MULTIMODAL TRANSPORTATION IN SELF-UNLOADING CONTAINERS

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ABSTRACT

Delivery of goods in 40-foot containers in mixed traffic according to the existing technology can be carried out only through container terminals using specialized equipment (container trucks, gantry cranes, forklifts, etc.), since typical containers themselves cannot be unloaded from and loaded onto rolling stock. The article proposes a new technology that is based on the design of a self-unloading container developed by the authors. It is proved that it reduces the time of delivery of goods by more than 20 % and reduces the operating time of road transport by 7,4 times. This creates a significant economic effect, which allows to quickly recoup the purchase of a self-unloading container in just 14 runs along the calculated route.

Keywords: multimodal transportation, self-unloading container, cargo delivery, rolling stock, technology.

Background. *Every year, more than 200 million deliveries are made to different parts of the world, involving a total of almost 20 million containers. At the same time, the share of domestic carriers is not very large – the container transport system of Russia lags far behind the global one. This, in particular, is explained by the fact that container terminals and container trucks are necessary for carrying out technological operations, which are insufficient in the Russian Federation due to the obvious lack of investment and the high cost of maintenance.*

The technology of multimodal transportation of containers consists of sequential and interrelated stages and operations that regulate all actions for their movement from the place of loading of cargo to the place of its unloading. Improving the overall efficiency of such transportation can be achieved by improving the technology at some of its stages, for example, when using road transport.

The existing technology of multimodal transportation of containers has the following features:

- *a container with or without cargo which, as a rule, is dispatched as a transported unit with the appropriate details;*
- *containers are transported by various types of transport, are subject to reloading operations at senders and receivers of goods and are often used as transport capacity in technological processes of industrial enterprises;*
- *their parameters are unified, which facilitates handling and transportation;*
- *loading and unloading operations with containers are fully mechanized.*

The technology in question, of multimodal transportation of containers contains a large number of operations and is based primarily on the advantages of container terminals. The number of such terminals in the Russian Federation is much less than cargo stations. This leads to the need to transport containers by road over long distances, which increases the time of delivery and total costs. In addition, losses are increasing due to considerable downtime of rolling stock (RS) associated with unloading cargo at the final delivery point.

To reduce the cost of transporting containers by road, the authors of the article developed a new design of a self-unloading container with hydraulic load-lifting racks [7] and proposed a new technology of multimodal transportation using such containers [8].

The proposed container is equipped with load-lifting racks with electric drive, which allow using the battery energy of rolling stock or station network to lift a container above a railway platform and then lower it to the RS platform to deliver cargo to its destination with its help.

After a self-unloading container is delivered to the destination, the inverse operation is performed: load-lifting racks independently remove the cargo case from the RS platform and are set to a height convenient for unloading-loading processes and using mechanization tools, facilitating operations and increasing labor productivity [8].

When introducing a new technology, the RS is not completely idle while waiting for the container to be unloaded, so it can be used for other shipments, which increases the efficiency of its operation.

In order to assess the real benefits of an innovative approach, we will analyze some parameters and time expenditures in transit of rolling stock with a container using the existing and the proposed technology.

For clarity, we consider delivery of goods in a 40-foot container from the city of Volzhsky to a consumer in Novosibirsk.

Objective. *The objective of the authors is to consider and analyze advantages of multimodal transportation in self-unloading containers.*

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

Results.

* * *

The existing technology makes it possible to deliver containers by rail from the terminal station of JSC Russian Railways in Sarepta to the container station «Tomsk-Gruzovoy» and then by road to Novosibirsk.

Travel time from the departure point to the consumer is calculated by the formula [1]:

$$t_{path} = S/v_t, \quad (1)$$

where v_t – technical speed of transport, km/h; S – distance from the site of reloading to the consumer, km.

Table 1 presents the results of calculating the time spent on the stages of the route under consideration.

The time values of each operation and the equipment used for the delivery of a 40-foot container using the existing technology on Volzhsky–Novosibirsk route are presented in Table 2.

The delivery of newly designed containers under the proposed technology allows them to be transported by a universal cargo platform (for example, a tractor with a semi-trailer), as well as for loading, reloading and removing a container from rolling stock; no special loading and unloading mechanisms are required at any cargo station not equipped with cranes.

Table 1

The results of calculating the time spent on the stages of the route under the existing technology

Stages of the route	Transport	Time, h
1) Volzhsky–terminal of JSC Russian Railways in Sarepta	road	1,5
2) terminal of JSC Russian Railways in Sarepta–terminal «Tomsk-gruzovoy»	railway	72
3) terminal «Tomsk-gruzovoy»–Novosibirsk	road	4

Table 2

Time values of each operation and equipment used in the delivery of a 40-foot container using the existing technology

No.	Operation	Equipment	Time, h
1	Loading cargo in a container	forklift	0,747
2	Waiting for loading	–	0,282
3	Maneuvering of a car-container carrier	container carrier	0,066
4	Preparing a car-container carrier for loading	container carrier	0,093
5	Container loading on a car-container carrier	container carrier	0,165
6	Transportation of a container to a terminal complex	container carrier	1,5
7	Maneuvering of a car-container carrier	container carrier	0,066
8	Waiting for removal of a container from a car-container carrier	container carrier	0,282
9	Removal of a container from a car-container carrier	container carrier + gantry crane	0,165
10	Waiting for loading on the main transport	–	0,282
11	Preparing the main transport for loading	railway transport	0,093
12	Container loading on the main transport	railway transport	0,165
13	Container transportation by the main transport to the second terminal complex	railway transport	72
14	Waiting for removal of a container from the main transport	railway transport	0,282
15	Unloading of a container from the main transport	railway transport + gantry crane	0,165
16	Maneuvering of a car-container carrier	container carrier	0,066
17	Preparing a car-container carrier for loading	container carrier	0,093
18	Waiting for loading of a car-container carrier	container carrier	0,282
19	Container loading on a car-container carrier	container carrier + gantry crane	0,165
20	Transportation of a container to the consignee's site	container carrier	4
21	Maneuvering of a car-container carrier	container carrier	0,066
22	Waiting for removal of a container from car-container carrier	container carrier	0,282
23	Removal of a container	container carrier	0,165
24	Unloading goods from a container	forklift	0,747
Total			82,219

Table 3

Results of calculation of time spent on the stages of the route under consideration according to the new technology

Stages of the route	Transport	Time, h
1) Volzhsky–station Trubnaya, Volzhsky	road	0,08
2) station Trubnaya, Volzhsky–station Novosibirsk	railway	62
3) station Novosibirsk–finished goods warehouse	road	0,21

Table 4

Values of time of each operation and equipment used when delivering a 40-foot container using a new technology

No.	Operation	Equipment	Time, h
1	Loading cargo in a container	forklift	0,747
2	Maneuvering of a car	tractor lorry	0,033
3	Preparing a car	tractor lorry	0,093
4	Loading a container on a car	tractor lorry	0,1
5	Transporting a container to the railway station	tractor lorry	0,08
6	Maneuvering of a car	tractor lorry	0,033
7	Removal of a container from a car	tractor lorry	0,1
8	Preparing the main transport for loading	railway transport	0,093
9	Loading a container on the main transport	railway transport	0,1
10	Transporting a container by the main transport to the second railway station	railway transport	62
11	Unloading of a container from the main transport	railway transport	0,1
12	Maneuvering of a car	tractor lorry	0,033
13	Preparing a car for loading	tractor lorry	0,093
14	Container loading on a car	tractor lorry	0,1
15	Transportation of a container to the consignee's site	tractor lorry	0,21
16	Maneuvering of a car-container carrier	tractor lorry	0,033
17	Removal of a container	tractor lorry	0,1
18	Unloading goods from a container	forklift	0,747
Total			64,795

Table 5

The cost of using each type of rolling stock

Type of RS	The cost of use, rub./h
Car-container carrier	1600
Tractor lorry	1400

Table 6

Indicators of container delivery under the existing and proposed technology of multimodal transportation of goods

Indicators	Existing technology	Proposed technology
Number of stages of delivery	24 stages	18 stages
Delivery time	82,219 h	64,795 h
Operation hours of road transport	7,456 h	1,008 h
Cost of transportation by road transport per a run	11929,6 rub./run.	1411,2 rub./run.

Table 3 presents the results of calculating the time spent on the stages of the route using the new technology with the use of self-unloading containers.

The time values of each operation and the equipment used for the delivery of a 40-foot container using the proposed technology on Volzhsky – Novosibirsk route are presented in Table 4.

According to the existing technology, the operating time of road transport (Table 2) is:
$T_{road.\ exis.} = 7{,}456$ *h.*

According to the proposed technology, the operating time of road transport (Table 4):
$T_{road.\ propos.} = 1{,}008$ *h.*

Average values of the cost of using a car-container carrier and a tractor lorry are presented in Table 5.

Transport costs for the run are calculated by the formula [3]:

$$C_{day} = S_{hour} \cdot t_{tr}, \quad (2)$$

where C_{day} – daily transport costs, rub.; S_{hour} – hourly cost of transportation, rub./h; t_{tr} – transport time, h.

According to the existing technology, the cost per run:
$C_{run.\ exist.} = 1600 \cdot 7{,}456 = 11929{,}6$ *rub./run.*

According to the proposed technology, the cost of the run:
$C_{run.\ propos.} = 1400 \cdot 1{,}008 = 1411{,}2$ *rub./run.*

The delivery rates of containers under the existing and new technology of multimodal transportation of goods with participation of road and rail transport are presented in Table 6.

The economic efficiency of the run is the difference in transportation costs for delivery under the existing and proposed technology:
$E = C_{run.\ exist.} - C_{run.\ propos.} = 11929{,}6 - 1411{,}2 = 10518{,}4$ *thous. rub.*

The average price of a 40-foot container is 115 thousand rubles, and the price of a container of a new design is 143,75 thousand rubles.

The payback period for purchase of containers of new design can be calculated by the formula:

$$T_{payback} = C_{cont.}/E_{run.}, \quad (3)$$

where $C_{cont.}$ – cost of a container, rub.; $E_{run.}$ – efficiency per run, rub./run.

In our example, the payback period:
$T_{payback} = 143750/10518{,}4 = 14$ *runs.*

Conclusions. *The considered variant showed that the use of a new technology of multimodal container transportation with participation of road and rail transport, based on the use of self-unloading containers, allows:*

1) to reduce delivery time by more than 20 % by reducing the number of related operations (up to 25 %), since the self-unloading container performs part of the operations independently, and also eliminates the need to wait for the release of loading and unloading mechanisms;

2) to reduce the time and costs of road transport (by 7,4 times), because the new container design provides for raising and lowering the rolling stock onto the platform independently, without using special equipment at any station, which significantly reduces the transport work of road RS;

3) to obtain an economic effect as compared with the existing technology (on a real route – 10518,4 rubles per one run);

4) to quickly recoup the purchase of a self-unloading container (in the considered example, for 14 runs);

5) to improve the performance of automotive RS by reducing downtime.

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