

LOGISTICS OF MATERIAL FLOWS IN SHIP REPAIR PRODUCTION PROJECTS

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Abstract. A logistics system is a complexly organised, integrated economic system consisting of interconnected links in a single process of managing material and related flows. Project management in logistics systems uses the application of project management methods and models in the process of designing logistics systems and managing changes in them, as well as solving the problems of managing resource flows in logistics systems. The design, creation and management of logistics systems is accompanied by their presentation as an integral set of elements in certain relationships and connections between them. The logistics system should meet the goals of their design and management. The article outlines elements of the mechanism of logistics management of material costs of ship repair production. Efficient use of the company's resources is possible through the systematic development of a system of organisational and technical measures to reduce costs. All cost-cutting measures are closely interrelated and comprehensive, reflecting the relationship of each of them with the entirety of ship repair production elements. The paper substantiates the production features of a ship repair enterprise and analyses the factors that determine the level of costs. It identifies types of ship repair works and stages of preparation of vessels for repair, which makes it possible to plan costs for formation of the production programme. This text presents the production structure of a ship repair enterprise and discusses the peculiarities of product costing. Ship repair companies use planned, indicative, estimated (technical) and reporting costings. This makes it possible to develop a mechanism for managing the costs of ship repair projects and the production process of a ship repair company.

Keywords: resources, costs, value, logistics, projects, information system, ship repair production, ship repair.

JEL Classification: L23, M11

1. Introduction

Ship repair production has the following characteristics: a high degree of uncertainty in the planning and execution of ship repair projects, one-off and small-scale production, the influence of seasonality on the workload of ship repair enterprises, a significant production duration, uneven costs during the repair process, a significant number of incoming cargo flows. These characteristics are due to the structural and technological complexity of the repair production facility, the diversity of ships, ship mechanisms and equipment.

Efficient use of enterprise resources is possible through the systematic development of a system of *organisational and technical measures* that reduce costs. All cost reduction measures are closely interrelated and complex in nature, which reflects the connection of each of them with the entire set of elements

of ship repair production. The development and implementation of cost management mechanisms based on modern information technologies is an urgent task in the development of a management system for ship repair production.

The principles of cost classification in the production of goods and services, as well as the economic mechanisms of formation and analysis of enterprise costs are described in the literature. The organisational and production peculiarities of ship repair production are outlined in the works (Fateev, 2020, 2021). Cost management in projects implemented in matrix organisational structures is considered in the paper (Zaporozhets, 2021). However, cost management technologies taking into account the specifics of ship repair production require further study, analysis and selection of appropriate information systems.

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The *article is aimed* at developing mechanisms for managing the costs of ship repair production, taking into account the specifics of project implementation and analysis of the factors that determine the level of costs.

2. Methods of Designing Logistics Systems

Designing logistics systems consists of two stages:

1. Macro-design involves solving functional and structural issues.

2. Micro-design is associated with the breakdown of links and elements of the logistics system, taking into account their interconnection and interaction, and the specifics of performing the main functions.

Logistics system design methods are divided into three classes:

- Analytical methods used to evaluate and analyse existing logistics systems;
- optimisation methods are based on various types of programming. In the design of logistics systems, optimisation methods are used to build supply chains and select transport schemes (Kharrison, 2007);
- modelling methods used in designing under uncertainty to make management decisions (Blaha, 2021).

The design of logistics systems requires taking into account a number of regularities inherent in logistics systems:

- The law of equal capacity of the logistics system, where the productivity of each subsequent link should be no less than the previous one;
- the law of conservation of logistics flow implies structural and parametric integrity of the flow;
- the law of relative resistances stipulates that the structural stability of a system depends on the lowest relative resistances of all its elements.

Designing a logistics system involves designing the following subsystems (Danchenko, 2017):

- Design of the structure;
- design of the process;
- management subsystem design.

These subsystems, being part of the logistics system, are interconnected and interact with each other, so their organisation is possible only with due regard to the integrity of the system (Nehoda, 2023).

3. Features of Cost Management in Ship Repair Enterprise Projects

It is customary to classify all production costs into two groups: budgetary and estimated. *Budget classification of costs* – corresponds to the main elements involved in the production process. The aggregate of costs constitutes the cost estimate for production and management of the enterprise.

Costing – reflects the costs of producing certain types of products and determines the production cost of products. Depending on how they are included in costing, these costs are divided into direct and indirect costs. *Direct costs* are costs that are directly attributable to each type of product, i.e., costs determined by the norms for the manufacture of a specific product or repair of a specific facility. *Indirect costs* include costs that cannot be directly attributed to individual products, i.e., costs associated with managing the production process. Along with the division into direct and indirect costs, which is determined by the method of allocating them to the cost of production, costs are divided into semi-variable and semi-fixed costs. The group of *semi-variable costs* consists of costs that vary in proportion to changes in production volume. *Semi-fixed costs* are not directly related to the volume of production and remain relatively constant when it changes within certain limits.

The cost of ship repair is influenced by: types of ships, type and organisation of repairs, price ratio of various types of industrial raw materials, composition and level of qualification of personnel, level of innovative development of production, quality of management system.

Depending on the purpose and content of the work, ship repair is divided into the following types:

- Current repairs include cleaning and painting of the vessel's hull structures, maintenance of engines and electrical mechanisms;
- overhaul is the complete restoration of the vessel's reliability as a technical system;
- maintenance is carried out on obsolete vessels in the last years of their service to ensure that they can operate with certain restrictions;
- restoration repairs for vessels that have lost their Register class, as well as vessels that have suffered significant damage in accidents.

The ship repair process is divided into 8 stages:

- The preparatory stage includes the preparation of documentation (repair lists), design and technological preparation of production and zero-stage work;
- fault detection stage – technical diagnostics, which determines the technical condition of the vessel and, based on the data obtained, establishes the optimal scope and methods of repair;
- dismantling stage – dismantling of units and housing structures. The disassembly procedure is determined by the operating and repair documentation;
- the fault detection stage involves inspection and determination of the scope of repair work on the unit's parts using the flaw detection method;
- the parts restoration stage involves work to restore the shape and dimensions of parts, internal and surface properties of metal using restoration methods;

- the assembly stage is the assembly of components and units;
- the installation stage is carried out both during the repair of the vessel afloat and at the dock;
- vessel testing (mooring and launching).

The production structure of a ship repair enterprise is determined by the nomenclature and the scope of work. The basis of the operating system of a ship repair company is formed by production units performing a certain group of functions (hull repair, repair of mechanisms and electrical equipment, dock work, transport operations, mechanical processing, etc.). The workshops of a ship repair company are divided into sections according to subject or technological characteristics. The content and scope of the workshop's work is planned on the basis of the total labour intensity of all orders for the planning period, as well as separately for each vessel. Repair and installation and procurement workshops implement the main technological chain ensuring the repair and delivery of the vessel to the customer.

Preparation of ships for repair is carried out in two stages: preliminary and technical preparation of the ship repair facility.

Preliminary preparation of ship repair production:

1. Preparation for repair:

- Assignment of the vessel to the ship repair company;
- transfer of the repair list, drawings and projects to the company;
- zero stage of work;
- agreeing on the scope of work and the cost of the ship repair – concluding a contract.

2. Proper repair.

3. Delivery of the vessel and its commissioning.

Technical preparation of the ship repair production:

- General plant (calculation of repair lists and orders, preparation of estimates, adjustment of projects and drawings, preparation of work schedules);
- intershop (development of technological processes, manufacturing of equipment and billets);
- workshop (preparation of the workplace, issuing work orders, dispatching).

Costing is the calculation of total costs (planned or actual) for the production of certain types of products and services for a certain period. Ship repair companies use planned, approximate, and estimated (technical) costing and reporting costing.

The *planned cost* reflects the amount of the required ship repair costs. It is set on the basis of material consumption rates, as well as labour productivity and utilisation of the company's production facilities. It applies to all vessels in the planning period, including engineering facilities. The planned cost is calculated on the basis of the estimated cost. Their difference is as follows: the planned cost is based on the amount of repair work for the planned year, while the estimated cost covers the entire repair

of the vessel, without taking into account the fact that some of the repair work is to be carried out in the next year or has already been completed in the previous year.

The *approximate cost* is determined on the basis of information about the repair provided by the customer to clarify the scope of the repair and bring it to the planned limit.

An *estimate* is a calculation of the cost of the planned ship repair work. This calculation is made on the basis of repair lists, price lists for typical repair work and other applicable standards and price tags. Based on the estimate, a ship repair contract is concluded, the duration of which is determined by the scope of work and the shipyard's capabilities.

4. Information Systems in Ship Repair Enterprise Projects

The ship repair plan is developed in the project management information system, which is presented on the information systems market (MS Project Standard, 2024). The hierarchical structure of works, the establishment of resource cost limits and the determination of resource costs in terms of the work breakdown structure are carried out at individual stages of repair. The elements of the ship repair network model are then integrated. The model obtained in this way allows to formulate the expenditure part of the repair budget in terms of production shops.

It is advisable to carry out the formation of budgets at higher levels of the hierarchy in the enterprise management information system (SAP, 2024). In this case it is necessary to ensure two principles: consistency and integrity of the budget system. This is achieved due to the fact that the basis of the basic repair plan is the project work parameters, and all corrective actions are reflected in the current budget system. Thus, as a result of the implementation of the project, the expenditure part of the budget is formed upon completion. This mechanism for monitoring ship repair processes enables to keep all types of production costs under constant review.

Budgets for management costs and investment resources for production development are formed in the management information system on the basis of the ship repair enterprise standards. It is advisable to form a consolidated budget of ship repair production.

The *reported cost* of ship repair, which reflects the actual costs of the enterprise, is determined by making changes to the estimated cost of the repair work if these changes occurred during the production process. Taking into account these changes, all forms of estimate documentation are drawn up anew.

The determination of the initial cost of ship repair is no longer final. For example, if the scope of work was overestimated after the stated scope of work was clarified, the difference in the scope of work is included in the *consolidated estimate*. If, after acceptance of an already agreed estimate, undeclared scope of work is discovered, such work shall be included in the *additional estimate*.

All estimates and *consolidated calculations* for one or more orders form the total cost of ship repair. It can also be noted that the cost of ship repair work differs in the ratio between labour costs, materials and overheads. Some of them are labour-intensive (straightening the outer skin, cleaning tanks, dismantling components and mechanisms). Others require large volumes of material or the use of expensive materials (painting ships, replacing zinc protectors, refilling bearings). Still others consume large amounts of heat or electricity (foundries and blacksmiths). The fourth cannot be performed without the development of design documentation and the manufacture of unique specialised process equipment and tools.

The cost of a ship repair project at a ship repair company is controlled using the earned value method. It allows to estimate the deviation of actual project costs from the planned ones and is the basis for analysing the project status and forecasting its key indicators upon completion. The basic principles of the earned value method are outlined in the paper (PMBOK, 2021). The system has a built-in project tracking mechanism (MS Project Standard, 2024).

The following methods are used to analyse costs by production department and management structure:

- Simple analysis of deviations of actual results from planned results;
- monitoring of the shop budget execution with elements of factor analysis of deviations;
- strategic approach to the analysis of deviations.

The analysis is carried out by product unit, individual object and order, and for all products manufactured. Deviations between the actual work performed and the budgeted amount result in cost deviations.

The analysis of direct costs is accompanied by a corresponding analysis of production maintenance and management costs. The amount of overheads in the cost of production depends on their absolute value, production volume and direct production wages (for a particular order or facility). An analysis of shop and plant-wide costs shows that over 50% of them are related to the maintenance of shop and plant-wide personnel.

The analysis of workshop and general plant expenses is carried out by item, taking into account the following provisions:

- Workshop expenses are analysed by workshops and budget items;
- when analysing expenses that vary depending on the plan performance, their amount is adjusted in accordance with the budget (energy costs of all types, bonuses for meeting and exceeding the plan, and so forth);
- complex cost items are analysed based on the analysis of the cost of products and services of auxiliary shops;
- analysis of non-production costs and production losses.

At a ship repair company, the completion of a project is reflected in the *reported cost*, which shows the actual costs of the company, determined by making changes to the scope of repair work in the estimated cost if these changes occurred during production. Taking into account these changes, all forms of estimate documentation are drawn up anew.

5. Conclusions

1. In the management process, the need to solve complex problems of designing and creating logistic systems in conditions of severe limitations of material and financial resources and, above all, time, requires the use of project management as a scientific and practical approach to solving such problems. Ship repair production is characterised by a high degree of uncertainty in the planning and execution of work and by the uneven use of all types of resources. Therefore, feedback between the subject and object of management is of fundamental importance in ship repair. Project management mechanisms should reveal the existing immanent elements of self-governance and ensure their use within the framework of the goals set for the project.

2. The analysis of cost formation, taking into account the specifics of ship repair production, allows to develop effective cost management mechanisms for projects and production units. Modern logistics tools make it possible to build an effective system for managing material flows in projects, which makes it possible to determine the cost of each set of works with the required level of detail, form a cost structure by technological packages, control the execution of project works using the earned value method, track the work of subcontractors, and influence project results in a timely manner.

3. The analysis of the operating system of a ship repair enterprise presented in the article is the basis for reengineering the management system and provides a focus on continuous improvement of operations and cost management. Management information systems used at ship repair enterprises allow integration of tools for managing material flows and project management. This improves the quality of management and the competitiveness of the ship repair company.

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