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INTELLIGENT DECISION 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. The role of the modern information systems in the manufacturing as an independent scientific and applied direction serving as a connecting link in the triad "raw product – ngineering process – end product" is substantiated. Some problems connected with plantation of the informating-controlling systems in the pipe manufacturing is formulated. It broadens a traditional view over information systems just as if it were only an instrument of a computer data analysis. 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.

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Introduction. 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] the role of the computer control systems in cast iron production is accentuated. In [2] 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] 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 [4] a new approach to mathematical modeling of metal turning in section extruding based on the finite elements method is suggested.

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.

This article is devoted to the peculiarities of elaboration of the information systems of the new type on the example of the controlling processing characteristics of the products rolled by the pipe-rolling plant 140 (PRP-140).

Nowadays, the technology of constructing IS is partially based on the PRP-140 with lengthwise-rolling mills. Let us have a look at the process of its construction (fig. 1).

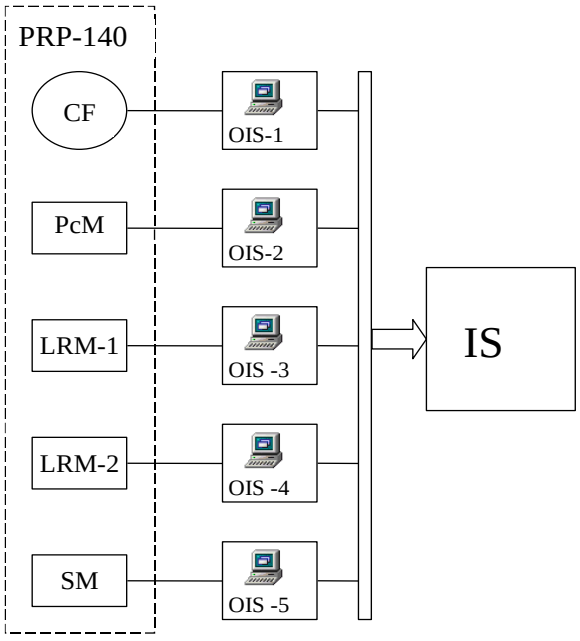

Fig. 1. Structural scheme of the information system

In the fig. 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.

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.

It should be noticed that the IS, according to their classical definition, are a set of facilities permitting to give integral data for their further analysis and making decisions as to the control. It means that the information storages give only a long-range architecture of the intelligent cooperative enterprise scale decision system construction, and they are its central part. The task of the research suggested is to elaborate a set of special software environment, which would enable to construct a polyfunctional system of intelligent decision-making, where such software environment is oriented towards the analytical data processing technologies – the technologies of intelligent data analysis (IDA). Then the above-mentioned technologies must be integrated for making correspondent decisions as to adjusting the processing characteristics of the rolling process.

Software environment system. In order to solve the tasks set, a software environment system was elaborated. It requires the following resources:

– Operating system: Microsoft Windows−95 and higher or Microsoft Windows NT 4.0 and higher.

– On-line storage: 16 Mb (32Mb is recommended). For Windows NT 4.0 48 Mb is recommended.

– Internet Explorer 3.0 (or of more modern versions).

– MS Office 97 or higher composed of Database Management System Access, MS Excel.

– MathCad of 2000 Version or higher for data processing.

– During installation of the software environment a setup box appears, wherein one can indicate the correspondent modes. At this stage, it is possible to refuse some modes. Other settings may be used later.

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 fig. 2. Here, ISISD stands for the information system of intelligent support of decision-making.

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.

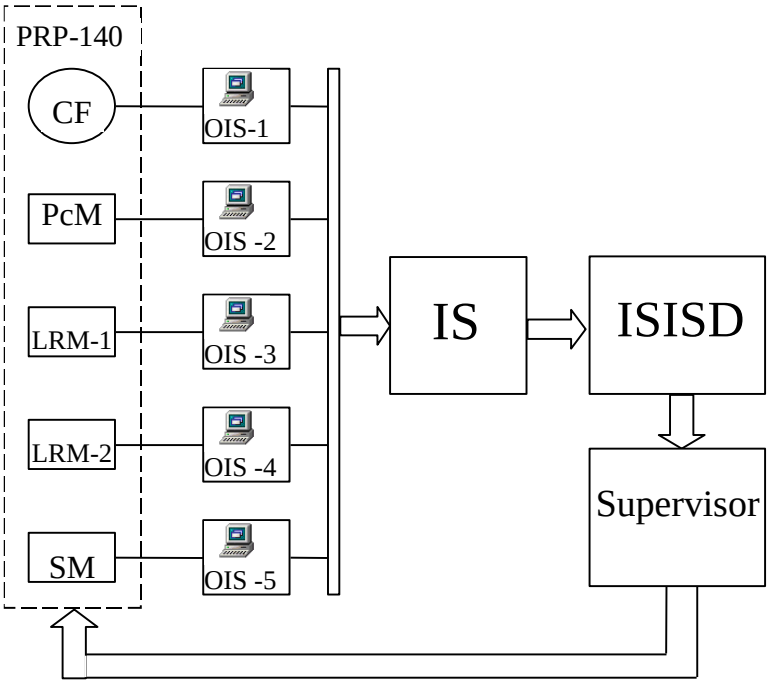

Fig. 2. Structural scheme of the information system of intelligent support of decision-making

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 [5]. 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:

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

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 [6]. 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, for instance, as it is shown in the fig. 3. The user has decided to analyze the information for the 24 working hours of 21 March, 2021 of the PRP-140.

Fig. 3. IS calendar's working mode

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 (fig. 4).

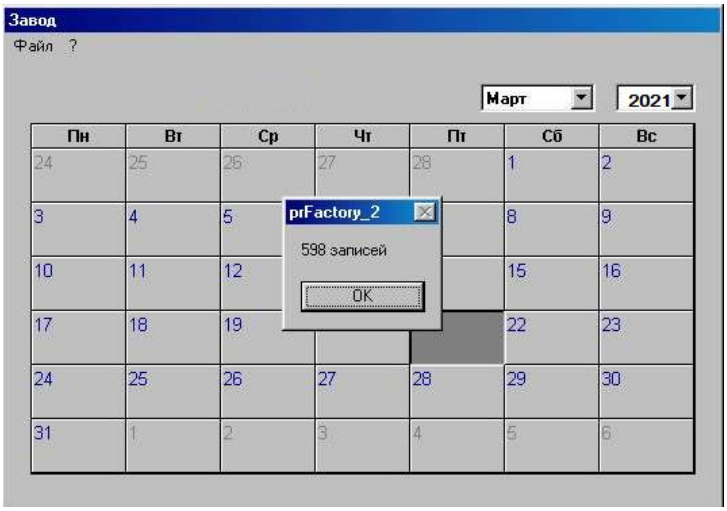

Fig. 4. IS data's analysis subject to the chosen date

Further on, the information as to the functioning of the PRP that day in whole appears on the screen. (fig. 5).

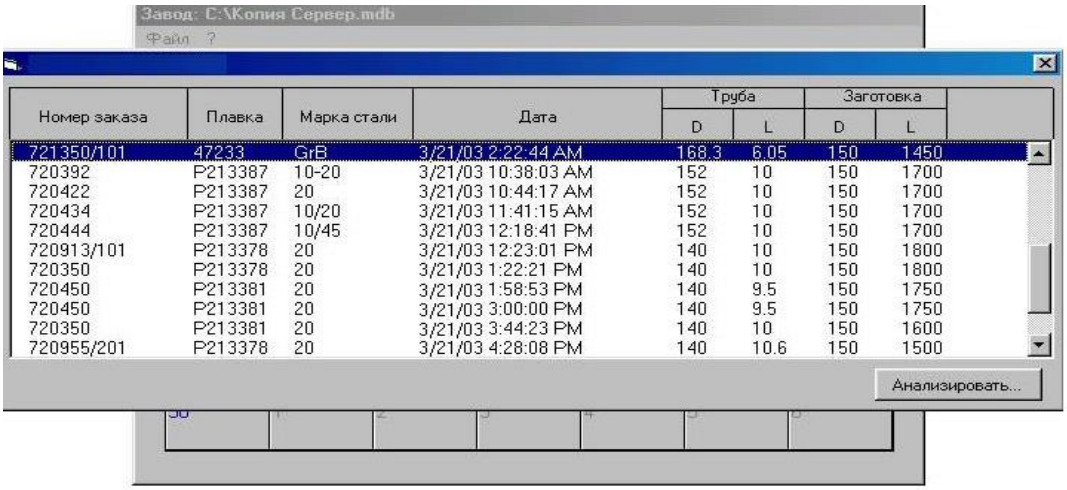

Fig. 5. Data as to the PRP's functioning for 21/03/21

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 fig. 6, 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.

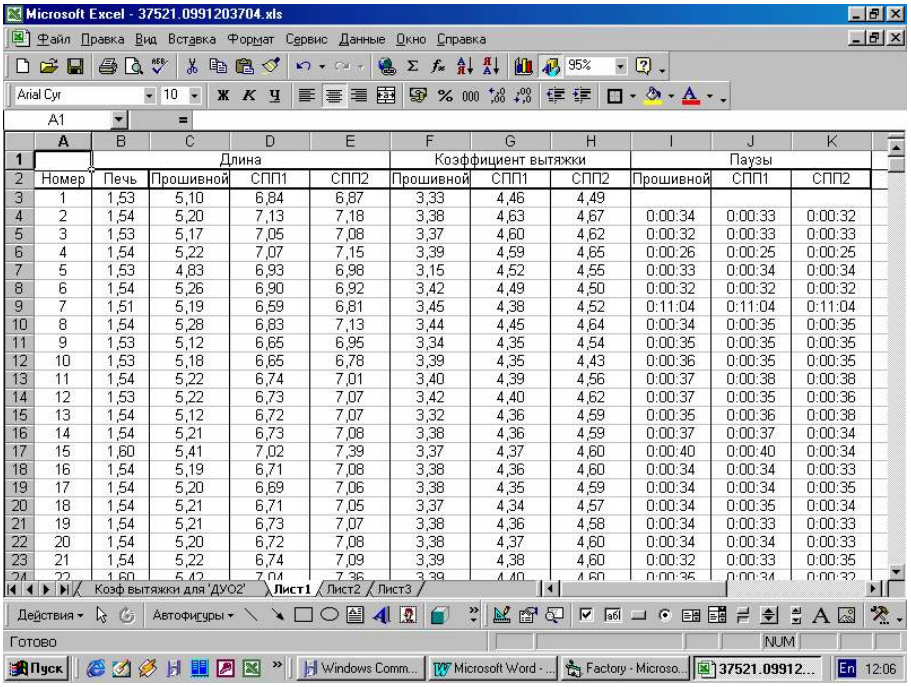

Fig. 6. Data analysis in the Excel environment

Besides the analytical procedure of information processing, the environment permits to form the required graphical dependencies (drawing 7).

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 (fig. 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.

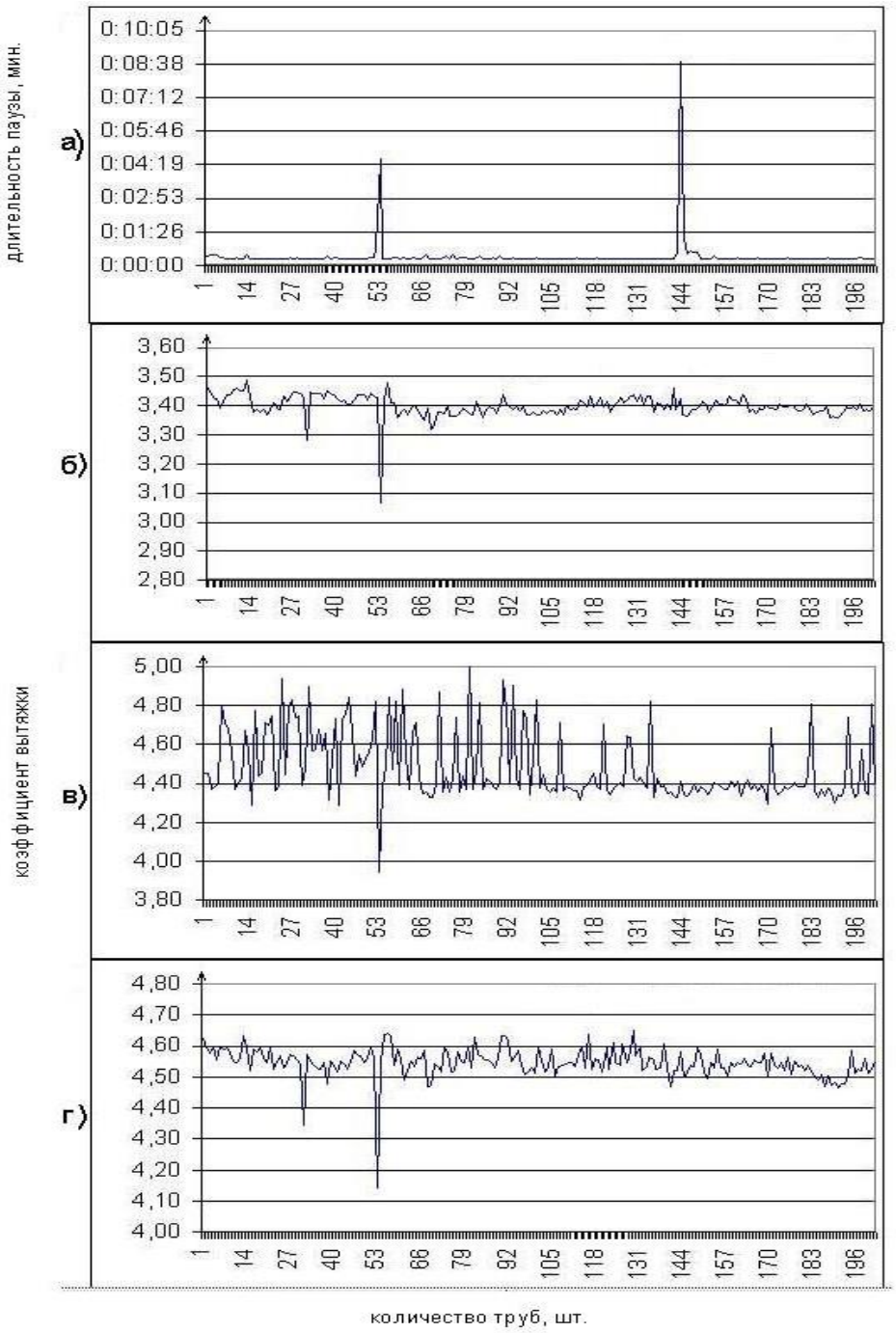

Fig. 7. Elongation ratio changes and the pipe sized 168 x 7.0 rolling process porosity; a) – pause duration before the hollow billet piercing; b); c); d) – elongation ratios in the PcM, LRM-1, LRM-2 (per pipes' number (in pieces)).

The pause of 4.5 minutes before piercing the 53-th hollow billet (drawing 1a) led to reducing the elongation ratio on the piercing mill up to 3.08 (drawing 7b) and is observed on the following mills (drawing 7c, 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 7 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.

Techniques of analyzing the data by the supervisor. When analyze the information, people often come across to the fact that the theoretical excellence of methods of analysis break down against the reality. It is explained by the fact that perfect, from the theoretical point of view, methods of analysis have very little in common with practice. More often, the supervisor faces the situation, when it is rather difficult to do some assumptions concerning the task investigated. It is not always possible to construct a PRP model, and the table of experiment-based data of an "input-output" type, where each line contains values of the input characteristics of the object and the correspondent values of the output characteristics, becomes the only source of information for the rolling process. In the result, the supervisor has to use heuristic or expert assumptions as to the processes developing in the PRP systems. These supervisor's assumptions are based on his experience, intuition, depth of understanding of the analyzed engineering process. The conclusions drawn from such an approach are based on a simple but fundamental hypotheses about monotony of the decision space. This hypotheses may be expressed as follows: "Similar input situations lead to the similar output reactions of the system". In the result of such a decision-making method, an academic severity is sacrificed to the real situation.

Of course, the supervisor is ready for the analyzed process to turn out to be too sophisticated and not capable of being strictly analyzed with the help of exact analytical methods. Nevertheless, taking into account the information received by means of the ISISD, one can get a pretty clear idea of the PRP's performance in different circumstances, approaching the task from different points of view and following the correspondent data domain. Here, on basis of the ISISD, the process of progressing from a raw model to more adequate ideas of the analyzed process is realized. The flow-block of methods of analyzing the data by the supervisor is presented in the fig. 9.

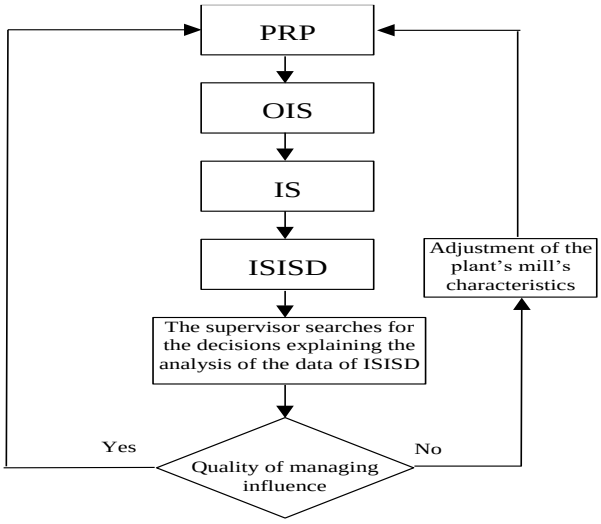

Fig. 9. Flow-block of methods of analyzing the data by the supervisor

The data as to the functioning of various PRP mills come to the OIS which contain information concerning the engineering characteristics of the rolling process. The data are extracted from the OIS and put into a single information source – the IS. The block of data is the basic information for the ISISD. The ISISD enables to process the data as required and to present the data analysis in a suitable table and graphical form. Besides, the ISISD prognosticates adjustment of the plant's mills' characteristics. Following the received information, the supervisor makes the appropriate decision as to the PRP's functioning modes. Here, either an appropriate adjustment of the mills' characteristics is realized, or the rolling process followed by accumulation of information goes on.

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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