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Organisational and Technological Aspects of Transport of Especially Valuable Goods in Rail Containers

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ABSTRACT

Growth of railway container transportation volumes in the Russian Federation obliges to pay attention to ensuring the safety of cargo transportation. In this regard, it is advisable to outline organisational and technological aspects of transport of especially valuable cargo in rail containers.

The analysis of current regulatory and technical documents, domestic and foreign experience, allowed identifying the most effective areas of ensuring safety of transported goods, which are based on making changes to the design of the automatic coupling device of the rolling stock. The paper substantiates the need to use indicators of careful handling, impact, tilt of cargo, vibrations, and temperature as well as the need to revise the insurance system for transportation of goods by rail.

This article describes a review and analytical study of the issue of ensuring safety of transportation of especially valuable cargo by rail, through the use of basic (making changes to the design of the rolling stock) and related (use of indicators (sensors) and improving the cargo insurance system) technical and organisational measures.

Keywords: *railway transport; freight wagons; platform wagons for transportation of large-capacity containers; dynamics of wagons; transport of especially valuable cargo; dampers; floating centre sill; container; rail cargo insurance.*

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INTRODUCTION

Cargo transportation by rail in the Russian Federation and the Commonwealth of Independent States occupies a leading position. Railway transport is best suited for mass transportation; it operates at any time of the year and regardless of atmospheric conditions [1].

Since the early 2000s, active development of railway container transportation has begun in the Russian Federation. This is due to creation in October 2003 of the Centre for Transportation of Cargo in Containers «TransContainer» – a branch of JSC Russian Railways (now – Public Joint-Stock Company TransContainer) [2].

A container is a reusable standardised tare for transportation of a wide range of goods by all modes of transport (railway, road, air, sea).

A wide range of cargo is transported in containers, including valuable and expensive ones (household appliances, satellite equipment, microscopes, microcircuits, sculptures, archaeological finds, porcelain, glass, ceramics, etc.).

It should be noted that some regulatory and technical documents (hereinafter referred to as RTD) do not consider special requirements and conditions for transportation of fragile cargo (for example, Standards for calculation and design of wagons for the railways of the Ministry of Railways with a gauge of 1520 mm (non-self-propelled))[1]. RTD pays more attention to forces and loads, while almost no issues are raised about safety of transportation of valuable cargo in containers.

In this regard, a review study of the issue of ensuring the safety of the transportation of especially valuable goods by rail is relevant, particularly in terms of the application of the main (making changes to the design of rolling stock) and related (use of indicators (sensors) and improvement of the cargo insurance system) technical and organisational measures.

RESULTS

Technical Arrangements

In many cases, shock-absorbing devices play an important role in ensuring the reliable delivery and safety of especially valuable goods.

Shock-absorbing devices of railway rolling stock in the Russian Federation [3] are generally like the same foreign devices. At the same time, it should be emphasised that domestic rolling stock uses variants of the SA-3 (Soviet automatic coupling, 3rd variant) with absorbing devices of various modifications in terms of the method of absorbing energy [4].

Addressing the history of the issue, the geometric parameters of the shock-absorbing devices of rolling stock have remained structurally unchanged since the 1930s. At the same time, the length, weight, and speed of cargo trains increased rapidly. Since 1950, the railways of the Union of Soviet Socialist Republics have begun to widely introduce hump yards, but the regulated speed of collision of wagons [5] during their disassembly is not always observed. To ensure safety of cargo, it was necessary to change the design of the automatic coupling device, increasing the stroke of the shock-absorbing device from 70 (90) to 110 (120) mm. However, simply increasing the stroke does not allow obtaining the set collision speed at a given level of longitudinal loads. The choice of possible changes in the geometric parameters can only be made based on thorough theoretical research. Priority measures include development of theoretical models of various models of automatic coupling devices and/or methods of shock absorption of cargo.

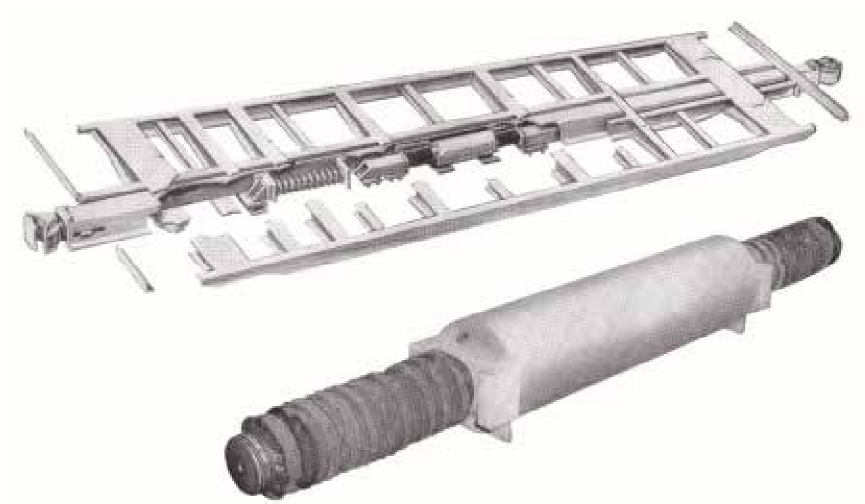
In this regard, it is advisable to briefly analyse the design, history and experience of using the shock absorbers operated and being now operated, e. g., on US railways. American shock absorbers tend to increase the shock absorber stroke. US railway experience shows that increasing the shock absorber stroke requires increasing the length of the automatic coupling tail (Pic. 1).

The increase in the length of the coupler tail is implemented by increasing the stroke of the absorbing device, which in turn requires making design changes to the cantilever part of the centre sill. One of the approaches to ensuring safety of the transported cargo is to change the design of the centre sill in the area of the thrust angle and replace the centring beams, as well as use a deflecting device of the coupler [6]. We emphasise that this approach cannot fully ensure safety of valuable cargo.

On the US railways, various design options for the implementation of floating centre sills have been developed (Pic. 2). The tasks of ensuring safety of the transported cargo are solved simultaneously with the tasks of

[1] Standards for calculation and design of railway wagons of the Ministry of Railways with a gauge of 1520 mm (non-self-propelled). Moscow, GosNIIV–VNIIZhT, 1996, 317 p. [Electronic resource]: https://dwg.ru/dnl/2822. Last accessed 01.10.2023.

Pic. 1. AAR Alternate Standard Controlled Slack Coupler with Drawbar [USA Car and Locomotive Cyclopedia of American Practice. 2nd edition by C. L. Combes (Editor). New York, Simmons-Boardman Publication Corporation, 1970, 1074 p. ISBN-10 1122559348, ISBN-13 978–1122559348].



Pic. 2. Spinal beam with hydraulic damper in the central part (USA) [Idem].

eliminating the spontaneous uncoupling of wagons from trains.

For transportation of special cargo, cars with floating centre sills of Pullman-Standard Car Manufacturing Company were built and tested (Pic. 3). However, this unit was used primarily on heavy-duty wagons, which was due to the need to use them with a long console. These solutions were implemented only within the framework of testing special-purpose wagons, for example, the model 11–9960 wagon built by JSC «TVZ» [7].

At present, JSC Russian Railways solves the problems of ensuring safety of train traffic and safety of transported goods using high-energy absorbing devices (elastomeric absorbing devices of classes T2 and T3). The elastomeric absorbing devices used, currently in serial production, have characteristics due to the need to absorb energy. With participation of one of the authors, elastomeric absorbing devices were developed [9; 10], which are currently widely used in wagons for transportation of dangerous goods.

Considering the design of passenger cars, it should be noted that rubber-metal absorbing devices (R-2P and R-5P) are widely used on this rolling stock [11]. It is known that the use of rubber elastic elements leads to a change in rigidity at low temperatures. Note that the calculation models do not consider the possibility of changing the liquid characteristics at a temperature of –60 °C.

Foreign experience in ensuring safety of transported goods shows its effectiveness. It is based on monitoring the acceleration level, including recording impacts, tilts and falls. ShockWatch® 2 indicators (USA) are widely used for monitoring careful handling, impact, load tilt, vibrations, temperature. These indicators are disposable (Pic. 4) and reusable. In disposable indicators, the control element (glass tube) is irreversibly painted red if an impact exceeding the permissible value occurs. Reusable indicators ensure recording of values and are reused within the standard service life[2].

Since there is currently a consistently high flow of cargo transported in container trains from

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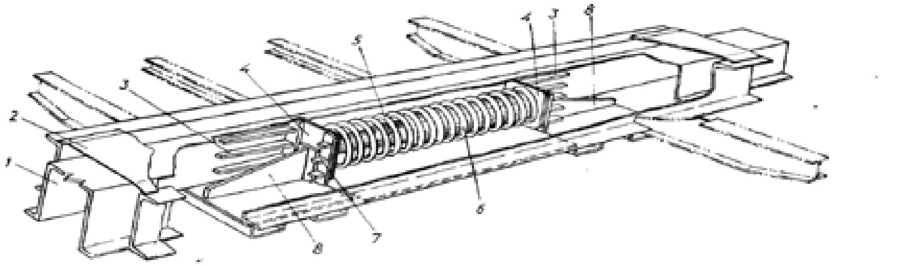
[2] Shock and tilt indicators ShockWatch® 2 (USA). Shockwatch GC «Control Technologies». [Electronic resource]: https://rosplomba.ru/g6920376-indikatory-udara-naklona. Last accessed 01.10.2023.



Pic. 3. Floating centre sill of a cargo wagon manufactured by Pullman-Standard Car Manufacturing Company (USA) [8].

Pic. 4. Disposable shock indicators ShockWatch 2 [2].

the People's Republic of China to the countries of the European Union through the territory of the Russian Federation, some of the above indicators will probably be used to monitor dynamic load conditions. The use of these indicators (their analogues) will increase the responsibility of each participant in the transportation process and minimise the incidence of damage to particularly valuable cargo.

Ensuring safety of transportation of particularly fragile and valuable cargo can only be achieved by comprehensive measures, in particular, by making changes to the design of the automatic coupling device of the rolling stock, as well as by installing special technical devices inside the container.

Based on the studies of shock-absorbing devices conducted by Russian University of Transport [12–15], it is possible to create probabilistic models of the occurrence of damage to transported cargo under current operating conditions.

Currently, work is underway to increase the stroke of shock-absorbing devices using standard absorbing devices.

In our opinion, an accompanying mechanism for increasing the safety of the transportation of especially valuable cargo by rail is a perfect system of cargo insurance on railway transport adapted to the conditions of transportation.

There are various approaches to cargo insurance on railway transport, including the use of state systems and programs, widely used in the world. Analysis of information on cargo insurance on the world's railways shows that each country uses systems and programs that are maximally adapted to local transportation conditions [16][3].

The existing transportation insurance system in the Russian Federation does not fully consider the requirements for ensuring safety. In our opinion, it is advisable to consider a possibility of creating a state cargo insurance system to ensure a single approach to cargo insurance. We believe that it is necessary to ensure the introduction of requirements at the level of state bodies, considering the specific conditions for ensuring the safety of certain types of cargo (for example, especially valuable), with the definition of the legal aspects of the work of supervisory authorities and insurance organisations.

BRIEF CONCLUSIONS

Even a brief review and analytical study have shown that achieving unconditional provision of

[3] Insurance Requirements for Federally Regulated Freight Railway Companies – Implementation guide [Electronic resource]: https://otc-cta.gc.ca/eng/publication/insurance-requirements-federally-regulated-freight-railway-companies-implementation. Last accessed 01.10.2023.

safety for the transportation of especially valuable cargo by rail can only be achieved under the condition of an integrated approach (a set of technical and organisational measures).

The quoted examples of both technical and organisation nature can be considerable complemented and systemised, and the first step towards it was to state the problem.

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