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Development of an Automated System to Improve the Efficiency of the Oil Pipeline Construction Management

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Abstract: The given paper considers the possibility of improving the oil pipeline construction management through the development and application of automated system for management of construction project. Automated information systems of project management are the most effective and economical way to regulate the activities of companies in solving specific tasks, allow to achieve coherence in collaboration at all levels of the organization. Further the existing automated project management systems were analyzed and also we identified the main shortcomings of the existing systems to apply them in the pipeline construction management. Due to the necessity of establishing a specialized AS the structure of the methodology was designed. Based on the characteristics of the pipeline construction project, structure consists of 7 interconnected models. Further we described the method of key performance indicators prediction for the project in more detail. On the basis of the methodology design of the automated system has been made; the basic features and advantages of the proposed system have been described.

Key words: Project management · Automated systems · Automation · Pipeline construction · Methodology · Prediction · Efficiency

INTRODUCTION

Existing Problems in MP Construction Management: Pipeline construction management meant to guide and coordinate the human and material resources to achieve the project results on the composition and volume of works, their cost, time and quality of implementation to meet the expectations of the project participants.

The responsibilities of the project manager include:

- Allocation of responsibilities and resources;
- Work planning in view of the existing risks and opportunities;
- Constant monitoring of the situation;
- Timely response to emerging changes and variations to achieve the project objectives within a set time, budget and quality [1].

The oil pipeline construction is often carried out with deviations from the contract schedule, resulting in additional expenses that are associated with the renewal of the lease of land, etc. In the MP construction management process, there is a need to improve the efficiency of construction management process.

Despite significant advances in the procedures that facilitate the management of projects, at present, there are also decisions based on assumptions and subjective judgments, which causes frequent overruns of the project [2]. To address this issue it is recommended to use a number of techniques and tools that are designed to help project managers.

These management tools should be used by a client as well as contractor [1]. The most important and effective are solutions that will automate not only individual operations, but also the entire process of construction management. They allow to coordinate material and human resources, volume of work performed and other information, taking into account all peculiarities of this industry.

Development and application of these systems will allow the company to:

- Achieve the project results of the required quality;
- Saves money, time, resources for the implementation of the project;
- Reduces the risk of project failure;
- Increases the reliability of the product.

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Table 1: Project management software products

Name	System type	Developer	Cost (professional edition)	Description
Microsoft Office Project	Application software / web	Microsoft	˜ 35 000 rub.	Development of plans, allocating resources to tasks, tracking progress and analysis of work volumes.
Spider Project Professional	Application software	Spider Technologies Group (Russia)	120 000 rub.	Taking into account all constraints, risks and uncertainties.
Primavera Project Planner Professional	Application software / web	Primavera Systems, Oracle	≈ 130 000 rub.	Calendar network planning and control, project portfolio management, resource management, collecting evidence, administrative support projects.
Open Plan	Application software / web	Welcom Corp	173 000 rub.	Means a resource and cost planning, organization of work and the ability to build multi-user open, scalable solution.
1C-Rarus Project management	Application software	1C-Rarus (Russia)	˜ 155 000 rub.	Planning, organization, coordination and supervision of project activities and resources.

Overview of Project Management Systems: Today, there is a lot of software products (Table 1), the most famous of them are:

- Microsoft Office Project
- Spider Project Professional
- Primavera Project Planner Professional
- Open Plan
- 1C-Rarus: Project management

The main field of application of these products is marketing and IT sector. All products have a high purchase cost, implementation and support. When implementing project management software systems there is a need to meet various challenges - both the differences in management approaches and accountability. You must configure the selected AS for characteristics of a particular project, which in turn is a challenge and has a number of disadvantages:

- The amount of time required for the selection of parameters for the specified characteristics of the project;
- The complexity of AS adaptation and process-specific submission.

Most of the existing project management systems are universal, therefore, can not cover all the aspects of the process of pipeline construction.

The Structure of the Developed Methodology: To address the shortcomings of these systems and address the oil pipeline construction management problem, the methodology has been developed, which later became the basis for the automated system. First you need to define a structure methodology and provide a detailed description of key models.

Project on construction of a magistral oil pipeline is sufficiently specific.

Especially when you consider the features of the oil transport company "JSC"Transneft".

In particular there is no need to add the "Project cost management" module to developing methodology [3]. This is due to the fact that the contract that is concluded between the customer and the contractor, contains pre-installed and continuing strong contract price. Therefore, the cost of the entire project or selected tasks it dealt only with the contractor and can be resolved by him as loss as well as profits for your company. Based on the characteristics of the pipeline project, the specifics of the company "Transneft" and relationships with partners, you need to identify the following models of methodology:

- Project management;
- Organisation;
- Resource management;
- Time Management;
- Quality Management;
- Risk Management;
- Human Resource Management.

Each model is a separate part of the methodology. At the same time, models are interconnected to function as a whole methodology [3]. Figure 1 shows the structure of the developed methodology.

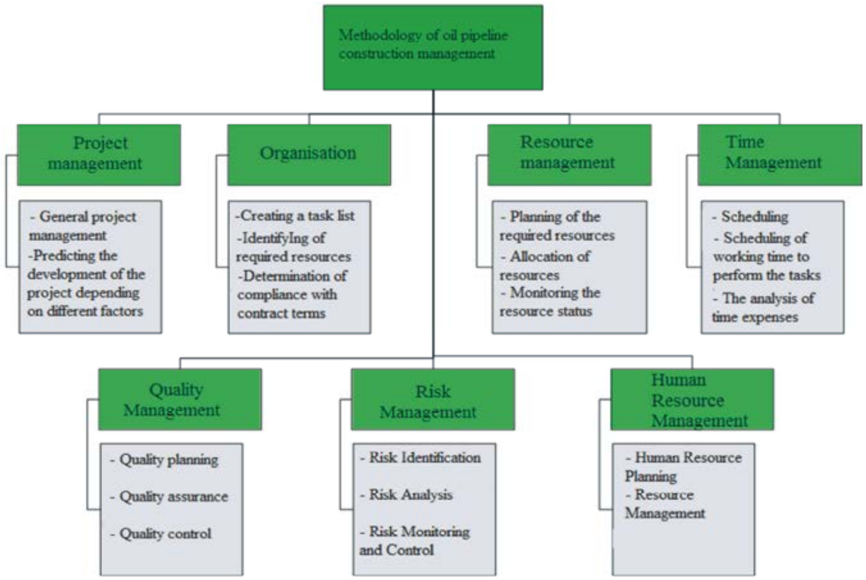

Fig. 1: The general structure of the developed methodology

The Method for Prediction of the Project's Key Performance Indicators: Bad strategy of the project is one of the main reasons for the project failure. However, many projects have not fully developed strategy, leading to bad consequences in later stages. Thus, the draft strategy is crucial to the success of any project [4, 5].

During the project implementation man must perform not only periodic redistribution of resources depending on the stages of the project or risk analysis, but also requires continuous overall project management. For the analysis, modelling and forecasting of the pipeline construction processes is advisable to apply the methods of direct modelling observational data [6]. These methods reveal the implicit cause-and-effect relationships and patterns hidden in the data and construct mathematical models explicitly. Problems of forecasting in the study area can be resolved by adapting the Method of Group Data Handling (GMDH) for the construction of an oil pipeline. However, to date in research productivity in construction GMDH wasn't used, which determined the main tasks on.

To solve the problem of forecasting in pipeline construction, man must do the following:

- Explore the features of GMDH application with regards to the pipeline construction, i.e. to provide the construction process in the form of a mathematical model.
- Enter in the GMDH algorithm an additional criterion linked to the quality and quantity of information about the construction process.

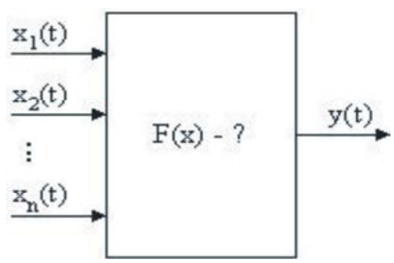

Fig. 2: Information model of data flow

- Adapt GMDH algorithm with prediction features to construction of the main pipeline.
- To develop a forecast module that will be part of the pipeline construction management automated system.

Figure 2 shows data flow model, where Xn (t) – a lot of input on the construction,output, the search function shows the dependence between input parameters [7, 8].

The observation is necessary to define F (x). And structure of F (x) model is unknown. Suppose we have a sample of N paired observations:

{X(1) Y(1)}
{X(2) Y(2)}
....
{X(N) Y(N)}

Most complete dependence between the inputs X (i) and Y outputs (i) can be represented using generalized Kolmogorov-Gabor polynomial (1). Let $X = \{x_1, \ldots x_n\}$, then a polynomial of the form:

$$Y = a_0 + \sum_{i=1}^{N} a_k x_i + \sum_{j=1}^{N} \sum_{i \le j} a_{ij} x_i x_j + \sum_{i=1}^{N} \sum_{j \le i} \sum_{k \le j} a_{ijk} x_i x_j x_k + ... \quad (1)$$

where all the coefficients "a" is unknown. By increasing the accuracy of the polynomial approximation functions it increases and then decreases. At a time when the maximum accuracy, the process of polynomial complexing ends. Number of experiments points can be considerably less than the number of polynomial terms.

The most common criteria for selecting the degree of the polynomial are the criterion of regularity (2):

$$\overline{e^2} = \frac{1}{N} * \sum_{i=1}^{N} (y_i - f(x_i))^2 \quad (2)$$

and criterion of unbiasedness (3):

$$n_{CM} = \frac{1}{N} * \sum_{i=1}^{R} (y_i^* - y_i^{**})^2 \quad (3)$$

The original sample in GMDH is divided into two parts: tutorial and test sequence.

The main indicator for prediction during construction of the pipeline is welded joints for a set period of time – it is necessary to clarify the relationship between the output of the system, i.e. the indicator and quantitative/ qualitative composition of human and technical resources, external factors (weather conditions, specific area of NP). Based on the established dependence is possible to do both short and long-term forecasts.

To find the relationship between the indicators we need to find a function F (4).

$$Y = F(x_1, x_2, ..., x_n) \quad (4)$$

The first stage selects the reference function. These may be a functions of the form:

- y=a0+a1xixj;
- y=a0+a1xi+a2xj;
- y=a0+a1xi+a2xj+a3xixj and others.

The next step is to determine the coefficients of the equation by MLS:

$y_1 = f(x_1, x_2)$, $y_2 = f(x_1, x_3)$,...,$y_{n-1} = f(x_1, x_n)$,..., $y_p = f(x_{n-1}, x_n)$
$p = C_n^2$

Once all identified depending on external criteria select the best. Those dependencies that selected we renumber and get $y_1, y_2, ..., y_s$ where s - number of selected dependencies.

In the next step by MLS we determine the coefficients of these relationships:

$z_1, = f(y_1, y_2)$, $z_2 = f(y_2, y_3)$,...,$z_r f(y_{s-1}, y_s)$
$r = C_s^2$.

The further procedure is similar to the above. If the value of an external criterion is improving, the selection continues, otherwise optimal model complexity is obtained.

In the proposed GMDH algorithm the external regularity criterion in each number of selection is used twice:

- First time (as usual) - for selecting variables in the following series;
- The second time-to find a single solution in the 'degenerate' case.

Functional Model of the System: To build a hierarchical model of the system use the IDEF0 notation. You can use it to effectively display and analyse models of a wide range of complex systems in various cuts.

Consider the context diagram of the pipeline construction management automated system (Fig. 3).

The main functions of the system:

- Continuous monitoring of the project progress, supervision of works, cost of funds and resources, as well as other indicators of the project;
- Continuous complex and predictive planning, taking into account the prevailing situation on the specific moment of time;
- Control of the implementation of the project through its rescheduling with the work performed and the current situation in and around the project.

As an input to the system we will use characteristics of the project, which must be set in advance (Figure 4):

- Name of the project;
- Start and end dates;
- Volume for all types of work;
- The distribution of this amount, by dates.

The system's work is in accordance with the methodology of the oil pipeline construction: algorithms for specific tasks corresponding with the models of developed methodology.

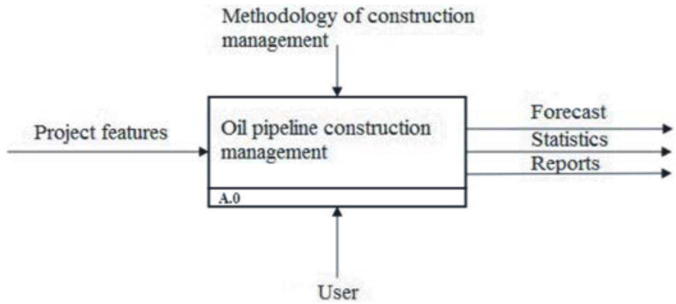

Fig. 3: Context system diagram

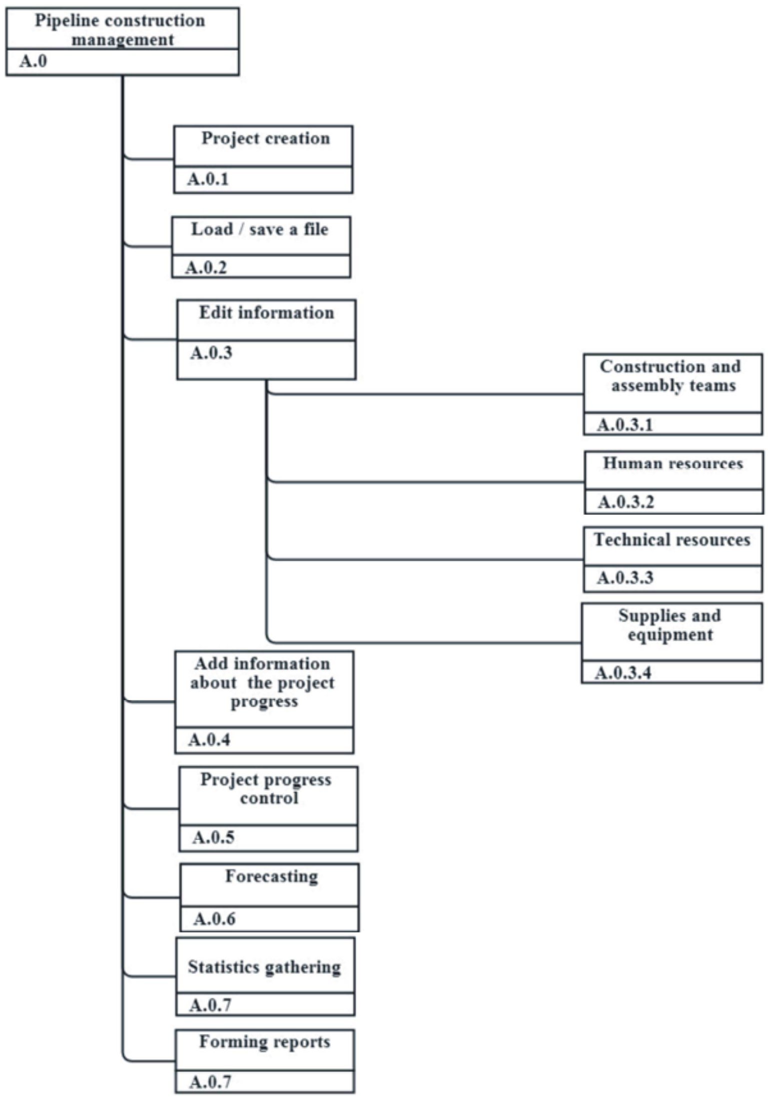

Fig. 4: A tree of system nodes

The mechanism that acts on the system is the user. He adjusts the system by changing the input data, performing planning, etc.

With the help of this system, the user is able to monitor the progress of the project to build an oil pipeline to obtain statistical data, generate reports. As well as using predictive capability and the redistribution of resources from the system to receive information on the need to adjust the course of the project.

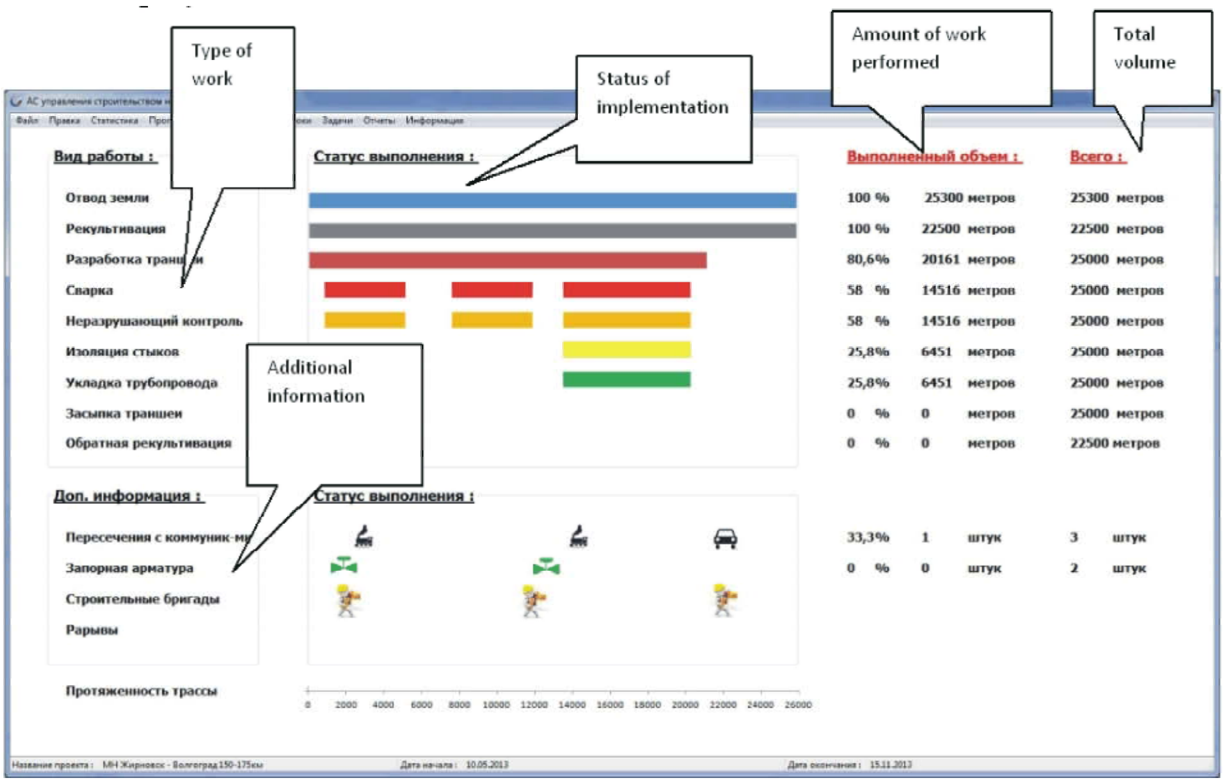

Fig. 5: The main form of user interface

To understand the overall structure of the system, the location and interconnection of functional blocks in the figure shows a tree of nodes (Figure 4).

User Interface: When you start the program there is a main form of the program as shown in Figure 5. The feature of the program is the visibility of the state of the main types of construction works of the pipeline. User can see a performance as a percentage and numerically. It is also possible to see sections of the route, in which:

- Each specific type of work have already completed;
- Are currently under construction by working construction and installation teams;
- Are crossing the pipeline with communications;
- Shut-off valve is located.

Legend intersections, valves and construction crews are links when you hover on that additional information about the status of implementation, the number of active employees, etc. becomes available.

The control system performs continuous monitoring of the current status of the project to ensure compliance with the contractual schedule. To do this when you create a new project, you specify the volume of all the required activities, project start and end dates, as well as the amount of work that must be done at several checkpoints, one month.

AS of construction management maintains statistics. It is a detailed information about each employee: working hours, place of work, the volume of work performed, etc. Statistics window has a search form for easy retrieval of information.

System has the ability to generate reports of work performed in a given time period – reports. After the period of time provided by the user, the application generates summary *.xls report.

CONCLUSION

Project management systems has broad prospects, given the flow of information, the multiplicity of participants of the investment process, etc [9, 10].

As a result of research, concept of automating the management of pipeline construction has been proposed. For its implementation, the methodology for the management of the pipeline construction has been designed. Application of the above methodology for the overall management and method of resource management in particular, allows you to adjust the process of construction of the pipeline, as well as to predict the situation on the object depending on the status of resources. The proposed method of time management allows you to adjust the project construction process, by making changes to the schedule.

In the process of adapting the GMDH for using in the construction of the pipeline area optional external criterion was introduced. When testing the algorithm on a sample of data we obtained model to calculate the performance of construction of the pipeline. Forecast on the current model depends on the values of input parameters. The model provides adequate predictions by varying the input parameters in a fairly wide range.

Pipeline construction management program is a specialized system. Currently undergoing testing in the oil transporting company of "JSC" Transneft ".

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