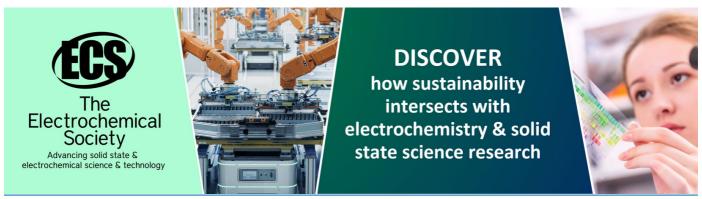**PAPER • OPEN ACCESS**

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To cite this article: S Y Krotova *et al* 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **976** 012004

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Production automation system for company manufacturing oil country tubular goods

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Abstract. This work presents a developments of a single integrated solution for the process automation of oilfield service companies that allows organizing production and management systems in a single information space. The analysis of the main factors and causes that affect the occurrence of production losses, and their consequences. In the scope of this work, algorithms for solving individual automation problems that are interconnected into certain algorithm modules have been developed. The results of the integration analysis of modern ERP automation systems are presented, in particular, their level of adaptation to the stages of the product life cycle, compliance with standards and safety requirements, and the complexity of the transition to an automated system. Possible risks of the implementation of the algorithms were also assessed, describing an applied importance of the development of a single production control algorithm. Further, an evaluation of main advantages and economic effect of the introduction of process control automation system at the company manufacturing oil country tubular goods is presented.

1. Introduction

Currently available automated systems used in oil and gas extracting, processing and storing companies are not suitable for the technological process of oil country tubular goods manufacturing or organization and management accounting at oilfield service companies. Therefore, the development of a single integrated solution for the process automation of oilfield service companies that allows organizing production and management systems in a single information space, optimize information flows, and reduce production costs, is an urgent task. This would allow improving financial results through increasing the controllability of the company and rational distribution of all types of resources thus leading to the reduction of production and services cost.

Currently, the development of an automated production cycle management system for oil and gas enterprises gained a special interest in scientific research [1]. Most of the works are focused on the systems for the companies that are extracting, processing, storing, transporting and selling oil and gas.

There is a yearly increase in oil and gas patch with exploration of new fields and installation of new pipelines. Successful drilling and service of wells requires quality tubular products.

2. Materials and methods

In the course of this research, General scientific and theoretical-empirical methods were used: analysis and synthesis, generalization, comparison, systematization, modeling.

In particular, the analysis of modern ERP-class automation systems is based on the study of the integration area, the level of adaptation to the stages of the product life cycle, compliance with the requirements of Russian standards and safety, and the complexity of the transition to an automation system.

The following types of calculations and analyses were used to evaluate the economic efficiency of designing and implementing software modules of the unified algorithm for organizing and planning a technological line for manufacturing pump and compressor pipes: quantitative calculation of the economic effect, calculation of capital costs for design and implementation, calculation of savings due to increased labor productivity, as well as project risk analysis when implementing the algorithm for organizing and planning a technological line [2].

3. Results

There are two rather independent ways of industrial company management automation.

A modern automated company management system consists of several levels, one of which is the ERP (Enterprise Resources Planning) level. A versatility of production tasks arising at the oilfield service companies impose different requirements on functionality, scalability and technology. Therefore, a reasonable choice of an ERP automation system plays a paramount role in the further successful work of the whole company [3].

According to the specifics of the production process at oilfield service companies, the main criteria for choosing an automated ERP system were identified: integrability; the possibility to transfer initial balances and other data from programs that were previously used at the company; system flexibility; adaptability of the information system to new conditions, new needs of the company; functions and possibilities of the ERP system; data exchange and subsequent automatic data export / import in ERP systems; adaptability of the system to the stages of the product life cycle at an the oil and gas company; the integrity of quality management processes at all stages of the product life cycle; preparation of integrated reports; adaptation of the system to the requirements of Russian standards.

There are 10 automated ERP systems that to a given extent meet main criteria for automated management systems of oilfield service companies: SAP R/3 (SAP AG – Germane), Oracle Applications (Oracle – USA), IFS Application (IFS – Sweden), Baan ERP (SSA Global – USA), iRenaissance (Ross Systems – USA), MBS Axapta Navision (Microsoft – USA), J.D.Edwards OneWorld (J.D.Edwards – USA), Galaktika (Galaktika – Russia), 1C: Enterprise (1C – Russia), BOSS-Corporation ("IT" Company – Russia) [4-6].

These ERP products were analyzed from the point of view of the main criteria required by the oil-well tubing manufacture process at oilfield service companies. The analysis was carried out according to the following criteria: Integrability; System flexibility; Data exchange; Adaptability to the stages of the product life cycle; Integrity ofquality management processes; Preparation of integrated reports.

SSAP R/3:

- Electronic document management is possible with significant modifications to the software.
- Meets all the standard business processes within the entire company, but the modernization of the program code is complicated.
- Its implementation requires a preparation of a complete information base and recording of operations online.
- Needs refinement, depending on the accounting specifics of the end-user company.
- Each module performs specific business tasks independently, but is closely connected to other modules.
- A production planning system that allows taking into account a large number of technological process details and perform very detailed calculations.

Oracle Applications:

- Used in projects for the implementation of information systems based on Oracle products, including interfacing with software products and software and hardware platforms of other manufacturers.
- A large number of open interfaces, the composition of the database is described in detail and comes with open source code.
- Extensive protocol support standards deployment: RosettaNet, Electronic Data Interchange - EDI, Applicability Statement 2 - AS2.
- Needs refinement, depending on the accounting specifics of the end-user company.
- One of the most fully covering the main areas of company management. The set of ERP applications includes more than 90 modules.
- Very flexible in reporting according to the requirements.

IFS Application:

- Initial setup is done by an automation company.
- With the help of additional levels in the configuration module of the system, the cost of ownership is reduced, and programmers are developing specific business tasks instead of re-adjusting the current modification of the system.
- Electronic information exchange with other software.
- Needs refinement, depending on the accounting specifics of the end-user company.
- The entire product life cycle is managed using PLM programs.
- Automated business processes, 3LM management concept that works simultaneously with fixed assets, customer service and products.

Baan ERP:

- Implemented in a three-tier client-server architecture, can interact with other software (supports CORBA, OLE technologies). The "Enterprise Modeling" package provides the possibility of a phased analysis of the company, allowing obtaining the complete structure of the system. The package is compatible with many information databases and has a fairly easy pairing with systems already installed at a customer.
- Written in 4GL - 4 Generation Language - that allows working with events. Allows using existing scripts when programming.
- Allows connecting with third-party industry solutions.
- Requires refinement; various relationships can be established between units of measurement, the conversion of units of measurements can be specified.
- Has the following features: adaptability, scalability, versatility of functions, covers a large number of management tasks.
- Provides grounds for the distribution of both complex functional modules and a variety of analytical reports.

IRenaissance:

- Configured to receive data directly from the field automation controllers (pressure and temperature sensors, weighing equipment), the enterprise is controlled at the process management level.
- It is possible to add the necessary functions to the system using the built-in CASE-tools and 4GL.

- The following DBMSs are used: Oracle Database, MSSQL-Server, Sybase SQL Server, or RDB.
- Needs refinement, depending on the accounting specifics of the end-user company.
- The system has the following modules: manufacturing; finance; personnel accounting; payroll preparation.
- The system stores 1400 ready-made business – procedures. A single database contains all corporate information. Analysis of the accumulated information is possible using decision support tools (DSS): DSSuite, ROSS Systems proprietary system.

MBS Axapta, Navision:

- The built-in COM/DCOM mechanism allows that internal objects work with external applications. To do this, a special Axapta COM Connector library is used, which allows an external application to see Axapta as a COM object and provides a possibility to directly access Axapta data, manage transactions and use the system's business logic to process them through the COM/DCOM interface. This ensures that Axapta is fully integrated into the company's document management technology.
- Has an integrated development environment MorphX. To change the standard business logic, as well as to create new functionality, the system provides an object-oriented language X ++, as well as access to SQL data.
- The COM / DCOM mechanism allows the system to interact with third-party applications, the interaction is carried out using COM objects created in the system.
- Needs refinement, depending on the accounting specifics of the end-user company.
- A multifunctional ERPII solution covers the business of the company as a whole, including production and distribution, supply chain management (SCM) and project management, financial management and business analysis tools, customer relationship management (CRM), and personnel management.
- Axapta - an integrated automated manufacturing company management system, which provides company's managers and investors with full information about the company's activities. Reports are divided into operational (to which the requirements of business processes apply) and statistical (processing a large amount of information).

Galaktika:

- Possible integration options: documents export and import (using standard system interfaces; data export and import in generally accepted formats; a possibility to organize direct interaction of third-party development tools with physical tables through the SQL query mechanism.
- ERP and BI systems are free of charge. Only support and implementation are charged. Free software options have limited functionality compared to the paid versions. "Galaktika express" contains the same source code as the paid version of the ERP system, but part of it has become open.
- The system is not integrated. A large number of modules are not connected. Documents in the finance module require manual input that significantly.
- Needs refinement, depending on the accounting specifics of the end-user company.
- The system does not implement algorithms for generating optimal production and supply requests depending on the demand, plans, forecasts, or their combination.
- The toolkit allows building stand-alone reports based on a simple database query language (SQL). Reports can be saved for reuse and exported to MS Excel, HTML, GIF, JPG, PNG, BMP, CSV, TXT, PDF formats.

1C: Enterprise:

- Supports the most common types of operating systems and databases: Linux, Windows, Mac OS, PostgreSQL, MS SQL Server, IBM DB2, Oracle Database.
- An open system that enables the exchange of data with many external applications and technical equipment, thanks to open standards and data transfer protocols.
- The system is written in its own internal programming language, which provides access to data and a possibility to interact with other programs.
- Needs refinement, depending on the accounting specifics of the end-user company.
- The system does not implement algorithms for generating optimal production and supply requests depending on the demand, plans, forecasts, or their combination.
- The toolkit allows building stand-alone reports based on a simple database query language (SQL). Reports can be saved for reuse and exported to MS Excel, HTML, GIF, JPG, PNG, BMP, CSV, TXT, PDF formats.

BOSS-Corporation:

- The architecture of the system has an integrated and modular structure, which allows phased automation of a company.
- Is an open client-server system that allows increasing functionality and access data through any programming tools.
- Allows data exchange with other expert and decision-making systems.
- Needs refinement, depending on the accounting specifics of the end-user company.
- Does not have a product quality management function at all stages of product life cycle.
- The system has a unique graphical tool for configuring the business logic of the application, which governs all possible stages of reporting.

The analysis of the automated EPR systems and to which extent they meet main needs of manufacture process at oilfield service companies has demonstrated that none of the evaluated systems fully solves all the problems of the company. Therefore, an additional module with necessary functionality shall be purchased or developed and consequently, integrated. Besides, the statement that the ERP-system is already integrated is rather questionable, since an installation of a new version of any module included in the ERP-system requires updating of other modules. Therefore, suppliers should provide a possibility to implement various versions of their applications, which also requires integration [7].

None of the analyzed ERP systems is adapted to the oil pipes production specifics and cannot receive reports at the stages of the product life cycle at oilfield service companies.

BAAN and AXAPTA systems have shown the largest integration possibilities, since they have mechanisms allowing that the external applications work with internal system object.

The lowest integration was observed in the SAP R/3 system, as it requires significant software improvements, entailing high financial investments. Most Russian automation systems are not aimed at the idea of quality management processes integrity at all stages of the product life cycle [8].

Thus, in the automation of oilfield service companies a development of a single algorithm for organizing and planning of oil-well tubing manufacture process that would optimize the operation of production, management and information flows, as well as reduce downtime and overproduction, is highly relevant.

The developed automation system of an oil and gas industry company at the process control level includes an algorithm for organizing and planning of oil-well tubing manufacture process divided into algorithm modules according to individual tasks (functions). The tasks of the system are

interconnected in such a way that individual modules of the general algorithm work in specific production processes [9].

The algorithmic support for an automated process control system is based on the progressive principle of modularity, according to which software can be decomposed into a set (or synthesized from a set) of autonomous parts of algorithmic tasks [10].

Automation system of an oilfield service company at the process control level developed on a basis of a single algorithm for organizing and planning of oil-well tubing manufacture process was implemented in an active service company that manufactures and sells tubular goods along with a wide scope of maintenance services.

4. Discussion

The result of the present study is the development of a single algorithm for solving the main tasks of the automation system of an oil and gas industry company at the process control level.

The main economic effect of the implementation of the process control automation system at the company manufacturing oil country tubular goods is an optimization of accounting processes, which results in increased economic indicators.

The direct benefits of introducing the algorithm for organizing and planning of oil-well tubing manufacture process include employees' time saving, saving on raw materials, etc.

Indirect benefits from the implementation of the algorithm include transparency of management, balanced production processes, control of the workload of the production line, tracking of defects and planning of raw materials procurement. Savings due to increased productivity are calculated based on the user-performed tasks, such as:

- Information input - input of the information about a new order (order number, oil-well pipe type and geometry, and deadlines) into the database, entering into the database the information from the reference documentation and standards (order number and technological process operation), entering into the database; information about the defects in the oil-well pipe (order number and operation of the process, at which a defect was discovered).
- Calculations - calculation of the amount of raw materials needed to meed customer requirements and assessment of the possibility of launching a new order in the production cycle.
- Preparation and printing of reports - generation of reports on the workload of the production line and tracking of each order at the stages of the product life cycle, including deadlines.
- Data analysis and sampling - defect detection in operations of a production line. Defect/operation ratio calculation.

The assessment of the economic efficiency of designing and implementing of program modules of single algorithm for organizing and planning of oil-well tubing manufacture process demonstrates mid- and long-term benefits [11]. An expected economic efficiency is about $ 25 000.

5. Conclusion

Based on the algorithms of the tasks analyzed within the project, an oil and gas industry company automation system software was developed. The tasks are solved using forms.

The implementation of the algorithm for solving the tasks "Launch to the plant" and "Plant load" allows: determination of the logical sequence of the process from receiving of raw materials to finished products; showing the stages of coordination of technological and technical communication between the main operations of the production process; visualization of the workload of the production line; assessment of the possibility of fulfilling a new production order in accordance with the technical specifications before deadline and of timely material preparation for manufacturing.

A balance between the loading of the production line and the timely execution of orders without delay is essential allows avoiding overproduction and save on storage of finished products.

Solving of the task "Defect detection" allows systematization of the factors affecting the production losses. A table allows displaying the ratio of defects to production line operations over a given period. The developed module for solving the "Procurement planning" task, included into the algorithm for organizing and planning of oil-well tubing manufacture process allows increasing the conversion accuracy from tons to meters and minimizes production losses associated with irrational raw materials procurement planning.

According to the economic efficiency assessment verified at an active company, the costs of implementation of program modules of single algorithm for organizing and planning of oil-well tubing manufacture process are minimal, and the estimated project payback is around one month.

Application of the developed procedure allows adjustment of the business process itself, as the tasks are completed faster. Employees can process larger amounts of information during their working hours, which can be used either to reduce staff expenditures or for quick business growth at the same number of employees.

The technical contribution of the research project lies within the fact that the developed algorithm for organizing and planning of manufacture process can be integrated into any production accounting system, because each algorithm module allows downloading data in xls format.

The results of the project can be applied in the companies producing oil country tubular goods for oil and gas industry.

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