EFFICIENCY OF CARS IN MULTIMODE TRANSPORTATION OF HIGH-CAPACITY CONTAINERS

Ryabov, Igor M., *Volgograd State Technical University (VSTU), Volgograd, Russia.*
Gorina, Vera V., *Volgograd State Technical University (VSTU), Volgograd, Russia.*

ABSTRACT

The article is devoted to evaluation of efficiency of functioning of cars in mixed transportation while servicing consignors and consignees of high-capacity containers according to the existing and proposed technology. It is shown that the existing technology has a significant disadvantage: a total of 16 stages is used in the process of cargo delivery. A more rational technology is proposed with the use of a container developed by the authors with folding load-lifting pillars, which makes it possible to reduce the number of stages by almost half. The analysis of the factors determining the efficiency of road transport in the maintenance of containers based on the proposed self-unloading models is carried out.

Keywords: car, mixed transportation, transportable container, load-lifting pillars, terminal complexes, cargo delivery, quality of service.

Background. *Mixed transportation (the European term used in EU countries: multimodal transport) is the most complex type of transportation, provided there are at least two types of transport in different combinations. The use of container loads in such transportations gives a significant economic effect and a gain in delivery time [1].*

In the world practice, the following schemes of multimodal transportation with the participation of road transport are common:

1) road transport – air transport – road transport;

2) road transport – railway transport – road transport;

3) railway transport – air transport – road transport;

4) railway transport – sea transport – road transport;

5) railway transport – road transport – air transport – road transport.

In Russia the second scheme is the most common (Pic.1).

Objective. *The objective of the authors is to consider efficiency of cars in mixed transportation of high-capacity containers.*

Methods. *The authors use general scientific and engineering methods, comparative analysis, evaluation approach, mathematical apparatus.*

Results. *In 2014, the number of container shipments on domestic routes along the network of Russian Railways increased by 1,7 times. The increase was facilitated by an improvement in the general level of service on railways. The company tries to offer favorable tariff conditions for each consignor, uses consolidation of cargo of several consignors into one train, speed of movement of container trains increases (up to 1341 km per day at an average speed of cargo shipments of 850–900 km per day) [8].*

In the mixed transportation of goods in containers, road transport is the link between consignors (consignees) and the main transport. However, in [1] it was shown that the existing technology of container transportations in mixed traffic has a significant drawback, which consists in a large number of delivery stages (16 of them) and a new technology based on the use of containers developed by the authors with folding load-lifting pillars [1, 2], which allows almost halving the number of technological steps.

Pic. 1. Loading of containers.

Table 1

Comparison of existing and proposed container delivery technology by the used equipment and rolling stock

No.	Operation	Equipment and rolling stock	
		Existing technology	Proposed technology
1	Loading of cargo into a container	Multi-purpose mechanical loaders (e.g. fork lifters)	
2	Loading of a container on RS	Special loading devices (e.g. front and side container loaders)	–
3	Transportation of a container to a consumer and a terminal complex	Specialized semitrailers-container vehicles	Specialized semitrailers-container vehicles, multi-purpose load platform
4	Removal of a container from RS	Specialized unloading devices (e.g. gantry)	–
5	Unloading of cargo from a container	Manual loading-unloading using bogies or loaders	

Table 2

Expert evaluation of the performance of cars in the transport node when delivering containers according to the existing and the proposed technologies

No.	Factors	Expert evaluation		Changes	
		Existing technology	Proposed technology	Absolute values	Growth rate, %
1	Reliability and quality of operations	7	11	4	57,1
2	Technological equipment	9	12	3	33,3
3	Waiting time for transshipment	12	1	-11	-91,7
4	Convenience of entry and exit	8	10	2	25,0
5	Availability of parking lots and free places	7	12	5	71,4
6	Compliance with sanitary norms	11	12	1	9,1
7	Additional services	7	9	2	28,6
8	Availability of waiting places for operations	6	11	5	83,3
9	Information support	10	10	0	0
10	Competence and professionalism of the staff	11	11	0	0
11	Service culture	8	9	1	12,5
12	Affordability of prices	5	10	5	100,0

Load-lifting pillars have an electric drive and make it possible to lift the container with the energy of the battery of rolling stock (RS) or the power grid of the station, and then lower it to the platform of the car with which the cargo is delivered to the destination [2–4] both at the transport node and at the client.

In this regard, it is of interest to evaluate the efficiency of functioning of road transport in the mixed transportation of containers using existing and proposed technologies. The typical maintenance scheme for the consignees and consignors of containers is shown in Pic. 2.

A comparison of the existing and proposed container delivery technology according to the equipment and rolling stock used is presented in Table 1. The analysis shows that fewer technical devices are required to carry containers using the new technology and the use of non-specialized automobile rolling stock is possible.

A set of factors determining the efficiency of functioning of road transport in the service of consignees and consignors of containers is shown in Pic.3.

With the indicator «reliability» it is possible to assess the guarantee of the performance of operations, the sequence and timeliness of their conduct, it is determined by the expression:

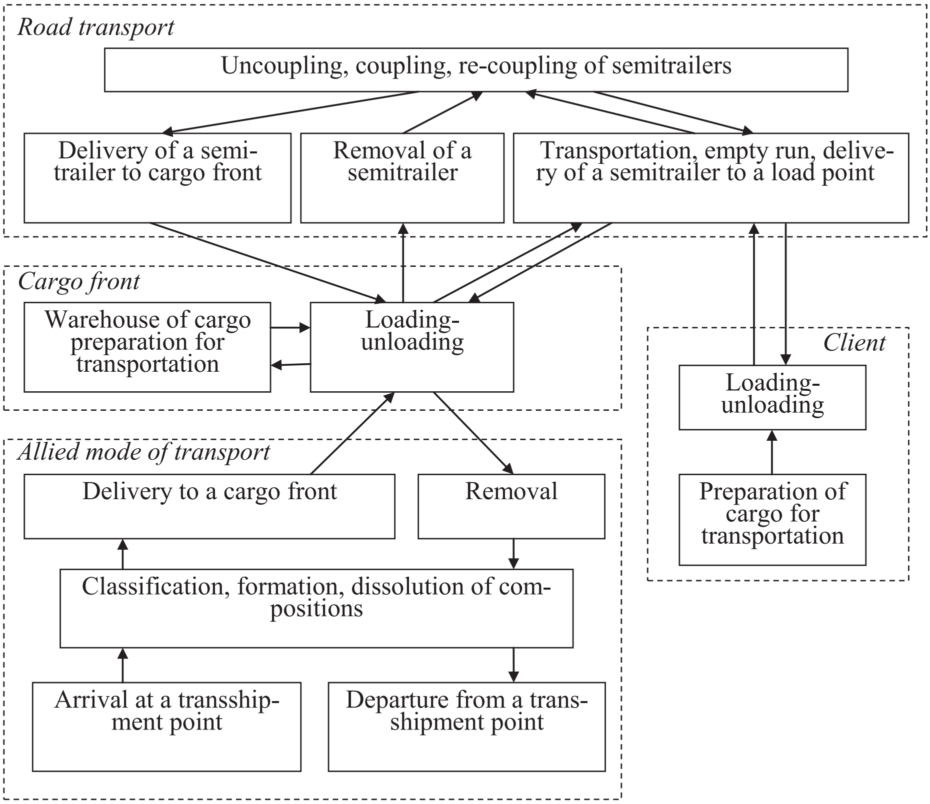
$$S_{rel} = \frac{U_{perf}}{U_{appl}}, \quad (1)$$

where U_{perf}, U_{appl} – the number of applications performed with a sufficient degree of reliability, and the total number of applications for services, respectively [10].

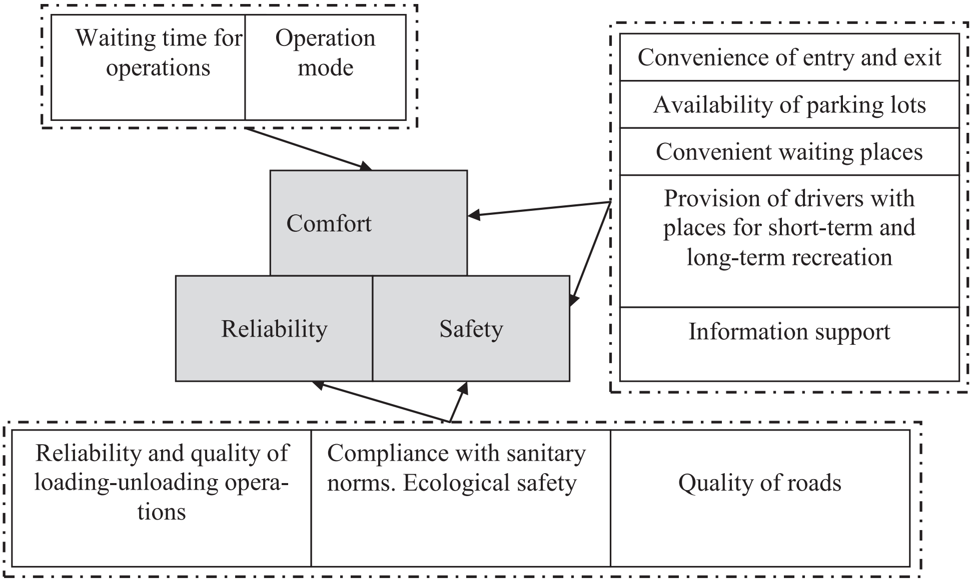
The indicator characterizing the reliability of performing operations «just in time» is found by the formula:

$$S_{relt} = \frac{t_{nom}}{t_{act}}, \quad (2)$$

where t_{nom}, t_{act} – nominal and actual time of the execution of operations, respectively.



Pic. 2. Scheme of functioning of road transport when servicing the consignees and consignors of containers.



Pic. 3. Factors determining the efficiency of the functioning of road transport in the delivery of containers.

The nominal time for performing operations is based on regulatory requirements, taking into account the working conditions of the transport complex, as well as the wishes of customers [10].

The safety criterion primarily reflects the degree of traffic safety in the locations of transport complexes and is determined by the expression:

$$S_{saf} = \frac{1}{k}\left(\frac{F_{appr.norm}}{F_{appr}} + \frac{F_{st.norm}}{F_{tot.}} + (1 - D_{TSOD})\right), \qquad (3)$$

where F_{appr}, $F_{appr.norm}$ – actual and normative number of approaches of transport with containers to the places of transshipment; F_{tot}, $F_{st.norm}$ – total number of terminal complexes (TC) and the number of T C equipped in *accordance with regulatory requirements; $D_{TSOD.}$ – partial defectiveness factor, which is based on the availability and compliance with the requirements of the necessary technical facilities and conditions for servicing containers in the TC (with full compliance with $D_{TSOD.} = 0$); k – number of individual safety criteria for approaches, container reloading and departure of transport*

The criterion of comfort is a complex of estimated parameters of the environment and the conditions for providing services in terms of convenience for the consumer and is determined by sociological research [10].

To assess the processes of functioning of road transport in the delivery of containers in accordance with GOST R9001–2008 and GOST R51004–96, 12 private indicators were selected that take into account:

1) reliability and quality of operations;
2) technological equipment;
3) waiting time for transshipment;
4) convenience of entry and exit;
5) availability of parking lots and free places;
6) compliance with sanitary norms;
7) additional services;
8) availability of waiting places for operations;
9) information support;
10) competence and professionalism of the staff;
11) culture of service;
12) affordability of prices.

To quantify individual indicators and determine the complex indicator of the efficiency of the functioning of road transport in the delivery of containers, a technique based on the application of registration methods and methods of sociology (surveys, questionnaires, use of scales) in the collection of initial information, followed by processing by methods of mathematical statistics and mathematical calculation is used [7, 9].

Table 2 presents experts' assessment of the efficiency factors of road transport when delivering containers using the existing and proposed technologies on a 12-point scale (1 – low value of the indicator, 12 – high value of the indicator). Absolute change in performance indicators is determined by the formula:

$$\Delta_{\text{abs.j}} = A_{prop.j} - A_{exist.j}, \quad (4)$$

where j – number of an indicator; $A_{exist.j}$, $A_{prop.j}$ – a score, assigned to the j-th indicator by the expert on the existing and proposed delivery technologies, respectively.

The growth rate of quality indicators is fixed by the formula:

$$T_{GR} = \frac{\Delta_{\text{abs.j}}}{A_{exist.j}} \cdot 100\ \%. \quad (5)$$

Conclusions. *The evaluation of the efficiency of the functioning of road transport in the delivery of containers on the existing and proposed technologies on the basis of the opinion of experts showed that the use of new mechanisms and procedures allows:*

– double the affordability of prices for operations;

– reduce the waiting time for transshipment to a minimum;

– increase the number of waiting places for reloading, parking and free places;

– increase the reliability and quality of operations.

REFERENCES

1. Ryabov, I. M., Gorina, V. V. Technology of Container Transportation Using Load-Lifting Pillars. *World of Transport and Transportation*, Vol. 14, 2016, Iss. 4, pp. 52–61.

2. Patent for utility model No. 168036, Russian Federation, IPC B65D90/14, B60P1/64. Loading-unloading device of a transportable container [*Patent na poleznuju model' № 168036 Rossijskaja Federacija, MPK B65D90/14, B60P1/64. Pogruzochno-razgruzochnoe ustrojstvo transportabel'nogo kontejnera*]. Patent holders I. M. Ryabov, V. V. Gorina, Volgograd State Technical University, 2017.

3. Gorina, V. V. Expansion of the possibilities of using containers at the expense of load-lifting pillars and improving the technology of their delivery [*Rasshirenie vozmozhnostej ispol'zovanija kontejnerov za schjot gruzopod'jomnyh stoek i sovershenstvovanie tehnologii ih dostavki*]. 21st Regional Conference of Young Researchers of the Volgograd Region (Volgograd, November 8–11, 2016): Abstracts. Volgograd, 2016, pp. 65–66.

4. Gorina, V. V. Expansion of the possibilities of using transportable containers due to the improvement of their design [*Rasshirenie vozmozhnostej ispol'zovanija transportabel'nyh kontejnerov za schjot sovershenstvovanija ih konstrukcii*]. *Contest of scientific, design and technological works of students of Volgograd State Technical University (Volgograd, May 10–13, 2016): Abstracts*. Volgograd, 2016, pp. 120–121.

5. Velmozhin, A. V. [*et al*]. Freight road transportation. Textbook for high schools [*Gruzovye avtomobil'nye perevozki: Uchebnik dlja vuzov*]. Moscow, Gorjachaja linija–Telekom publ., 2006, 560 p.

6. Gudkov, V. A., Shiryaev, S. A., Tarnovsky, V. N. Motor transport and loading-unloading devices. Study guide [*Avtotransportnye i pogruzochno-razgruzochnye sredstva: Ucheb. posobie*]. Volgograd, 1996, 98 p.

7. Gudkov, V. A., Shiryaev, S. A., Ganzin, S. V. Automated control systems for road transportation: Study guide [*Avtomatizirovannye sistemy upravlenija avtomobil'nymi perevozkami: Ucheb. posobie*]. Volgograd, VolgGTU, 1993, 119 p.

8. Gudkov, V. A. [*et al*]. Fundamentals of logistics. Textbook for higher schools [*Osnovy logistiki: Uchebnik dlja vuzov*]. Moscow, Gorjachaja linija–Telekom publ., 2004, 351 p.

9. Container shipments grow due to chemical and liquid cargo [*Kontejnernye perevozki prirastajut za schjot himicheskih i nalivnyh gruzov*]. [Electronic resource]: http://www.alternativa.in/container/konteynernye-perevozki-prirastayut-za-schet-khimicheskikh-i-nalivnykh-gruzov.html. Last accessed 25.04.2017.

10. Kuznetsov, E. A. Management of technical operation of cars [*Upravlenie tehnicheskoj ekspluataciej avtomobilej*]. Moscow, Transport publ., 1990, 272 p.

11. Serova, E. Yu. Providing high-quality roadside service to drivers and passengers on the basis of effective organization of the system of service enterprises. Ph.D. (Eng) thesis [*Obespechenie kachestvennogo pridorozhnogo obsluzhivanija voditelej i passazhirov na osnove effektivnoj organizacii sistemy predprijatij servisa / Avtoref. dis... kand. tehn. nauk*]. Volgograd, 2011, 16 p.

Information about the authors:
Ryabov, Igor M. – D.Sc. (Eng), professor of Volgograd State Technical University (VSTU), Volgograd, Russia, rjabov1603@mail.ru.
Gorina, Vera V. – Master's student at the department of Road transportation of Volgograd State Technical University (VSTU), Volgograd, Russia, im_ia@mail.ru.

Article received 25.04.2017, accepted 21.07.2017.