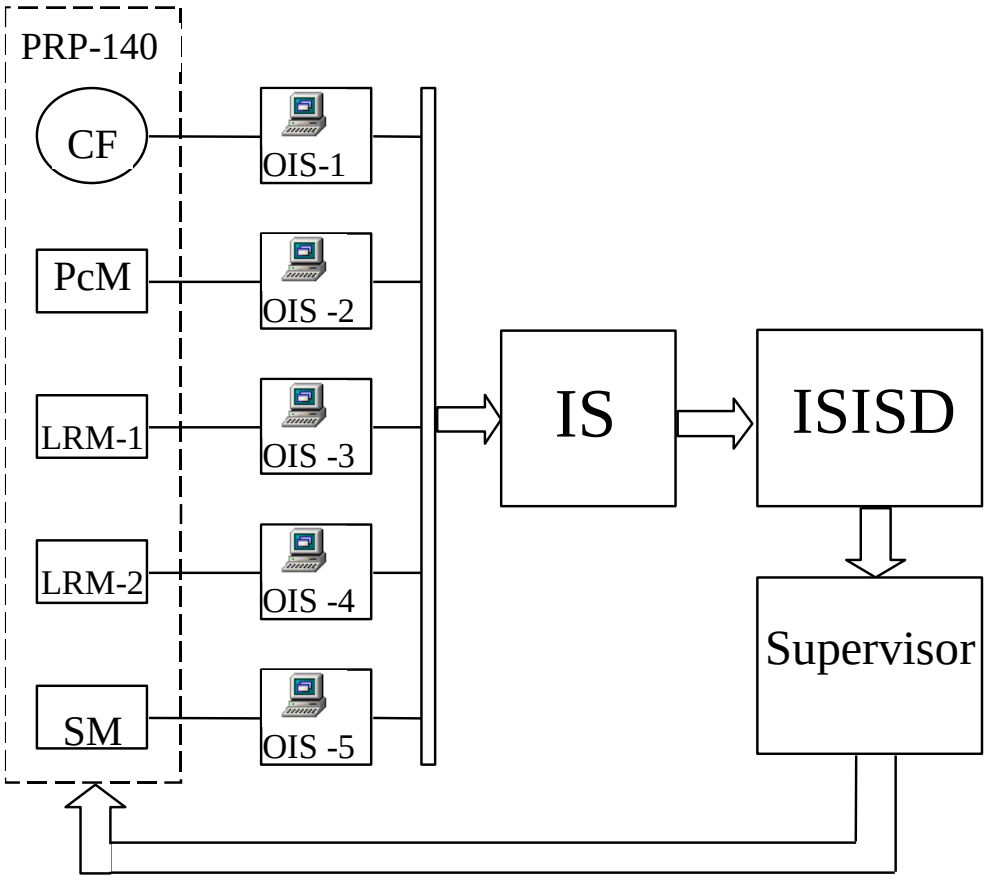
growth of requirements to the quality of the product inspire elaboration of new information systems of intelligent support of making decisions of a cooperative enterprise scale.

One of the approaches to creating systems of a new generation decision support is oriented towards integration of two interconnected information technologies: the technology of constructing information storages (IS) and the technology of intelligent data analysis.

The substance of the constructing technology of the IS is as follows. The distinctive feature of the engineering process of the pipe manufacturing by the PRP-140 with the lengthwise-rolling mills is in presence of single-type structural elements in the plant line which define the composition and configuration of the PRP-140. Such a peculiarity allows to create the OIS which contains a varied information as to the performance of the PRP-140 (date, time, fusion number, pipe grades, steel quality etc.). Further on, the data from the OIS are extracted and put into one source-the IS.

The main idea, put into the principle of the IS technology is to conduct the current analysis intermediately on the basis of the operative information systems is inefficient. It is explained by the fact that the data as to the performance of one of the PRP-140 mills do not enable to get a whole and objective picture of the performance of the plant in whole. All the necessary for the analysis data are kept in a single source-the IS. The main peculiarity of the IS data is their availability not only for reading. At the same time, no data modification is made, as it may break integrity of the IS.

Information system of intelligent support of decision-making. You can see the structural scheme of the information system of intelligent support of decision-making in the drawing 1. Here, ISISD stands for the information system of intelligent support of decision-making.



Drawing 1. Structural scheme of the information system of intelligent support of decision-making

In the drawing 1, we use the following abbreviations: CF—circular furnace; PcM-piercing mill; LRM-1 and LRM-2—lengthwise rolling mills No1 and No2; SM—sizing mill; OIS-1, OIS-2, OIS-3, OIS-4—operative information systems, IS—information storage.

Taking into consideration that the IS contain various information as to the performance of the PRP-140 (date, time, fusion number, pipe grades, steel quality, ingoing size of the round billet, pipe sizes after each mill etc.), the task of the suggested information system is to classify and to process the data for the purpose of resetting the PRP-140 mills' processing characteristics and those of the correspondent forecast.

At the same time, the information system enables to take a lot of measures as to the data processing. So, if necessary, one can follow dynamics of changing the characteristics of each pipe from the circular furnace up to the sizing or reducing mills inclusively. Besides, there appears a possibility to classify the data according to

the rolling characteristics (steel quality, ingoing size, round billet size, pipe grades etc.). The latter permits to carry out a number of researches connected with determining dependence of the rolling process results on the ingoing data and current characteristics.

For example, in the process of piercing a lot of one-sized hollow-billets, an elongation ratio shift under each hollow billet's deformation may be observed [6]. A variable pace of work of the piercing mill, preconditioned by essential processing pauses, implies a constant considering of the thermal condition of the plant which influences the total elongation value. The elongation ratio shifts under a lot of hollow billets piercing reach 30% of nominal (table) values. In order to stabilize the elongation ratio, the operating personnel (supervisor), following his own practical experience and intuition adjusts the mill settings by means of shifting the piercer plug before piercing the next hollow billet. For the purpose of reducing the supervisor's subjective influence, the suggested system chooses the required piercer plug's condition subject to the algorithm elaborated.

The suggested system is oriented towards application of the method of the exponential average magnitude, as a method which describes the process of the elongation ratio shifting process μ_{pr} of the piercing mill in the most accurate way. It is presented as a time series, and the exponential smoothing of the elongation ratios series is calculated according to the recurrent formula:

$$\mu_{pri} = \alpha \cdot x_i + \beta \cdot \mu_{pri\text{-}1},$$

where μ_{pri} is the exponential average magnitude (elongation ratio) at the point of time t_{pr};

α is the smoothing characteristics; $\alpha = const$, $0 < \alpha < 1$, $\beta = 1 - \alpha$;

μ_{pri-1} is the real elongation ratio under piercing the next hollow billet;

x_i is the time series.

The software support of the information system (IS) is constructed according to the algorithm which, in the final analysis, allows to receive the current pipe characteristics shifts from those given, or from those weighted average; and also the dependencies of the shifts upon the rolling processing characteristics. So, in order to

examine the metal crop volume it is necessary to estimate the rolled pipes' length's $l_{\phi i}$ deviations from the nominal (table) pipe length value (l_{Ti}): $\Delta l = l_{\phi i} - l_{Ti.}$ Estimation of the length deviations volumes is made by comparing the actual lengthes with their average magnitude (l_{av}) for the lot:

$$\Delta l = l_{\phi} - l_{av,}$$

where $\Delta l = \frac{1}{n}\sum_{i=1}^{n} l_{\phi_i}$,

where n is the number of the pipes rolled.

In order to estimate the received rolling characteristics, the algorithm uses the dependencies including the peculiarities of the pipe deformation process according to the fundamentals of the pipe manufacturing theory [8]. It should be noticed that among the analyzed characteristics, the principal figures are those of the hollow billets' and pipes' length, the elongation ratios for each mill and the plant in whole, crop values, dead time, unfinished sections number. Let us consider a variant of the suggested IS's functioning.

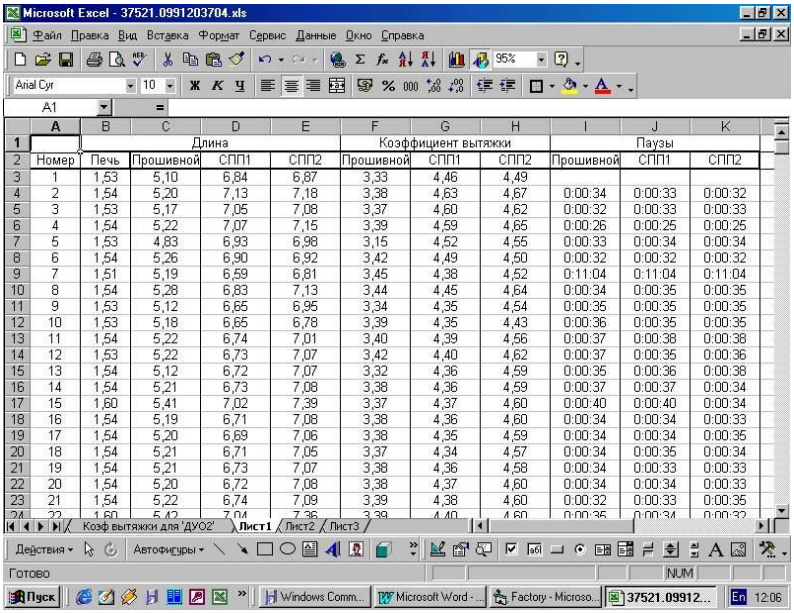
Example of the is's functioning. The suggested IS provides for several functioning modes. A large volume of information in the IS requires a preliminary data retrieval, which is made by means of classifying according to the date, pipe grades, fusion number, lot's number, order's number. Let us consider an example connected with the data processing and analyzing according to the calendar.

When switch to the calendar mode, a dialog box appears on the screen for the user to choose the year, month and day. Subject to the chosen date the IS data retrieval is activated. In the result of processing the information, the total number of records on this issue appears on the screen. Further on, the information as to the functioning of the PRP that day in whole appears on the screen. In this box, numbers of orders for pipe manufacturing, hollow billets sizes, the rolled pipes grades, rolling time etc. are shown.

If necessary, the required information can be printed out and analyzed (press the button "Analyze"). Here the data from the IS are transferred to the Excel environment, where their automatic classification and processing according to the

algorithm is given.

The data transfer from the IS to the Excel environment is explained by the fact that the given program product enables to realize the necessary data processing in rather a convenient and obvious manner. In the drawing 2, a fragment of processing the data as to the piercing mill and lengthwise-rolling mills No1 and No2 with the given length of the hollow billet before piercing and after heating is shown.

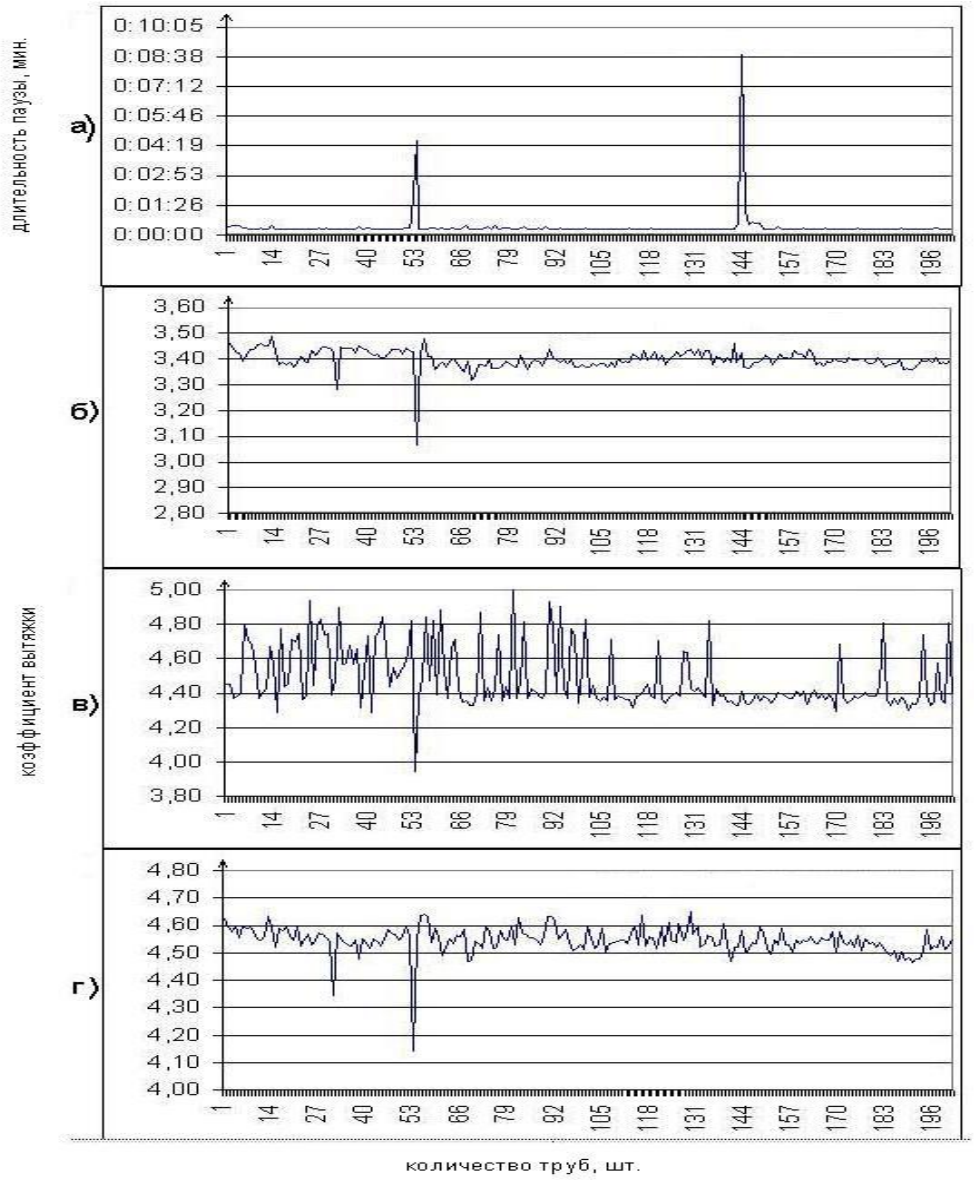


			Длина			Коэффициент вытяжки			Паузы		
Номер	Печь	Прошивной	СПП1	СПП2	Прошивной	СПП1	СПП2	Прошивной	СПП1	СПП2
1	1,53	5,10	6,84	6,87	3,33	4,46	4,49			
2	1,54	5,20	7,13	7,18	3,38	4,63	4,67	0:00:34	0:00:33	0:00:32
3	1,53	5,17	7,05	7,08	3,37	4,60	4,62	0:00:32	0:00:33	0:00:33
4	1,54	5,22	7,07	7,15	3,39	4,59	4,65	0:00:26	0:00:25	0:00:25
5	1,53	4,83	6,93	6,98	3,15	4,52	4,55	0:00:33	0:00:34	0:00:34
6	1,54	5,26	6,90	6,92	3,42	4,49	4,50	0:00:32	0:00:32	0:00:32
7	1,51	5,19	6,59	6,81	3,45	4,38	4,52	0:11:04	0:11:04	0:11:04
8	1,54	5,28	6,83	7,13	3,44	4,45	4,64	0:00:34	0:00:35	0:00:35
9	1,53	5,12	6,65	6,95	3,34	4,35	4,54	0:00:35	0:00:35	0:00:35
10	1,53	5,18	6,65	6,78	3,39	4,35	4,43	0:00:36	0:00:35	0:00:35
11	1,54	5,22	6,74	7,01	3,40	4,39	4,56	0:00:37	0:00:38	0:00:38
12	1,53	5,22	6,73	7,07	3,42	4,40	4,62	0:00:37	0:00:35	0:00:36
13	1,54	5,12	6,72	7,07	3,32	4,36	4,59	0:00:35	0:00:36	0:00:38
14	1,54	5,21	6,73	7,08	3,38	4,36	4,59	0:00:37	0:00:37	0:00:34
15	1,60	5,41	7,02	7,39	3,37	4,37	4,60	0:00:40	0:00:40	0:00:34
16	1,54	5,19	6,71	7,08	3,38	4,36	4,60	0:00:34	0:00:34	0:00:33
17	1,54	5,20	6,69	7,06	3,38	4,35	4,59	0:00:34	0:00:34	0:00:35
18	1,54	5,21	6,71	7,05	3,37	4,34	4,57	0:00:34	0:00:35	0:00:34
19	1,54	5,21	6,73	7,07	3,38	4,36	4,58	0:00:34	0:00:33	0:00:33
20	1,54	5,20	6,72	7,08	3,38	4,37	4,60	0:00:34	0:00:34	0:00:33
21	1,54	5,22	6,74	7,09	3,39	4,38	4,60	0:00:32	0:00:33	0:00:35

Drawing 2. Data analysis in the Excel environment

Besides the analytical procedure of information processing, the environment permits to form the required graphical dependencies (drawing 3).

As an example, let us examine a process of rolling a pipe of 168 mm diameter, 7.00 mm wall thickness and 6,000 mm length. In the table (drawing 6) the data as to the pipes' length, elongation ratios and processing pauses for the plant's mill are presented. The calculation (table) values of the following processing characteristics: the summary elongation ratio is 4.9; the elongation ratio on the piercing mill is 3.41; in the LRM-1-4.40; in the LRM-2-4.56.



Drawing 3. Elongation ratio changes and the pipe sized 168 x 7.0 rolling process porosity; a) – pause duration before the hollow billet piercing; b); c); d) – elongation ratios in the PcM, LRM-1, LRM-2 (per pipes' number (in pieces))

The pause of 4.5 minutes before piercing the 53-th hollow billet (drawing 3a) led to reducing the elongation ratio on the piercing mill up to 3.08 (drawing 3b) and is observed on the following mills (drawing 3c, d) –in the LRM-1 the elongation ratio reduced to 3.95, in the LRM-2-to 4.13. It is likely to lead to increasing the No53 pipe's wall thickness, and if the engineering process was passing without the supervisor's intermediation (as confirmed by the data in the drawing 3 c, d), the wall thickness will exceed the limits, so the pipe will be rejected.

Using this information in the on-line mode, the LRM supervisor has a

possibility to adjust the mill's settings in order to change the elongation ratio of the LRM-2 up to the value close to that from the table. Besides the mentioned table and graphical rolling process analysis, the IS enables to give short-term forecasts in the automatic mode with giving recommendations as to on-line adjustment of the mill's characteristics.

Summary. In the suggested approach, the key role in making decisions as to the control belongs to two technologies: the technology of IS and the technology of the intelligent data analysis. The suggested technologies are an essential component of the engineering process and serve as the connecting link in the triad "raw product-engineering process-end product".The practical application of this product permits the operating personnel of the enterprise to control the engineering process, analyze the processes passing in each mill, adjust the PRP mills' engineering characteristics in the pipe-manufacturing process. The suggested approach influences quite strongly the production's quality improving and enables to work stably in the thin-walled pipe grades sphere. The principal approach to task-solving may be used for other rolling mills, such as continuous rolling mils, flatting mills, small-section mills, hot-rolling mills that will help to save the metal and improve the quality of production.

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