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Development of an Automated Solution for Cost Accounting and Budget Calculation When Insulating Oil and Gas Pipelines with Foam Glass

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Abstract— *This study is dedicated to developing an automated system for calculating costs and budgeting for pipe insulation using foam glass based on the 1C:Enterprise platform. Due to increasing demands for efficiency in the oil and gas industry, this system solves key issues with manual calculations: high labor intensity, errors in estimates, and inability to account for price and exchange rate changes promptly. The system incorporates a unique algorithm for modeling the insulation of complex structures, considering factors such as pipe diameter, shaped elements, gaps, and material consumption rates. It also automatically updates data from external sources such as suppl ier databases and exchange rates. A key advantage of this solution is its ability to simulate budget scenarios and predict cash flow, making it a strategic man agement tool. The study confirms that the system not only increases the economic efficiency of projects but also ensures transparency of financial processes, speeding up decision-making at all levels of management. The results of the work open up new opportunities for the digitalization of the oil and g as industry, where the accuracy of calculations directly affects the competitiveness and sustainable development of companies.*

Keywords— *Automation, Cost optimization, Budgeting, Pipeline insulation, Efficiency, Strategic management, Calculation accuracy, Business process integration.*

I. Introduction

The oil and gas industry has been the foundation of economic development for many countries over the years, providing not only energy security but also stimulating growth in related industries. However, modern challenges present new issues, such as suboptimal resource consumption, which has a significant impact on the maintenance of pipeline systems. Repair and maintenance costs account for a substantial portion of the budget, and this has led to the search for innovative solutions [8]. One such solution is the use of foam glass as an insulating material, which has proven effective in extending the service life of pipelines and reducing the need for major repairs over time. But here a new difficulty arises- the process of calculating estimates for such projects requires taking into account a huge number of technical parameters, which makes manual calculations extremely time-consuming and error-prone. An analysis of existing software products has shown that none of the available solutions can fully meet the specific needs of the industry. This prompted us to create a specialized tool based on the proven 1C: Enterprise platform.

The purpose of the study is to create an automated solution for calculating costs and budgeting when insulating pipelines with foam glass. The peculiarity of our solution lies in its practical orientation. The system not only performs calculations but also becomes a full-fledged analytical tool that helps to identify hidden reserves for cost optimization, while integrating seamlessly into existing business processes without requiring drastic changes to usual work patterns. Such tools are particularly valuable today when resource efficiency becomes a key factor in maintaining competitiveness [2].

II. Material and Methods

The use of foam glass as an insulating material has proven its effectiveness over the long term. Due to its unique properties - high strength, zero water absorption, and resistance to aggressive media - such coatings increase the lifespan of pipelines several times, significantly reducing operating costs. The insulation of oil and gas pipelines with foam glass is an effective way to reduce heat loss and protect them from corrosion.

Advantages of insulating oil-and-gas pipelines with foam glass:

1. Energy efficiency. Foam glass helps reduce heat loss, saving energy resources and reducing heating costs.

$$Q = U * A * \Delta T \tag{1}$$

Where A is the insulation surface area (m²), the total insulation area. U is the heat transfer coefficient (W/m²·K), which is the amount of heat lost through a unit of surface area over a certain period, T is the temperature difference (K), which is the difference between the ambient temperature and the temperature inside the oil and gas pipeline.

Energy efficiency can be estimated based on the heat loss values obtained and the estimated energy costs to maintain the required temperature. The lower the Q values, the more effective the insulation.

2. Durability. Foam glass is highly resistant to mechanical damage and chemicals.

$$D = \frac{T * R * M}{C * A} \tag{2}$$

Where D is the durability of the insulation (in years), T is the operating temperature (degrees Celsius), R is the corrosion resistance of the material (determined by coefficient), M is the mechanical strength of foam glass (MPa), C is the coefficient of thermal conductivity, and A is the environmental impact.

This formula allows you to evaluate the durability of insulation materials taking into account various factors.

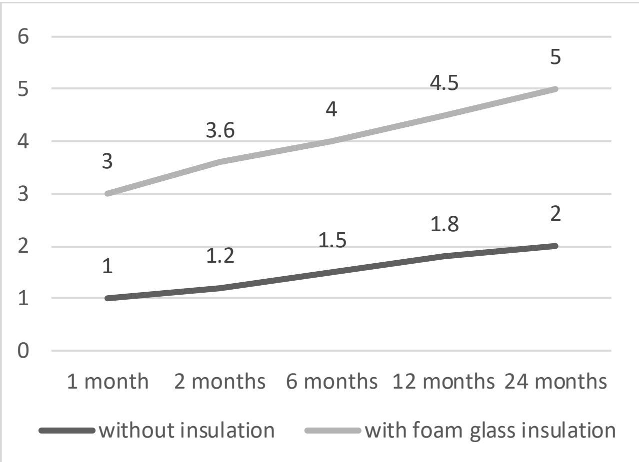

Fig. 1. Energy efficiency (loss ratio) with and without foam glass insulation on the oil and gas pipe.

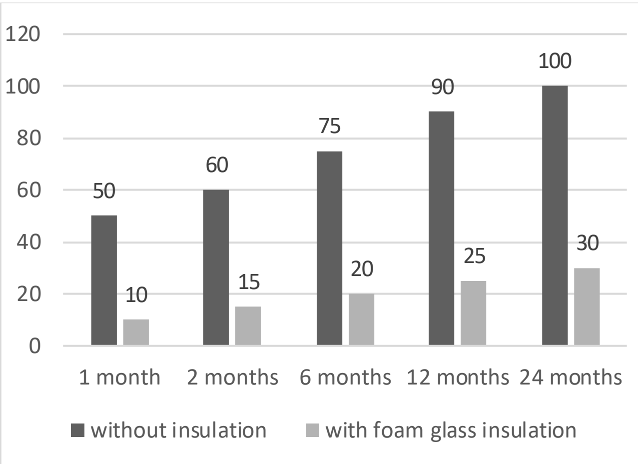

Fig. 2. Heat loss level (W/m) without insulation and with foam glass insulation of the oil and gas pipeline.

3. Moisture resistance. The low moisture permeability of foam glass prevents condensation and corrosion.

$$W = \frac{V * T * R}{S * L} \quad (3)$$

Where W is the moisture resistance of insulation (in percent or coefficient), V is the volume of pores in foam glass (in cubic centimeters), T is time of exposure to moisture (hours or days), R is resistance of material to moisture, S is surface area in contact with moisture, L determines degree of moisture in material.

The formula allows to evaluation of moisture resistance of insulations, considering time, area, and other factors.

4. Fire resistance. Foam glass has high fire-resistant properties, which increases safety.

$$F = \frac{T * A}{Q * D} \quad (4)$$

Where F is the fire resistance (coefficient or time in minutes), T is the exposure temperature (in degrees Celsius), A is the area of the burning material (in square meters), Q is the amount of heat generated during combustion (in Joules), D is the density of the material (in kilograms per cubic meter).

This formula allows you to estimate how foam glass will behave when exposed to fire, taking into account temperatures, area, and other parameters.

5. Easy to install. Foam glass slabs are easy to process and install, which reduces installation time. The formula for calculating the ease of installation of oil and gas pipeline insulation can take into account several key factors, such as weight, flexibility, and installation time:

$$L = \frac{(W * F)}{T} \quad (5)$$

Where L is the ease of installation (index), W is the weight of the insulating material (in kg), F is the coefficient of flexibility of the material (dimensionless units), and T is installation time (in hours).

This formula allows you to evaluate how convenient and fast the installation process is, which is important for reducing costs and increasing work efficiency.

6. Environmental friendliness. The foam glass material does not emit harmful substances and is safe for the environment

The formula for calculating the environmental friendliness of oil and gas pipeline insulation against fire can be described by taking into account several factors, such as toxic emissions, smoke content, and combustion temperature:

$$E = \frac{C * T}{V * R} \quad (6)$$

Where E is environmental friendliness (index), C is the concentration of toxic substances (mg/m³), T is combustion temperature (°C), V is the volume of combustible material (m³), and R is restriction coefficient that takes into account unfavorable component content.

This formula allows us to assess the impact of burning materials on the environment and human health and allows for a comparative analysis of different insulating materials [3].

The general formula for calculating the budget of foam glass insulation for oil and gas pipelines, which allows for estimating the total cost of the insulation project, can be presented as follows:

$$C = (A * P) + T + M \quad (7)$$

Where C is the total budget, A is the insulation area, P is the cost per square meter of foam glass, T is transportation costs, and M is installation costs and additional materials.

However, despite all the advantages of this material, the process of calculating its use is difficult and time-consuming. The manual calculation of pipeline insulation costs is fraught with several problems [4]. First, it requires a considerable amount of time, especially when working on large projects involving hundreds of kilometers of pipes with different diameters. Second, there is a high probability of arithmetic mistakes, which subsequently lead to financial losses. Third, the lack of operational adjustments when prices for materials change or exchange rates make estimates irrelevant even at the approval stage. In addition, traditional methods do not allow for quick modeling of different budget options, which is crucial for making management decisions [1].

The developed software allows not only accurately calculating the required amount of foam glass, but also

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promptly updating data taking into account market changes. Integration with supplier databases allows choosing optimal purchase options and built-in algorithms eliminate design errors in calculations. An additional advantage is the ability to predict cash flows and analyze project scenarios. Thus, transitioning from manual calculations to digital systems speeds up budgeting and significantly increases accuracy, reducing the total cost of construction and increasing return on investment [10].

TABLE I. Advantages of the 1C:Enterprise.

Category	Advantage	Description
Flexibility & Adaptability	Customization for Business Processes	The platform allows flexible customization of standard configurations to align with company-specific workflows
Integration	Compatibility with External Systems	Supports integration via APIs, web services, REST, ODBC, enabling connections with CRM, ERP, e-reporting systems, banks, and payment gateways
Automation	End-to-End Business Management	Ready-made solutions for automating accounting, logistics, HR, sales, inventory management, and other processes within a unified system
Regulatory Compliance	Up-to-Date Legal Requirements	Regular configuration updates to reflect changes in tax, accounting, and labor legislation (relevant for «EAEU»)
Cost Efficiency	Reduced Implementation & Maintenance Costs	Lower total cost of ownership (TCO) compared to foreign alternatives. Supports incremental upgrades without full system replacement
Scalability	Support for SMBs and Large Enterprises	Works locally or in the cloud (1C:Fresh, 1C:Cloud). Suitable for businesses with 1 to 10,000+ employees
Security	Data Protection	Built-in role-based access control, data encryption, backup, and audit trails
Technology	Modern Architecture	Supports mobile apps, web interfaces, browser access, and hybrid (offline/online) environments
Support & Training	Ecosystem for Developers & Users	Large community, courses, certifications, documentation, and forums. Technical support from 1C partners and official distributors

The 1C:Enterprise platform was chosen for developing our solution. An enterprise that provides deep integration with corporate accounting systems supports the processing of large amounts of data and offers ready-made tools for automating complex calculations. The most important factor in choosing the platform was its economic efficiency. The license for 1C is significantly cheaper than for analogs like SAP or Oracle, and the initial functionality covers a significant part of the needs of small and medium businesses. Additionally, it is worth noting the system's scalability, which does not limit the growth of a company - for example, clients increased their staff from 50 to 5,000 employees while maintaining the original configuration and adding only new modules [7].

The unprecedented flexibility of the system has become a major factor in our choice, allowing us to adapt it to any business process, even the most complex. Built-in development tools allow us to fine-tune the functionality for specific technological processes and accounting policies [9].

III. Results and Discussion

The implementation of an automated cost calculation system demonstrates a significant advantage over traditional manual methods. Practice shows that the transition to digital technologies reduces the time required to prepare estimates while increasing the accuracy of calculations. This difference is especially noticeable when working on large projects, where manual accounting for hundreds of items of materials and components inevitably leads to errors. Automation not only minimizes the human factor but also allows for rapid response to changes in market prices and exchange rates, especially important in times of economic instability [5].

The system being developed is a comprehensive solution based on the 1C platform. An enterprise designed to automate the entire calculation cycle for insulating pipelines with foam glass is based on a cost accounting module that includes a detailed calculation of material costs, taking into account current prices from manufacturers, logistics costs, and labor costs for installation work. A special feature of this system is its ability to quickly recalculate budgets when currency exchange rates change. This is especially important for projects that use imported materials.

The functionality of the system allows you to calculate the exact amount of insulation materials needed based on the input parameters of pipelines. The user can specify the diameters of pipes, and the number and types of shaped elements (bends, tees, valves), after which the system automatically calculates the volume of foamed glass, taking into account gaps and flow rates. Calculation algorithms take into account all design features, including the thickness of the insulating layer for different sections of the pipeline.

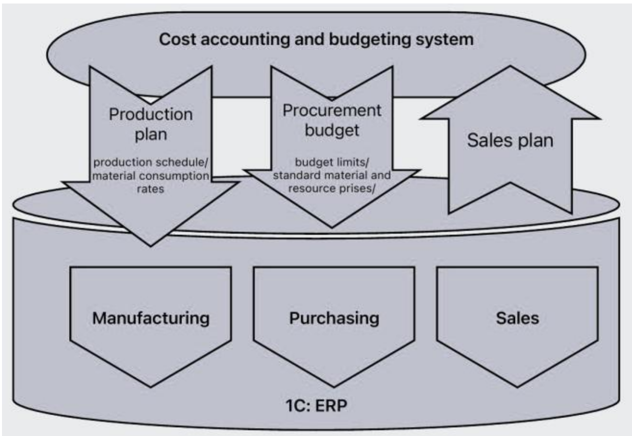

Fig. 3. Integration with 1C:ERP.

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An important component of the system is the ability to not only create a project budget but also model various implementation scenarios. The system ensures coordination of budgets between departments, control over budget execution, and cash flow planning. Built-in analytical tools allow for quick identification of deviations from planned targets and taking corrective measures.

The technical implementation of the system is based on the 1C:ERP configuration, which ensures reliable operation and the ability to integrate with other corporate systems. The user interface is designed to take into account the specific needs of cost estimators and designers, providing convenient data entry and visual representation of calculation results. The system supports working with different units of measurement and automatically converts values when necessary [6].

Special attention is paid to the integration capabilities of the system. Automatic loading of current exchange rates from official sources has been implemented, as well as the ability to connect to supplier databases to obtain current prices for materials. This minimizes manual data entry and ensures that calculations are highly up-to-date. The architecture of the system provides for the possibility of further expansion of functionality, including the addition of new types of insulation materials.

An example of the implementation of the system at an oil and gas facility showed a reduction of material overruns by 15-20% due to accurate calculation of technological gaps and optimal cutting of insulating elements. The system saved about $90,000 during the construction of insulation for a 12-kilometer-long main pipeline by automatically selecting the most profitable suppliers and optimizing logistics routes. At the same time, the time needed to approve the final budget was reduced from 14 working days to 3.

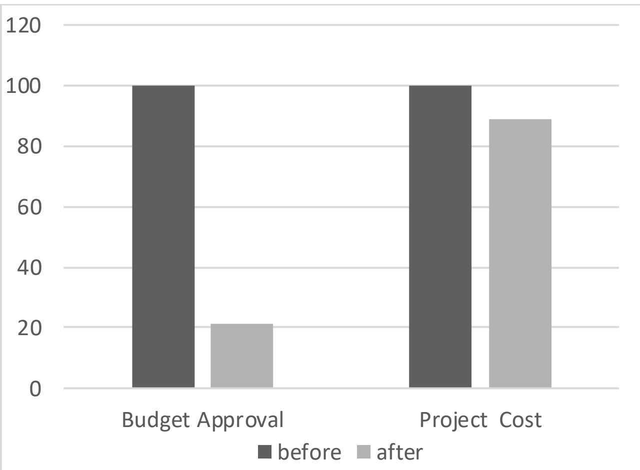

Fig. 4. The outcomes of the experimental project.

The main users of the system are construction and industrial enterprises engaged in the installation and maintenance of pipeline systems. In the oil and gas industry, the solution has already proved its effectiveness in implementing Gazprom projects. Energy companies can use the system to plan repairs to heating networks, and utilities can optimize infrastructure modernization costs. The flexible architecture of the 1C platform makes it easy to adapt the system to the specifics of a particular enterprise without the need for serious revision of the source code.

The prospects for the development of the system include expanding its functionality through the module for predicting insulation life and integrating it with BIM technologies. A mobile version is planned to be developed for working directly on construction sites, and an API is to be created for seamless connection to corporate systems. Special attention will be paid to introducing artificial intelligence elements to analyze historical data and automatically suggest optimal solutions.

IV. Conclusion

The results of the implementation confirmed that the developed system not only solves problems of accurate cost calculation but also becomes an important tool for strategic planning. Key achievements include shortening the time needed for preparing project documentation, reducing errors in calculations, transparency in budgeting, and the ability to quickly model different scenarios. For maximum efficiency, it is recommended to deploy the system in stages, starting with pilot projects providing mandatory training for staff and creating internal work procedures. Further development of the system will involve creating a single digital platform for all participants in the construction process, from designers to installation teams.

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