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Development of a mathematical model for the functioning of a river port discharge point

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Abstract: The current stage in the development of transportation in river ports is characterized by an increase in requirements for the timing of cargo delivery, quality of transportation, reduction of costs for transport and storage operations. In the transportation system, transport hubs are the central link, since cargo de-livery begins and ends in them, processes of transhipment of cargo from one mode of transport to another take place. Should be noted that transhipment operations at the port are among the most time-consuming and difficult work on river and sea transport, the implementation of which is impossible without the use of modern information technologies and automated systems. Since the use of such systems can reduce the time and increase the quality of cargo handling. A mathematical model of a discharge point at the port is explicated, which describes the process of its functioning, is a state graph for a transport node. To calculate the probabilities of all possible states of this system, a system of algebraic equations is used. This allows to simplify the calculation of the possibility of transition from one state to another, which are determined by the state of trucks, since the solution of the resulting system of linear algebraic equations is not difficult and can be implemented in any mathematical program package. The waiting and maintenance times of trucks A and B are determined, with calculated by the ratio of the probabilities of the system states, quantitative values can be considered as justification for deciding on determining the efficiency of the transport system.

Keywords: graph, states, transhipment point, freight autocar, transport system

1. Introduction

The transport industry is one of the basic elements of the state economy, which operates an extensive railway network, a developed network of roads, seaports and river terminals, airports and a wide network of air connections, cargo customs terminals. Transport is one of the basic elements of the state economy.

Therefore, meeting the needs of the citizens regarding the provision of necessary transport services and business development is prioritized.

2. Results

Tables Transhipment of cargo is a complex technological process, which depends on the following factors: uneven receipt of vehicles and goods, failure of loading and unloading mechanisms and points, interchangeable level of operational reliability, intra-terminal movement of goods, etc.

The incoming flow of actions is formed by machines that arrive at the transhipment point at random times. According to the survey, it was revealed that the cargo point is a queuing system (waiting line), the functioning of which is a random process with discrete states and continuous time. In addition, the analysis of statistical data showed that this process is Markov [8-10].

When developing a model, the following restrictions are used:

1) 1 point is considered, which is served by 2 trucks (machine A and machine B) with an equal priority of unloading among machines (A = B);

2) the conditions of the transport system are determined by the conditions of trucks A and B, which may be in the following states: 0 − absence of the machine at the unloading point; 1 − unloading the machine at the point; 2 − waiting for the machine for maintenance;

3) when developing a system state graph, due to the low probability of events, we exclude the simultaneous arrival and instant arrival of machine B after unloading machine A;

4) the model is stochastic and the states of the vertices of the graph are independent of each other.

If all possible transitions of the system from state to state according to the operating conditions of the unloading point are described graphically, we obtain a model of the point in the form of an oriented state graph, which describes the "behaviour" of the transport system.

$$\begin{cases} P_0 + P_1 + P_2 + P_3 + P_4 = 1 \\ -(\lambda_{10} + \lambda_{13}) \cdot P_1 + \lambda_{01} \cdot P_0 + \lambda_{41} \cdot P_4 = 0 \\ -(\lambda_{20} + \lambda_{24}) \cdot P_2 + \lambda_{02} \cdot P_0 + \lambda_{32} \cdot P_3 = 0 \\ -\lambda_{32} \cdot P_3 + \lambda_{13} \cdot P_1 = 0 \\ -\lambda_{41} \cdot P_4 + \lambda_{24} \cdot P_2 = 0 \end{cases} \quad (1)$$

The resulting system of equations (1) forms the basis of the created mathematical model of a discharge point in the port. The numerical values of λ_i of the system for equations can be determined experimentally or according to the standards [1–3]. The waiting and maintenance times of trucks A and B are determined, respectively, by the ratio of the probabilities of the states of the system P_4/P_1 and P_3/P_2, the expectation is not more than a given number in % of their service time.The developed graph-model of transshipment processes will allow to describe the functioning of the port transshipment point and effectively draw up routes for vehicles.

The proposed methodology for assessing the risks of vehicle downtime.The proposed approach is universal, since it does not depend on the type of cargo and machine. This model, after some refinement, can be used when servicing an item with many machines. The practical significance of the work lies in the application of its results to create new and improve existing processes for the transport of goods by road in the port, to evaluate the effectiveness of their work, to justify the cost of transportation of goods. The results can be used to justify production decisions.

3. Concluding

The approaches to the development of a mathematical model of a transport unit in the form of a graph-model considered in the article allow to solve the problem of the efficiency of cargo transhipment in a transport unit.

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