Automation system for oil and gas service enterprises

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Abstract. The paper presents the results of the development of a single integrated solution for the automation of technological processes of service enterprises of the oil and gas sector, which allows to organize the work of production and management in a single information space. Algorithms have been developed to solve individual problems that are interconnected into certain algorithmic modules. The results of the integration analysis of modern automation systems of the ERP-class are presented, in particular, the level of adaptation to the stages of the product life cycle, compliance with standards and safety requirements, the complexity of the transition to the automation system. The results of the analysis of possible risks of the project during the implementation of this algorithm are presented. The practical significance of the development of a single production management algorithm is described. Finally, the treatise evaluates the main advantages and economic effect of the introduction of an automation system for an enterprise engaged in the production of oil and gas pipes at the process control level.

1. Introduction

The concept of “oil and gas sector”, along with oil refining, includes two major components: oil and gas production and oil and gas service (enterprises and organizations which activities are aimed at providing services and ensuring the necessary level of oil production and transportation).

The development trends of the Russian economy are such that the revenues generated by the oil and gas sector provide the main inflow of investment resources, the stability of the national currency and form about 45–50 % of federal budget revenues [1].

Due to the irrational planning of the production cycle and the large time required to eliminate defects, the process of manufacturing oilfield and transportation pipes of various diameters and sizes assumes large losses [2, 3]. The consequence of production losses are material losses, which are expressed in cash.

To date, the automated systems used in enterprises involved in the extraction, processing and storage of oil and gas are not suitable for the technological process of manufacturing oil pipes and organizational and managerial accounting at the enterprises of oil and gas services [4].

The development of an automated production cycle management system for oil and gas enterprises occupies a special niche in scientific and technical research. Most of the works present systems aimed at enterprises engaged in the production, processing, storage, transportation and sale of oil and gas [5–7].
However, special systems for organizing and planning production processes at the oil and gas service enterprises have not yet been created.

Thus, the development of a single integrated solution for the automation of technological processes of enterprises in the service sector of the oil and gas industry, which allows organizing the operation of production and management systems in a single information space, optimizing information flows and reducing production costs, is an urgent task. Improving financial results by increasing the manageability of the enterprise and the rational distribution of all types of resources, leads, in turn, to reduced cost of production and services.

2. Methods and materials
As a systematization of the facts for this study, we used methods of collecting information and theoretical and empirical methods: analysis, comparison, selection of factors, the establishment of relationships between them.

In particular, the basis of the analysis of modern automation ERP-systems includes investigation of integration domain, level of adaptation to the stages of the product life cycle, compliance with Russian standards and safety requirements, the complexity of the transition to an automation system.

To evaluate the economic efficiency of designing and implementing software modules of a unified algorithm for organizing and planning a production line for pipe manufacturing, the following types of calculations and analyzes were used: quantitative calculation of the economic effect, calculation of capital costs for design and implementation, calculation of savings by increasing labor productivity, and also a risk analysis of projects when introducing an algorithm for organizing and planning a technological line [8].

3. Results
The developed system for automating the activities of oil and gas service enterprises at the process control level includes an algorithm for organizing and planning a production line for the production of tubing, divided into algorithmic modules that correspond to individual tasks. The tasks of the system are interconnected in such a way that individual modules of the general algorithm function in specific production processes (Figure 1).

The form of algorithmic support of an automated process control system is based on the application of the current principle of modularity, according to which mathematical software can be decomposed into a set (or synthesized from a set) of autonomous parts of algorithmic problems.

The task “Start in the Workshop” implements the input of a new production order and allows you to load input data, either in XLS-format from any ERP-system, or manually. This indicates a high integration ability of the organization and planning algorithm.

Figure 1. Algorithmic tasks of the production line of tubing

In the production process, tubing pipes go through all the operations of the production line, and each transition is accompanied by preparation of normative and reference documentation. The essence of the task is to combine many different documents (in accordance with GOST 633-80) in a single information field: the number of the order made following a particular request. Optimization and visualization of this process allows sufficiently and quickly determining the possibility of sending a
new order to production, as well as to identify the overload of the production line and deviation from the deadlines.

Thus, the following tasks can be solved: to calculate the possibility of fulfilling a new production order on time; show in detail the workload of equipment included in the production line; timely prepare materials for production consumption. At the same time, the work of the supply service directly affects the economic performance of the manufacturing enterprise. Only the exact balance between the loading of production capacities and the timely execution of orders without delay can do without an overabundance of products and save on storage of finished products.

This problem can be solved by the following algorithm: the initial information is entered into the database manually, or loaded from any ERP-system in XLS-format; the order number is checked for uniqueness, if duplication of data is detected, an error message is displayed; when choosing the type of tubing, a table opens, according to GOST 633-80, where it is necessary to choose the geometric parameters of the pipe and its coupling. If, according to the technical specifications, the parameters are different from the normative documentation, you can enter them manually. Then, when sent to the workshop, the order proceeds to the first operation of the production line for the production of tubing (tubing), and the technical specifications are stored in the database.

The task “Start in the Workshop” allows entering information from the normative and reference documentation into the database, and also viewing the workload of the workshop when moving orders for operations of the tubing production line and, if necessary, periodically adjust the data.

Algorithm for performing the task "Start in the Workshop": data is entered manually or loaded from any ERP-system in XLS-format; changes are introduced at the stages of the product (order) life cycle on the production line; adjusted data is stored in the information system. When one selects the module "Workload of the Workshop", the workload of the production line is displayed and each order at the stages of the product life cycle is monitored according to the deadlines.

Figure 2 presents a block diagram of the solution of the algorithmic problems of an automation system for an oil and gas service enterprise at a process control level.

Based on the algorithms of the tasks considered in the project, software was developed for the automation system of the oil and gas sector. Problem solving is carried out using screen forms.

Screen forms for the tasks “Start in the Workshop” and “Workload of the Workshop” are presented in Figs. 3 and 4.
Figure 2. Flowchart for solving algorithmic problems
The task “Defect Detection” captures the operations of the technological process in which production losses occur. The database accumulates information about detected defects in tubing, and a summary table is generated for a certain period.

The algorithm for performing the task “Defect Detection” is presented as a block diagram in Figure 5; the screen form of the problem is given in Figure 6.

The algorithm includes: loading data from an ERP-system in XLS-format or manual input; recording and saving data in the information system from the condition of choosing a time period; in a given period, the number of defects is calculated, the number of unfinished orders is considered; according to the results, a summary table is displayed on the number of defects on each operation of the production line and the total number of orders for the requested period.

Tabular visualization of defects in operations of the processing line displays their quantitative ratio for a certain period [3].
The task "Procurement Planning" allows moving on to rational planning of the procurement of raw materials. When placing a new order, there is a need to calculate the amount of raw materials needed to complete the technical task from the customer company.

Service companies face the problem of duality in providing production with raw materials. The nominal customer, when placing an order for pipe products, primarily relies on the required length. Products are sold in tons. From here, double conversion is carried out first by the customer from length to tons, then the manufacturer in the opposite direction from tons to length.

Differences in weight when purchasing raw materials for the manufacture of pipe blanks or selling pipe products are often a real problem for oil and gas service companies producing tubing and their customers. Excessive weight of finished products leads to financial losses of enterprises in the service
sector of the oil and gas industry and unreasonable benefits for customers. Lack of weight changes the situation in the opposite direction, without eliminating the bias.

Due to the double conversion described above, production losses occur when the tonnage is transferred to length and vice versa. The solution to the situation considered was taken into account when creating the algorithm for the procurement planning task.

The algorithm for solving the problem includes entering the source data manually, or by loading from any ERP-system in XLS format; data are referred to the International System of Units; sizes of the coupling for tubing are set; the length of the threaded pipe joint is calculated; the calculation of the raw materials necessary to meet the requirements of the customer is made. The block diagram of the algorithm for solving the "Procurement Planning" task is presented in Figure 7.

The implementation of an automation system for the activities of oil and gas service enterprises at the process control level, developed on the basis of a unified algorithm for organizing and planning a production line for tubing manufacturing, was carried out at a real service enterprise, including the production and marketing of pipe products, together with a wide range of services [9].
According to the results of calculating the economic efficiency of designing and implementing software modules for a unified algorithm for organizing and planning a production line for tubing manufacturing, the benefit is noticeable in the medium and long term [10]. Expected economic efficiency amounted to 1.6 million rubles.

4. Conclusion

An algorithm was proposed for organizing and planning a production line for the production of tubing, which underlies the developed system for automating the activities of oil and gas service enterprises at the process control level.

As a result of the implementation of the tasks of the algorithm “Start in the shop” and “Workload of the Workshop”: the logical sequence of the process is determined from the site of raw materials acceptance to the receipt of finished products; stages of coordination of technological and technical communication between the main operations of the production process are displayed; it becomes possible to visualize the workload of the processing line; the possibility of fulfilling a new production order and preparation of material for production consumption in a timely manner according to the technical specifications can be calculated.

The precise balance between the loading of production capacities and the timely execution of orders without delay allows avoiding an overabundance of products and saving on storage of finished products.

The performance of the task “Defect Detection” allows systematizing the factors affecting the occurrence of production losses. Tabular visualization of defects in operations of the processing line displays their quantitative ratio for a certain period.

The developed module, which solves the problem of “Procurement Planning” and is part of the organization and planning algorithm for the production line for the production of tubing, allows increasing the accuracy of converting tonnage to length and minimizes production losses associated with irrational planning of raw material procurement.

According to the calculations of economic efficiency, confirmed at a real enterprise, the costs of introducing the organization and planning algorithm into the existing management system are minimal, and the project payback period is about one month.

Using this development leads to the adjustment of the business process itself, as tasks are completed faster. Employees can process large amounts of information during their working hours, which can be used either to reduce staff costs or to quickly develop a business with the same number of employees.

The practical significance of the scientific project lies in the fact that the developed algorithm for organizing and planning the production line is integrated under any production accounting system, since each algorithm module allows loading data in XLS-format.

The results of the project can be used at enterprises engaged in the manufacture of oilfield (tubing) pipes for the oil and gas sector.

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