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THE METHOD OF DETERMINING THE OPTIMAL SCHEME OF PROJECT CARGO DELIVERY

МЕТОД ВИЗНАЧЕННЯ ОПТИМАЛЬНОЇ СХЕМИ ДОСТАВКИ ПРОЕКТНИХ ВАНТАЖІВ

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ABSTRACT

The search for optimal solutions that enable efficient development of the required transportation volumes at the lowest possible cost is currently one of the main challenges for the growth of the maritime transport sector. The process of project cargo transportation using the maritime transport is associated with the complexity of mass and geometric characteristics of these loads, which requires the development of new methods of their adaptation to the technical capabilities of the seagoing ships. Every case of project cargo transportation require thorough voyage planning with regard to loading, stowage and securing of oversized and heavy units. That is certainly lead to combination of solutions that require an individual approach, application of special techniques and skills for the development of delivery schemes and organization of transportation of this type of cargo and, of course, the adoption of measures to ensure the safety of the transportation process. Ensuring the proper level of functioning of transport systems, solving economic problems by expanding the volume of exports and transport services is always a topical issue. Due to the growing demand for project cargo transportation using sea freight, which is objectively the best option for international transportation in terms of economic component of the cost-effectiveness of its use and its role in international trade. The shipping of project cargo on a long distances using maritime transport is in high demand among the customers of high-tech equipment and machinery, which further increases the share in the statistics of general cargo transportation in whole. Issues of cargo safety among those that pay heightened attention, determines the guarantee of preserving the shipment, on-time delivery, as well as the absence of loss or damage to cargo.

Keywords: project cargoes, transportation, optimal delivery scheme.

РЕФЕРАТ

Забезпечення належного рівня функціонування транспортних систем, вирішення економічних проблем за рахунок збільшення обсягів експорту та транспортних послуг - завжди актуальне питання. Через зростаючий попит на проектні перевезення вантажів із використанням морських вантажних перевезень, що є об'єктивно найкращим варіантом міжнародних перевезень з точки зору економічної складової економічної ефективності їх використання та його ролі у міжнародній торгівлі. Доставка проектних вантажів на великі відстані за допомогою морського транспорту користується великим попитом серед споживачів високотехнологічного обладнання та техніки, що ще більше збільшує частку в статистиці перевезень генеральних вантажів у цілому. Стаття присвячена пошуку оптимальних рішень, що дозволяють ефективно розвивати необхідні обсяги перевезень за мінімально можливих витрат, що на сьогодні є однією з головних проблем для зростання сектору морських транспортувань. Процес перевезень проектних вантажів з

використанням морського транспорту пов'язаний із складністю масових та геометричних характеристик цих вантажів, що вимагає розробки нових методів та їх адаптації до технічних можливостей морських суден. Кожен випадок морського перевезення проектних вантажів вимагає ретельного планування та пророблення рейсу особливо щодо стадій завантаження, розміщення та закріплення великогабаритних та важких вантажних місць. Це, безумовно, призвело до поєднання рішень, які вимагають індивідуального підходу, застосування спеціальних прийомів та навичок, розроблення оптимальних схем доставки таких вантажів до транспортного вузлу та організації перевезень даного виду вантажів, і, звичайно, прийняття заходів для забезпечення безпеки транспортного процесу.

Ключові слова: проектні вантажі, процес транспортування, оптимальна схема доставки.

Formulation of the problem in general terms and it connection with important scientific practical tasks

Among the measures directed to the delivery process of the project cargo is the necessity of proper study and evaluation of the transportation route from the manufacturer's warehouse to the transport hub. Surely, it is difficult to overestimate the role of rail transport in transporting project cargo, where the capacity reaches 500 tons with cargo handling indicators over 80% from those that are transported through the sea ports. But in some instances of non-critical weight of cargo units and compare the cost of transportation between the rail and water-automobile connections, the latter option appears to be advantageous. An additional option method of delivery can be the use of inland water transport, if the availability of navigable waterways and the possibility of using such a variant, but in a number of cases the supplying company does not have direct access to inland waterways, or the long-term river ports do not have sufficient capacity of transshipping facilities, and the dimensions of cargo spaces can limit the passage under the bridges. Due to the fact that some cargo spaces can exceed the permissible load on railway bridges and overpasses, road transport can also serve as an alternative.

The last achievements and publications analysis, in which the solution of the problem is begun and selection of the unsolved aspects of the problem

The choice of mode of transport or their combination to implement the optimal scheme of cargo delivery should be based on the study of technical and economic characteristics of each type of transport and determination of the conditions under which each type of transport is the most economical. The way of comparison of transport efficiency options of different types of transport depends on specific conditions. The papers [1-3, 7] deals with mode of transport interaction, multimodal and intermodal transportation reveal the nature and classification of combined transports and development of transport and technological process options' concept for goods delivery with participation of maritime transport. Types of transportation of project cargoes and criteria for their distinction studied in [13]. Works [4-5, 8] devoted to modelling of changes in ship’s operational condition during transportation of oversized and heavy cargo, Markov model approach for determining vessel activity and assessment of potential negative impact of the system of factors on the ship’s operational condition during transportation of oversized and heavy cargoes. Effectiveness assessment of non-specialized vessel acquisition and operation project, considering their suitability for oversized cargo transportation reviewed in [6, 16]. Methodological aspect of substantiating the feasibility of intermodal technology for delivery of goods in the international traffic and substantiating the logistics chain, selection of a rational scheme of cargo delivery including time criteria analyzed in [9-12]. In [14] featured, project and specialized cargo, supply chain planning surveyed. Based on the studied works highlighted the lack of methods of substantiation of optimal delivery schemes of project cargoes, which causes the need for additional research aimed at expansion of the existing theoretical basis.

The paper purpose formulation

To solve the problem of optimal scheme of cargo delivery selection, as well as the method of transportation, it should be taken into account that the main criteria is not only to achieve the minimum cost of cargo delivery, but also the delivery time rate and cargo safety issue. Based on these factors, the main task is to justify the optimal scheme of cargo delivery and the choice of a rational combination of modes of transport, which is carried out by comparing the results of transport costs and delivery options for the same cargo.

Presentation of basic research material substantiating scientific results

The object of many researches includes the technological process of cargo delivery, peculiarities of operations related to their handling and transportation involving maritime transport. Among the reasons that are the basis for reducing the efficiency of cargo delivery, using maritime transport is the lack of theoretical basis for comprehensive review of the shipping process of delivery. As well as theoretical and practical aspects of the functioning of the maritime transport complex in interaction with related modes of transport in the framework of the organization of cargo delivery.

Over the last decades, along with the growth of project cargo shipments, the percentage of such shipments has been steadily increasing. Tough competitive conditions force market participants to look for new ways to increase company profits through alternative use of their own fleet, including transportation of oversized and heavy cargoes. Experts predict that the share of project cargo transportation will continue to grow in view of a considerable increase in demand for project logistics, which is one of the most complicated types of transportation where both practical experience and ability to promptly solve non-standard technical problems are especially important. Almost all project cargoes are oversized or out of gauge cargo; therefore, careful analysis of shipping options is required, depending on the different size and weight of each unit of the cargo shipment. Undeniably, the safety of such transports is always paramount especially for project cargoes. That is a critical factor to ensure a smooth process of transportation and solutions to contingency situations that may arise.

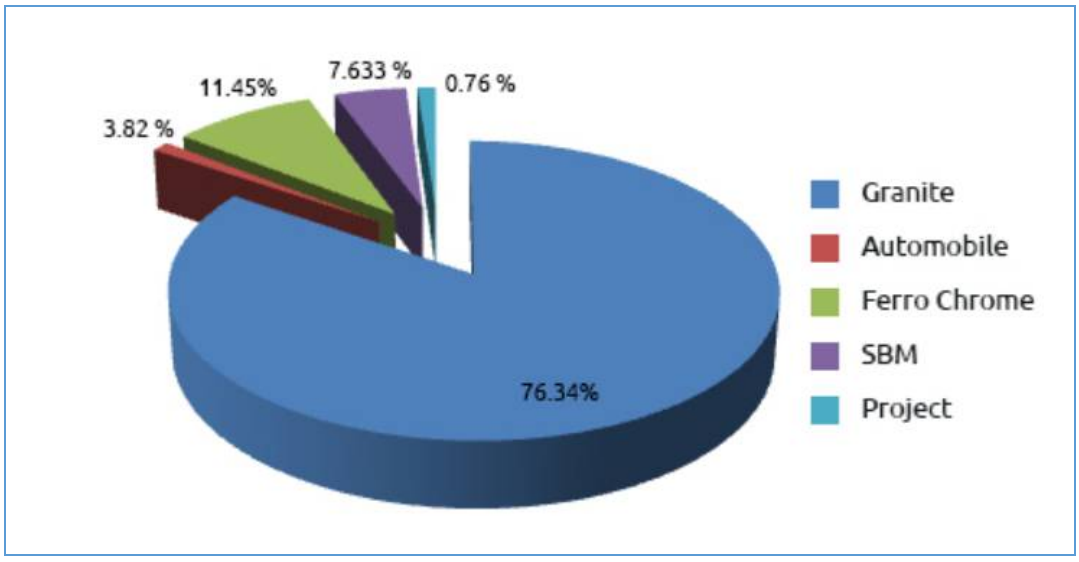

Figure 1. Share of project cargo transportation in the structure of ECL Group shipping company

Specific conditions of delivery and transportation of high-tech equipment do not allow for disassembly, demounting and dismantling into pieces, blocks, modules due to the high value and uniqueness of the production. Taking into account their shipping characteristics and specifics of transportation, the term "project cargo" has recently gained popularity in international practice [13], which unites under this term the cargo for transportation of which a separate project has to be

developed. Consignments of such cargo, as a rule, consist of oversized (large), voluminous, long-length units and are technologically complex components of special equipment and materials designed for remote assembly, installation and engineering in the process of construction of various kinds of projects [14].

The method of determining the optimal scheme of delivery abovementioned cargo depending on the total cost, delivery time and the probability of its damage in the process of transportation. That's specifies the key value of the following three indicators: total costs associated with the delivery of the shipment, the total delivery time of the shipment, and the probability that during the transportation of the shipment will remain unharmed. The value of each of these three indicators depends on the choice of delivery scheme. Table 1 shows the results of calculations of total costs associated with the delivery of the cargo, the total delivery time and expert estimates of the probability of damage to the cargo at various delivery schemes.

Table 1. Indicators of total costs, total delivery time and the probability of damage to the cargo with different delivery schemes

Scheme of cargo delivery, S_i	Total expenses, , $R_{ttl\ i}$USD	Total delivery time, $T_{заг\ i}$, days	Probability of cargo damage, P_i
S_1	20 000	5	0,005
S_2	80 000	4	0,003
S_3	40 000	6	0,001
S_4	30 000	7	0,008
S_5	50 000	1	0,003

Selection of the optimal delivery scheme can be formally reduced to the following problem of multi-criteria optimization:

$$(R_{ttl}, T_{ttl}, P) \underset{S_i}{\rightarrow} min, \quad (1)$$

where is necessary to find such a scheme of cargo delivery S_i, which simultaneously achieves the minimum value of three indicators - the total costs associated with the cargo transportation R_{ttl}, total delivery time T_{ttl}, probability of cargo damage, P.

As the calculations show (Table 2), the choice of the same cargo delivery schemes allows minimizing the values of T_{ttl}, However, in this case the values of $R_{ttl}$and P increase. When choosing other cargo delivery schemes, it is possible to minimize the value of R_{ttl} by increasing the values of other indicators. Thus, there is no such scheme of cargo delivery at which all three considered objective indicators would reach the minimum at the same time. So in order to substantiate the selection of such options for the cargo delivery S_i, in which a balance between these three indicators would be achieved, the decision maker must indicate the level of advantage for each of the examined target indicators.

To determine the level of benefit of each of the considered target indicators we will use the vector of valuation coefficients $\alpha=(\alpha_1, \alpha_2, \alpha_3)$ such that $\alpha_1, \alpha_2, \alpha_3 \geq 0$ and $\alpha_1+\alpha_2+\alpha_3=1$. The values of

coefficients α_1, α_2 and α_3 are selected by the decision maker, so that the value of α_1 will be chosen the closer to 1, the more priority is given to the value of the total costs of cargo transportation.

If the decision maker considers it reasonable to shift the balance of benefits in the direction of reducing the total delivery time of the shipment or reducing the probability of its damage, then, accordingly, a high value of the coefficient should be selected α_2 or α_3.

If all three objective criteria are equally important to the person making the decision, then you should choose $\alpha_1=\alpha_2=\alpha_3=0{,}333$. Thus, by setting the values of coefficients α_1, α_2 and α_3, the two-criterion optimization task (1) can be transformed into a one-criterion optimization task:

$$F(S_i) \underset{S_i}{\rightarrow} min, \tag{2}$$

where the function $F(S_i)$ is defined by the equilibrium:

$$F(S_i) = \alpha_1 \cdot \frac{R_{ttli} - R_{ttlmin}}{R_{ttlmax} - R_{ttlmin}} + \alpha_2 \cdot \frac{T_{ttli} - T_{ttlmin}}{T_{ttlmax} - T_{ttlmin}} + \alpha_3 \cdot \frac{P_i - P_{min}}{P_{max} - P_{min}}, \tag{3}$$

where R_{ttli} - total costs for the i-th scheme of cargo transportation; R_{ttlmax} - maximum achievable total costs for the various considered schemes of cargo transportation; R_{ttlmin} - minimum expected total costs for various considered schemes of freight transportation; T_{ttli} - total delivery time for the i-th scheme of freight transportation; T_{ttlmax} - maximum expected delivery time for the various considered schemes of cargo transportation; T_{ttlmin} - minimum expected delivery time for the various considered schemes of cargo transportation; P_i - the probability of cargo damage at the i-th scheme of transportation; P_{max} - the maximum probability that the cargo will be damaged at various considered schemes of cargo transportation; P_{min} - the minimum probability that the cargo will be damaged in various examined schemes of cargo transportation;

The function $F(S_i)$ takes its values on the range [0, 1] and dimensionless.

Consider the solution of the problem (2) with different options for determining the balance between the total delivery time, total costs and the probability of damage to the cargo. For example, if all three objective indicators that are considered are equally important for the person who makes the decision, then selecting the $\alpha_1=\alpha_2=\alpha_3=0{,}333$, we conclude that the optimal scheme of cargo delivery S5, because the lowest value of the function $F(S_5)=0{,}262$ is achieved for it (Table 2).

Table 2. Calculation of $F(S_i)$ function values

Delivery scheme	$F(S_i)$ at $\alpha_1=\alpha_2=\alpha_3=0,333$	F(Si) at $\alpha_1=0,5$, $\alpha_2=0,1$ and $\alpha_3=0,4$	F(Si) at $\alpha_1=0,9$, $\alpha_2=0,1$ and $\alpha_3=0$
S_1	0,412	0,067	0,067
S_2	0,595	0,950	0,950
S_3	0,389	0,383	0,383
S_4	0,722	0,250	0,250
S_5	0,262	0,450	0,450

For example, if we choose $\alpha_1 = 0.5$, $\alpha_2 = 0.1$ and $\alpha_3 = 0.4$ i.e. the main priority is given to reducing the total costs and reducing the probability of damages, in this case, as shown in Table. 2 the optimal choice will be the third delivery scheme S_3, because the lowest value of function $F(S_i)$ is achieved for it.

If the main priority is to reduce total costs, pay less attention to the delivery time and completely neglect the cargo preservation, then the value of the coefficients $\alpha_1 = 0.9$, $\alpha_2 = 0.1$ and $\alpha_3 = 0$, we can come to the conclusion that the optimal solution would be the third scheme for the cargo delivery S_i.

Task solution for selecting the optimal method of project cargo delivery, in general is led to the identification of a number of criteria for the degree of their importance, and is characterized by indicators among them minimization of total costs associated with the cargo delivery, reducing the total delivery time, and excluding the possibility of loss or damage to the cargo. But achieving a balance between these indicators requires increasing the level of adequacy for management decisions as well as prioritizing each of the examined target indicators.

Conclusion

Maritime transport of project cargo, as well as a wide range of other general cargo is characterized by the lowest speed and significant delivery terms. Factors of influence on these indicators do not depend directly on the speed of seagoing ships during the voyage, the time, which is the basis for the implementation of technological processes required for cargo operations, transportation and warehousing works in the seaports. That is why the use of multimodal or combined transportation significantly contributes to accelerate the shipping process. Using a road transport in interaction with the maritime especially in the format of intercontinental transportation of oversized cargo in a direct multi-modal road-water connection, used in most to ensure delivery and transportation between the transport hub and warehouses of the shipper and the receiver. Undoubtedly, the presence of the shifting work between modes of transport creates additional pressure on the cost of delivery, but at the same time, this option remains the most effective in terms of the organization of delivery and the total cost of transportation in general.

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