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Issue Article

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OPTIMIZATION OF THE METHOD OF ATTACHMENT OF SECURING VARIOUS VEHICLES TAKING INTO ACCOUNT THEIR LOAD-CARRYING CAPACITY AND THE VOLUME OF CARGO TRANSPORTATIONS

Abstract: *This article examines the optimization of the method of securing various vehicles, taking into account their load capacity and the volume of cargo transportation during combined transportation, as an important factor in ensuring the efficiency, safety, and reliability of transportation.*

Key words: *Combined transportation, intermodal terminals, logistics optimization, transport logistics, cost analysis, mathematical forecasting, cost scaling.*

Language: *English*

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Introduction

Introduction, combined transportation- this is a complex and important task that requires the integration of various modes of transport for the efficient and safe delivery of cargoes from the sender to the of the recipient.

Carriage of goods by various modes of transport, such as rail, road, sea and air, allows to take advantage of each mode of transport and create a more optimal logistics network. However, in such combined transportation, it is necessary to take into account load capacity and volume of each vehicle to ensure proper securing and safety of the cargo at every stage of the journey [1].

When optimizing the method of securing loads in combined transport, it is important to take into account the characteristics of each type of transport and their specific requirements for securing loads

For example. When transporting cargoes by rail, it is necessary to ensure the correct distribution and securing of cargoes in wagons to avoid shifts and damage during the movement of the train. Automobile transportation requires the use of cargo fasteners, belts and special devices to secure the cargo to the platform or the truck body. When transporting cargoes by sea or air, the requirements for packing, marking and fastening the cargoes in containers or on pallets should be taken into account.

For successful optimization of combined freight transport it is also necessary to take into account the synchronizing between different types of transport. This includes planning and organizing transitions

between vehicles, ensuring the timely delivery of cargoes to the next stage of transportation, as well as the effective use of warehouses and transshipment sites.

Modern technologies and logistics management systems play an important role in optimizing combined cargo transportation. Automated monitoring and control systems allow the position and condition of the load to be monitored at every stage of the journey, ensuring its safety and minimizing the risk of loss or damage.[2] At the same time, digital platforms facilitate the exchange of information between participants in the logistics process using electronic devices and make it more efficient.

As a result, optimizing the method of attaching various vehicles, taking into account their load-bearing capacity and the volume of cargo transportation during combined transportation is an important factor in ensuring the efficiency, safety and reliability of transportation. This requires careful planning, coordination and the use of specialized equipment and technology to secure cargo at each stage of the route. Optimal use of the load capacity and volume of each vehicle allows to minimize costs, reduce the damage risk of cargo and improve the overall efficiency of the logistics system [3].

For successful optimization of combined freight transportation with regard to load capacity and volume, it is necessary to take into account also the characteristics of each type of cargo. Different loads can have different fastening and packaging requirements and their characteristics may influence the choice and method of attachment of the vehicle. For example, fragile or temperature-controlled loads require special precautions in securing and protecting against vibration and temperature changes.

Methodology of the study

Optimizing combined freight transport also requires cooperation and coordination between various participants in the logistics chain, such as carriers, forwards, warehouses and terminals. Accurate planning and information sharing between participants helps coordinate the various stages of transportation and ensures smooth and timely delivery of cargo.

An important aspect of optimizing combined transport is to ensure that cargo is transported in a manner that takes into account both environmental aspects and energy efficiency. Selecting optimal routes and using environmentally friendly modes of transport in combined transport can reduce the negative impact on the environment and reduce greenhouse gas emissions

Let there be $(n(j = (j = \overline{1,n}))$ types of cargo in amount of $(Q = Q_j j = \overline{1,n})$ each. In combined transport, transportation can be carried out by different means of transport. *j*-th load, equal to a_i. Let w_{ij} inform the quantity of the *j*-th cargo, that can be delivered in the planning period by a unit of the *i*-th type of transport, a combined delivery method; x_{ij} – is an unknown quantity- the quantity of the *i*-x transport vehicle assigned to the transportation of the *j*-th cargo.

When forming the objective function and the mathematical model of the problem, it is convenient to distinguish between situations when all types of work are equal and unequal. In most specific tasks, the existing traffic units are not sufficient to perform the specified volumes of combined transport (mixed transport with different modes of transport) in a timely manner. Let Δ_j be the volume of the *j*-th cargo that will not be delivered due to the lack of a sufficient number of transport vehicles in combined transport [4].

In the case of equivalent types of cargo, the following deliveries are most typical. In such situations, if there is not enough transport, the volume of each load will be reduced proportionally to ensure that the shortfall proportionally to ensure that the shortfall is even across all loads. This means that each load will receive only a portion of its original volume, and the difference (Δ_j) will be evenly distributed among all loads.

However, in the case of unequal types of cargo, the situation is more complex. Different cargoes may have different importance and priority, as well as different delivery requirements. In such cases, if there is not enough transport means, some cargoes may not be delivered at all, while other cargoes will receive only partial delivery.

These features should be taken into account when formulating the objective function and mathematical model of the problem. The goal is to minimize the total volume of undelivered shipments ($\sum \Delta_j$), given the constraints on available resources and the delivery requirements for each shipment. The mathematical model must take into account various factors, such as the weight of the shipment, delivery priority, vehicle availability and other constraints to find the optimal solution to the problem.

Thus, when analyzing and solving combined transportation problems, it is important to take into account the equivalence or unequal value of types of work as well as to set priorities and optimize the delivery of cargoes, taking into account the available resources and requirements for each load [5]. This helps ensure the efficient and reliable operation of combined transport and achieve its goals. In the case of equivalent types of cargo, the following deliveries are considered the most typical:

In conclusion, optimization of the method of securing various vehicles taking into account their load capacity and the volume of cargo transportation during combined transportation is a complex and multifaceted process. It requires careful analysis and planning, cooperation between participants in the logistics chain, the use of modern technologies and

consideration of various factors such as types of cargo and environmental aspects [6]. Optimization of the securing method allows achieving optimal efficiency and reliability of transportation on combined routes and contributes to the development of a sustainable and efficient logistics system.

Discussion of results.

In order to successfully optimize the method of securing different vehicles, several key aspects must be taken into account.

Firstly, the load capacity and volume of cargo transportation play an important role in choosing the optimal method of securing. Different types of cargo require specific approaches and vehicles to ensure their safety and efficient transportation. For example, heavy loads require stronger, more stable lashings while fragile or shared loads may require special packaging materials or separate space.

Secondly, when, optimizing, it is necessary to take into account the type of combined transport. Combined routes may include different modes of transport such as rail, road, sea or air transport. Each type of transportation has its own characteristics and requirements for securing cargo. For example, in the case of multimodal transport, cargo must be properly packed and secured to ensure its safety and minimize the risk of damage during transshipment between different modes of transport [8].

In addition, environmental aspects should be taken into account when optimizing the fastening method. Modern logistics systems strive to reduce the negative impact on the environment. Choosing the right fastening method helps reduce energy consumption, waste and the environmental footprint of logistics operations.

In general, optimizing the method of protecting various vehicles during combined transportation requires an integrated approach and includes analyzing cargo needs, selecting suitable transport, using modern technologies and taking into account environmental factors. This ensures optimal transport efficiency and reliability, contributes to the development of a sustainable and efficient logistics system and also reduces the negative impact on the environment [9-10].

Figure 1 shows different types of transport and their carrying capacity in relation to the volume of cargo that can be transported.

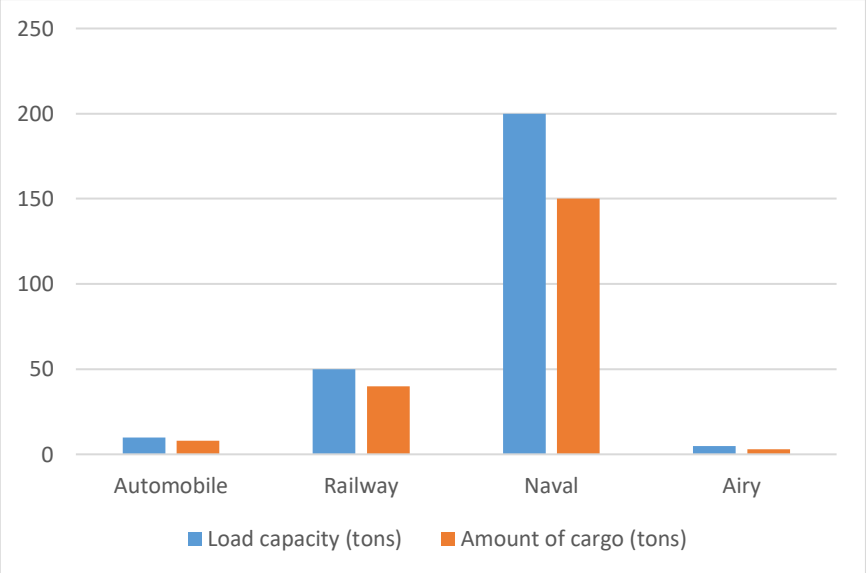

Figure 1. Diagram of the dependence of the amount of cargo on the carrying capacity of the vehicle

The graph in figure 1 shows how the amount of cargo that can be transported depends on the carrying capacity of different types of vehicles. Specifically, the graphic compares four modes of transportation: road, rail, sea and air. Two values are shown for each type of transport: the maximum carrying capacity (blue stripe) and the actual amount of cargo that can be transported (orange stripe).

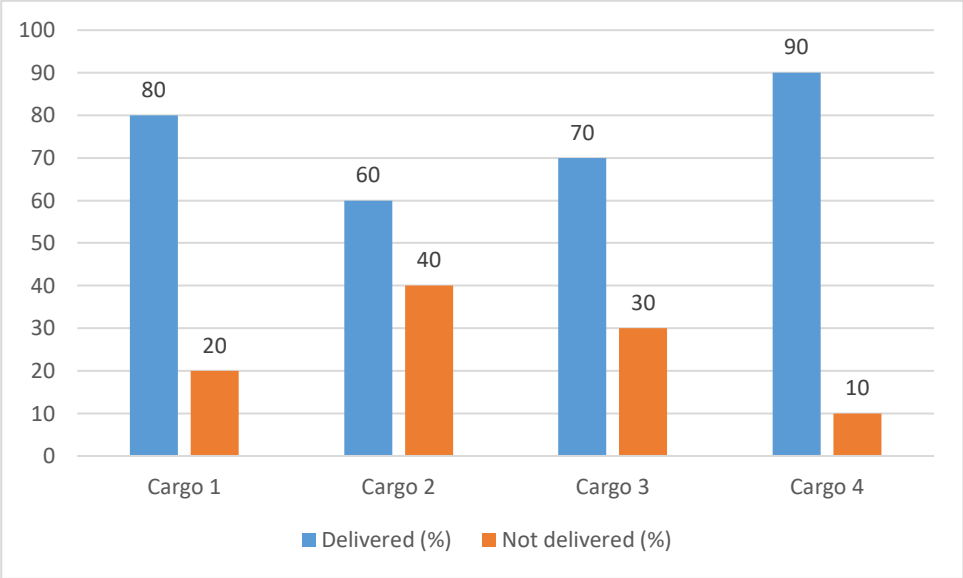

Figure 2. Distribution schedule of undelivered cargoes.

The graph in figure 2 shows how delivered and undelivered cargo is distributed for different types of cargo during times of vehicle shortages. The graph shows four types of cargo and shows two values for each cargo type: the percentage of cargo delivered (blue line) and the percentage of cargo not delivered (orange stripe).

Figure 3 compares the maximum cargo volume with the actual cargo transported for different modes of transport showing how the total cargo volume can be optimized.

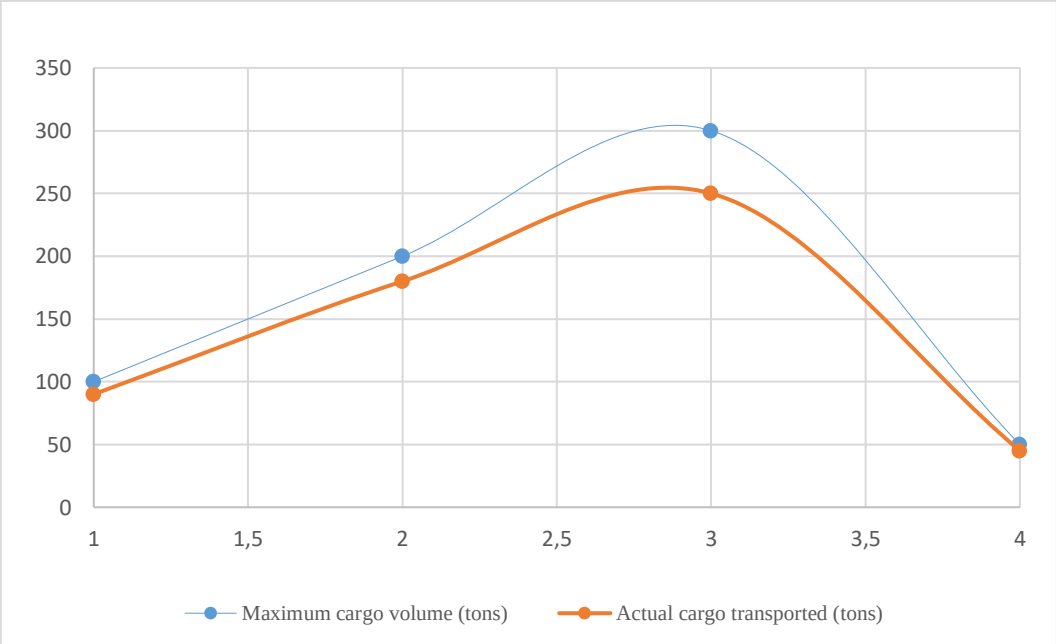

Figure 3. Total transportation volume optimization table

The graph in figure 3 shows what the maximum carrying capacity of various types of vehicles is compared to the actual transported cargoes. The graph shows four types of transport: road, rail, sea and air. Two lines are displayed for each type of transport: the maximum carrying capacity (dashed red line) and the actual loads transported (solid green line).

Conclusion

Optimizing the method of providing various means of transport, taking into account the volume of transportation and the volume of cargo carried in combined transport is a complex and multifaceted process. Different modes of transport such as road, rail, sea and air have their own specific characteristics that must be taken into account to maximize their

potential. To reduce shortages and optimize transportation volumes, it is important to properly distribute loads, especially if there is a shortage of vehicles. Effective coordination between different transport modes and supply chain participants as well as the use of modern monitoring and control technologies play an important role in successfully optimizing combined transport. At the same time, it is necessary to take into account environmental aspects, choose optimal routes and environmentally friendly modes of transport. Thus, an integrated approach to optimization allows achieving high efficiency and reliability of cargo transportation, contributes to the development of a sustainable logistics system and reduces the negative impact on the environment.

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