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JUSTIFYING THE PROLONGATION OF THE SERVICE LIFE OF THE BEARING STRUCTURE OF A TANK CAR WHEN USING Y25 BOGIES

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This paper substantiates the use of Y25 bogies under tank cars in order to prolong their service life. The reported study has been carried out for a tank car with rated parameters, as well as the actual ones, registered during full-scale research. Mathematical modeling was performed to determine the basic indicators of the tank car dynamics. The differential equations of motion were solved by a Runge-Kutta method using the Mathcad software package (USA). It was established that the use of Y25 bogies under a tank car with rated parameters could reduce the acceleration of its bearing structure by almost 39 % compared to the use of standard 18–100 bogies.

Applying the Y25 bogies under a tank car with the actual parameters reduces the acceleration of its load-bearing structure by almost 50 % compared to the use of standard 18–100 bogies.

The derived acceleration values were taken into consideration when calculating the bearing structure of a tank car for strength. The calculation was performed using the SolidWorks Simulation software package (France). The resulting stress values are 18 % lower than the stresses acting on the load-bearing structure of a tank car equipped with 18–100 bogies.

For the load-bearing structure of a tank car with the actual parameters, the maximum equivalent stresses are 16 % lower than the stresses when the 18–100 bogies are used.

The design service life of the load-bearing structure of a tank car was estimated taking into consideration the use of Y25 bogies. The calculations showed that the design service life of the bearing structure of a tank car equipped with Y25 bogies is more than twice as high as that obtained for 18–100 bogies.

The study reported here would contribute to compiling recommendations for prolonging the service life of the load-bearing structures of tank cars

Keywords: transport mechanics, tank car, load-bearing structure, dynamic load, structural strength, design service life

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1. Introduction

The improved efficiency of bulk cargo deliveries along international transport corridors predetermines an increase in the use of tank cars. It is important to note that this type of car is exposed to significant dynamic loads during operation, which are due to the pliability of the bulk cargo in a cistern. That puts forward special requirements for the operation of tank cars.

One of the most essential types of loads that act on tank cars during operation is dynamic loading. When moving over a butt rail, the car's load-bearing structure experiences the cyclic effect of dynamic loads in the vertical plane. Dynamic loads are partially damped by oscillation absorbers that are used in the spring suspension of a bogie.

It is known that the most common type of bogie widely used on railroads with a "wide gauge" is 18–100. This type of bogie has proven efficient during operation. At the same time, to improve the main dynamic indicators of cars and reduce their load, it is important to find and justify the use of alternative models of bogies with improved characteristics. The analysis of existing models of European car bogies has made it possible to highlight a Y25 type. This type of bogie has a series of significant advantages over "wide gauge" bogies. First of all, it is an improvement in the dynamic's indicator compared to that of the 18–100 bogies. Due to the use of an over-the-journal suspension, the dynamic loads that act on the load-bearing structures of cars in the vertical plane accept lower values than those for the 18–100 bogies. Given this, it becomes possible to prolong the service life of cars.

This issue is quite relevant since the replenishment of the car fleet of many European countries is insignificant. At the same time, ensuring an uninterrupted transportation process requires the presence of serviceable rolling stock. In this regard, the issue arises about the possibility of prolonging the service life of existing car fleets. One way to address this issue is to use bogies with improved dynamic performance, such as Y25.

However, a Y25 type bogie is used on European railroads while it is not common on wide-gauge railroads. Therefore, to justify the use of the specified type of bogie on tank cars, it is important to conduct appropriate research in this area. This could reduce the dynamic load of tank cars, prolong their service life, and, accordingly, bring down the cost of maintaining cars.

2. Literature review and problem statement

Work [1] reported an improvement in the load-bearing structure of a tank car by using modern software packages. To reduce loading on the bearing structure of a tank car, the authors proposed using boiler support devices that are optimal in terms of minimal material consumption. The proposed solutions were justified by theoretical and experimental studies.

Paper [2] suggested measures to improve the load-bearing structure of a long-base tank car. The boiler of the tank car was modernized. It is expected that the average probability of spills in an accident would decrease by almost 85 % compared to standard boiler designs.

It is important to note that the authors proposed measures to reduce stresses in the load-bearing structure of tank cars. However, the possibility of using more optimal bogie designs under them to reduce dynamic load and improve strength has not been investigated.

Work [3] reported a study of the dynamic load of a tank car whose boiler is underfilled with bulk cargo. In this case, the analytical model of displacements is integrated into the multi-body dynamic model of a railroad tank car. The model includes a nonlinear contact between the wheel and rail, as well as contact pairs of the suspension system.

Paper [1] reported modeling the dynamic load of the load-bearing structure of a tank car. The authors proposed a new approach based on a continuum, which takes into consideration the influence of the complex geometry of the liquid and boiler on the car's dynamics.

At the same time, the above works do not investigate the impact of running gear on the dynamic load and strength of the load-bearing structure of a tank car.

The effect of the thickness of the walls of a tank car on its dynamic load is investigated in work [5]. The authors also performed an analysis of the effect of changing the thickness of the boiler wall on the centrifugal forces and Coriolis force of inertia. They investigated the influence of increasing the thickness of the boiler on the wear of wheels. However, the cited work does not pay attention to measures to reduce the dynamic load of the bearing structure of a tank car.

Work [6] reported the dynamic modeling and an analysis of the dynamics of a tanker truck during braking. The movement of the bulk cargo was studied using the software package MATLAB/Simulink (USA). That model was combined with a vehicle model using the Trucksim software package (USA). That has made it possible to simulate the analysis of the movement of bulk cargo and its dynamic effect on the vehicle during braking.

At the same time, the cited work does not pay attention to measures to reduce the dynamic load of the vehicle during the transportation of bulk cargoes.

Paper [7] determined the dynamic load of a platform car with tank containers. The movement of the bulk cargo is described by a set of mathematical pendulums. The reported study has made it possible to determine the dynamic load of a platform car and tank containers at shunting.

Modeling the impact of bulk cargo on the dynamic load of a tank car at shunting is reported in work [4]. The study was carried out using a computer simulation that employed a finite-element method. In this case, the criterion of destruction, which depends on the three-axle stress, was used. That has made it possible to predict damage to a tank car boiler under dynamic loading.

However, works [4, 7] report studying the dynamic load of vehicles in a longitudinal plane. That is, determining the vertical load on vehicles was not paid attention to.

A study into the dynamics of the rolling stock equipped with 18–100 bogies involving the use of an experimental car-laboratory is reported in work [8]. The main indicators of the dynamics of the car were determined. The requirements for ensuring the safety of rolling stock were given. At the same time, there are no recommendations to improve the dynamics of rolling stock.

Features in the construction of computer models of railroad car dynamics for the 18–100 bogie model, the Y25 type, are highlighted in work [9]. The authors performed comparative studies of their dynamic qualities, indicators of traffic safety, and impact on the track. However, they did not determine the strength of the load-bearing structures of cars taking into consideration the use of the specified models of bogies.

A study into the dynamics of freight cars equipped with devices for providing the radial installation of wheelsets is reported in work [10]. The authors modeled the movement of freight cars with various variants of bogie designs, including 18–100, along the curved sections of the track. They choose the rational parameters for those devices. However, no measures to reduce the dynamic load on the bearing structures of cars during operation were proposed.

The authors of [11] determined the effect of transverse displacement of the freight car of the 18–100 type on its main dynamic indicators and indicators of the interaction of rolling stock with the track. The maximum possible values of transverse displacement of a freight car bogie were substantiated. At the same time, the issues of improving the dynamic load on the car bearing structure were not investigated.

Our review of the scientific literature [1–11] allows us to conclude that the issue of prolonging the service life of cars, including a tank car, implying the use of Y25 bogies has not yet been covered. This necessitates appropriate research in the specified area.

3. The aim and objectives of the study

The aim of this study is to substantiate prolonging the service life of the load-bearing structure of a tank car by using the Y25 type bogies.

To accomplish the aim, the following tasks have been set:

– to carry out mathematical modeling of the vertical dynamic load of the bearing structure of a tank car with rated dimensions;

– to perform mathematical modeling of the vertical dynamic load of the bearing structure of a tank car with actual dimensions;

– to determine the basic indicators of the strength of the load-bearing structure of a tank car equipped with Y25 bogies;

– to determine the design service life of the bearing structure of a tank car equipped with Y25 bogies.

4. The study materials and methods

Mathematical modeling was carried out to determine the main indicators of the dynamics of the load-bearing structure of a tank car. The chosen prototype was a 15-1443-06 model tank car. In this case, we employed a mathematical model given in [12], which describes the oscillation of the car in the vertical plane.

It is taken into consideration that an empty tank car moves over a butt irregularity. The track is considered viscoelastic. The reactions of the track are proportional to both its deformation and the rate of this deformation.

To determine the inertial coefficients of the model Y25 bogie, we used its constructed spatial model from the Pro/e software package. Calculations were also performed for freight cars equipped with 18–100 bogies.

To determine the inertial coefficients of the bearing structure of a tank car, its spatial model was built in the SolidWorks software package.

We solved the differential equations of motion using the software package Mathcad [13–15]. In this case, the initial movement and speed are taken to equal zero [16–18].

Based on the built spatial model of the bearing structure of a tank car, its calculation for strength in the SolidWorks Simulation software package was carried out. In this case, we employed a finite-element method.

The optimal number of grid elements was determined by using the graphic-analytical method [19, 20]. Isoparametric tetrahedra [21–23] were used as the finite elements. In this case, the number of grid elements was 771,284, nodes – 251,278. The maximum size of the grid element is 40 mm, minimum – 8 mm, the maximum aspect ratio of the sides of the elements is 123.84, the percentage of elements with a side ratio of less than three is 19.4, more than ten – 0.365.

We determined the strength of the bearing structure of a tank car for estimation mode I – “jerk – stretching”.

The model was fixed in the areas where the bearing structure rested on bogies. The material is the steel of grade 09G2S (an analog to steel 09G2D).

To determine the design service life of a tank car, taking into consideration the use of Y25 bogies under it, we applied the methodology by Professor Ustych [24].

5. The results of justifying the prolonging of the service life of the bearing structure of a tank car by using the Y25 type bogies

5. 1. Mathematical modeling of the vertical dynamic load on the bearing structure of a tank car with rated dimensions

The estimation scheme of a tank car that moves over a butt irregularity is shown in Fig. 1.

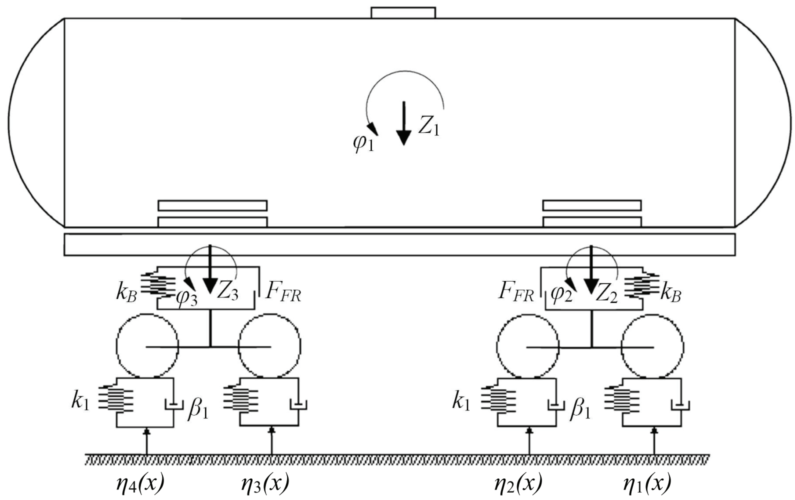


Fig. 1. Estimation scheme of a tank car

The motion equations of the estimation model are as follows:

$$M_1 \cdot \frac{d^2}{dt^2} q_1 + C_{1,1} \cdot q_1 + C_{1,3} \cdot q_3 + C_{1,5} \cdot q_5 = -F_{FR} \cdot \left(\mathrm{sign}\left(\frac{d}{dt} \delta_1 \right) + \mathrm{sign}\left(\frac{d}{dt} \delta_2 \right) \right), \quad (1)$$

$$M_2 \cdot \frac{d^2}{dt^2} q_2 + C_{2,2} \cdot q_2 + C_{2,3} \cdot q_3 + C_{2,5} \cdot q_5 = F_{FR} \cdot l \cdot \left(\mathrm{sign}\left(\frac{d}{dt} \delta_1 \right) + \mathrm{sign}\left(\frac{d}{dt} \delta_2 \right) \right), \quad (2)$$

$$M_3 \cdot \frac{d^2}{dt^2} q_3 + C_{3,1} \cdot q_1 + C_{3,2} \cdot q_2 + C_{3,3} \cdot q_3 + B_{3,3} \cdot \frac{d}{dt} q_3 = F_{FR} \cdot \mathrm{sign}\left(\frac{d}{dt} \delta_1 \right) + k_1 (\eta_1 + \eta_2) + \beta_1 \left(\frac{d}{dt} \eta_1 + \frac{d}{dt} \eta_2 \right), \quad (3)$$

$$M_4 \cdot \frac{d^2}{dt^2} q_4 + C_{4,4} \cdot q_4 + B_{4,4} \cdot \frac{d}{dt} q_4 = -k_1 (\eta_1 - \eta_2) - \beta_1 \cdot a \cdot \left(\frac{d}{dt} \eta_1 - \frac{d}{dt} \eta_2 \right), \quad (4)$$

$$M_5 \cdot \frac{d^2}{dt^2} q_5 + C_{5,1} \cdot q_1 + C_{5,2} \cdot q_2 + C_{5,5} \cdot q_5 + B_{5,5} \cdot \frac{d}{dt} q_5 = F_{FR} \cdot \mathrm{sign}\left(\frac{d}{dt} \delta_2 \right) + k_1 (\eta_3 + \eta_4) + \beta_1 \left(\frac{d}{dt} \eta_3 + \frac{d}{dt} \eta_4 \right), \quad (5)$$

$$M_6 \cdot \frac{d^2}{dt^2} q_6 + C_{6,6} \cdot q_6 + B_{6,6} \cdot \frac{d}{dt} q_6 = -k_1 \cdot a \cdot (\eta_3 - \eta_4) - \beta_1 \cdot a \cdot \left(\frac{d}{dt} \eta_3 - \frac{d}{dt} \eta_4 \right), \quad (6)$$

where M_1, M_2 are, respectively, the mass and moment of inertia of the bearing structure of a tank car with oscillations of jumping and galloping; M_3, M_4 are, respectively, the mass and moment of inertia of the first bogie in the forward movement with oscillations of jumping and galloping; M_5, M_6 are, respectively, the mass and moment of inertia of the second bogie in the forward movement with oscillations of jumping and galloping; C_{ij} is the characteristic of elasticity of the elements of the oscillatory system; B_i is the scatter function; a is the half of a bogie base; q_i is the generalized coordinates corresponding to the translational movement relative to the vertical axis and the angular movement around the vertical axis; k_i is the hardness of spring hanging; β_i is the damping coefficient; F_{FR} is the force of absolute friction in a spring set.

The butt irregularity is described by the following periodic function [12]:

$$\eta(t)=\frac{h}{2}(1-\cos\omega t), \tag{7}$$

where h is the depth of irregularity; ω is the oscillation frequency, determined from the formula $\omega=2\pi V/L$ (V is the speed of car movement, L is the length of an irregularity).

The matrix of elastic coefficients takes the following form [12]:

$$\tilde{N}=\begin{vmatrix} 2\cdot k_B & 0 & -k_B & 0 & k_B & 0 \\ 0 & 2\cdot l^2\cdot k_B & l\cdot k_B & 0 & -l\cdot k_B & 0 \\ -k_B & l\cdot k_B & k_B+2\cdot k_1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 2\cdot a^2\cdot k_1 & 0 & 0 \\ -k_B & -l\cdot k_B & 0 & 0 & k_B+2\cdot k_1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 2\cdot a^2\cdot k_1 \end{vmatrix}, \tag{8}$$

the matrix of dissipative coefficients takes the following form [13]:

$$B=\begin{vmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 2\cdot\beta_1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 2\cdot\beta_1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 2\cdot\beta_1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 2\cdot\beta_1 \end{vmatrix}. \tag{9}$$

To determine the inertial coefficients of the bearing structure of a tank car, its spatial model was built (Fig. 2).

Fig. 2. A spatial model of the bearing structure of a tank car

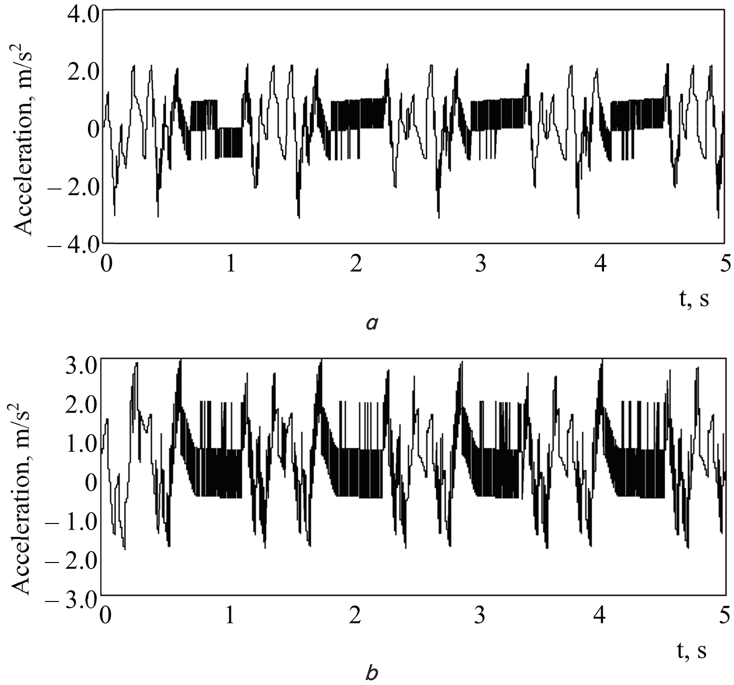


Fig. 3. Acceleration of the load-bearing structure of a tank car in the center of masses: *a* — 18–100; *b* — Y25

The software package options helped us establish that the mass of the bearing structure of a tank car with rated dimensions is 14.9 tons, and the moment of inertia is 223.9 tons m^2.

The results of simulating the dynamic load of the load-bearing structure of a tank car are shown in Fig. 3, 4.

The basic indicators of the dynamics of a tank car with rated dimensions are given in Table 1. The calculation was carried out at a car speed of 80 km/h.

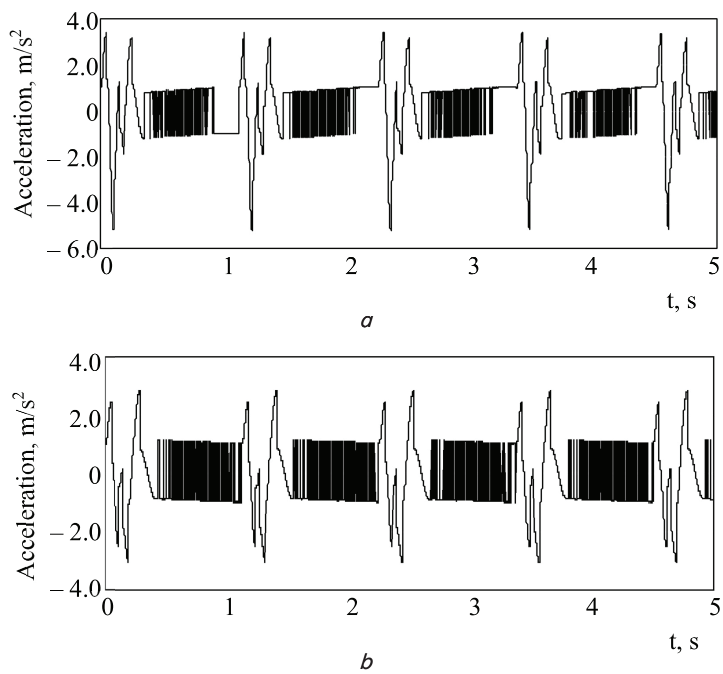


Fig. 4. Acceleration of the load-bearing structure of a tank car at the points of resting on bogies: *a* — 18–100; *b* — Y25

Table 1

Dynamic indicators of an empty tank car movement

Indicator	Bogie type	
	18–100	Y25
Carriage acceleration, m/s^2	3.19	1.96
Carriage acceleration at the region of resting on a bogie, m/s^2	5.18	3.06
Force in the bogie spring suspension, kN	38.5	22.7
Bogie dynamics coefficient	0.52	0.3

The results of our study allow us to conclude that the dynamics indicators are within the permissible limits. The movement of a tank car is rated “excellent” [25–27]. Comparative analysis of the obtained indicators of the dynamics of a tank car is shown in Fig. 5.

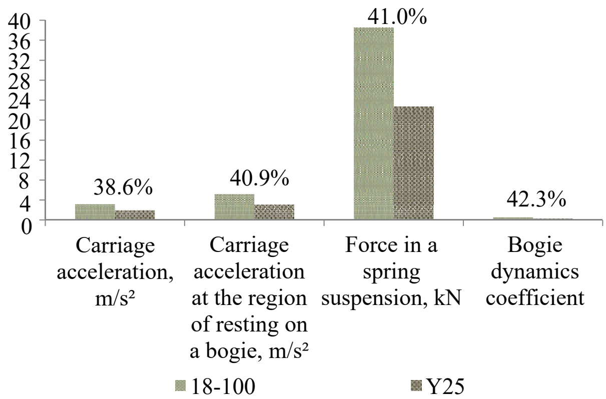


Fig. 5. Comparative analysis of the tank car dynamics when using the 18–100 and Y25 bogies

Thus, the use of Y25 bogies under a tank car could reduce the acceleration of its load-bearing structure by almost 39 % compared to the use of standard 18–100 bogies.

5. 2. Mathematical modeling of the vertical dynamic load on the bearing structure of a tank car with actual dimensions

The mass of the load-bearing structure of a tank car with actual dimensions was 13.7 tons, and the moment of inertia was 205.5 tons·m^2. The percentage of a decrease in the mass of a tank car was 8.2 % compared to the prototype car.

Our results were taken into consideration when determining the main indicators of the dynamics of a tank car with actual dimensions. The calculations were carried out based on the mathematical model (1) to (6).

The accelerations acting on the bearing structure of a tank car in the center of mass are shown in Fig. 6, *a*; the accelerations at the points of resting on bogies – in Fig. 7.

The basic indicators of the dynamics of a tank car with actual dimensions are given in Table 2.

The above results allow us to conclude that the dynamics indicators of a tank car are within the permissible limits. The car movement is rated “excellent” [26–28].

The comparative analysis of the obtained indicators of the dynamics of a tank car is illustrated in Fig. 8, which indicates a percentage improvement in certain indicators of the dynamics of a car equipped with Y25 *bogies* compared to 18–100.

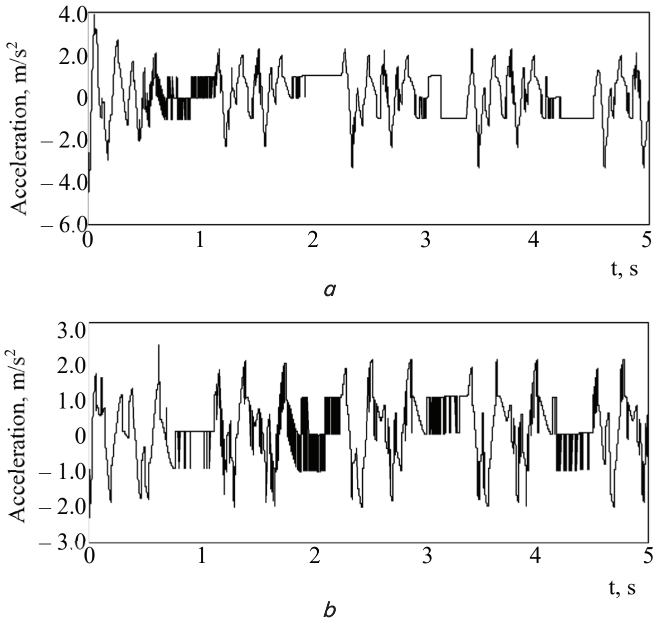


Fig. 6. Acceleration of the load-bearing structure of a tank car in the center of mass: *a* — 18—100; *b* — Y25

Table 2

Dynamic indicators of an empty tank car movement

Indicator	Bogie type	
	18–100	Y25
Carriage acceleration, m/s^2	4.7	2.4
Carriage acceleration at the region of resting on a bogie, m/s^2	6.4	3.9
Force in the bogie spring suspension, kN	43.5	26.2
Bogie dynamics coefficient	0.64	0.38

Thus, the use of Y25 bogies under a tank car could reduce the acceleration of its bearing structure by almost 50 % compared to the use of standard 18–100 bogies.

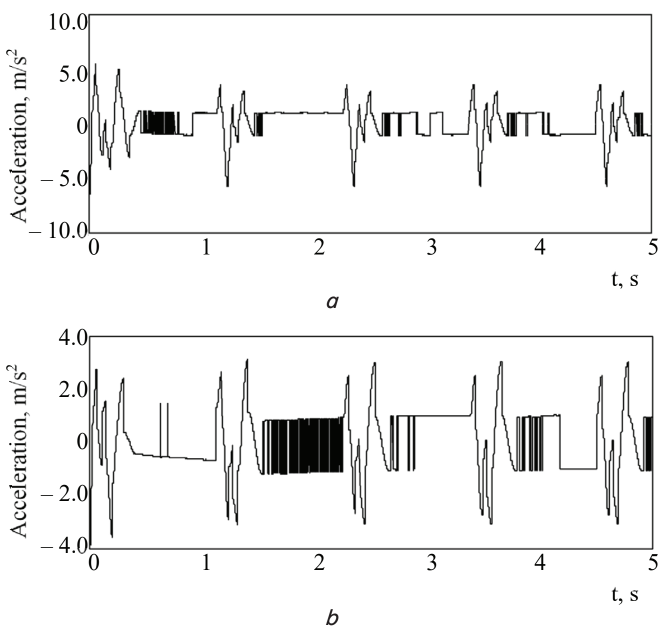


Fig. 7. Acceleration of the load-bearing structure of a tank car at the points of resting on bogies: *a* — 18 100; *b* — Y25

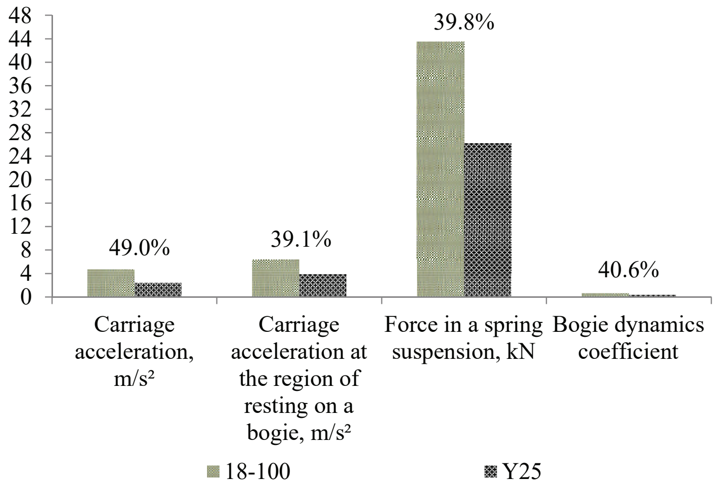


Fig. 8. Comparative analysis of the dynamics of a tank car equipped with 18–100 and Y25 bogies

5. 3. Determining the basic indicators of the strength of the load-bearing structure of a tank car equipped with Y25 bogies

A finite-element model of the bearing structure of a tank car is shown in Fig. 9.

Fig. 9. A finite-element model of the bearing structure of a tank car

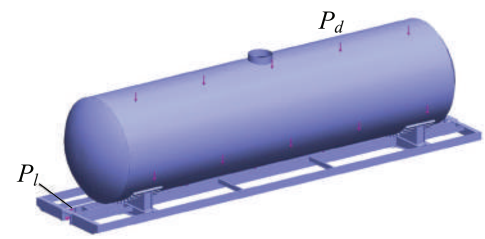
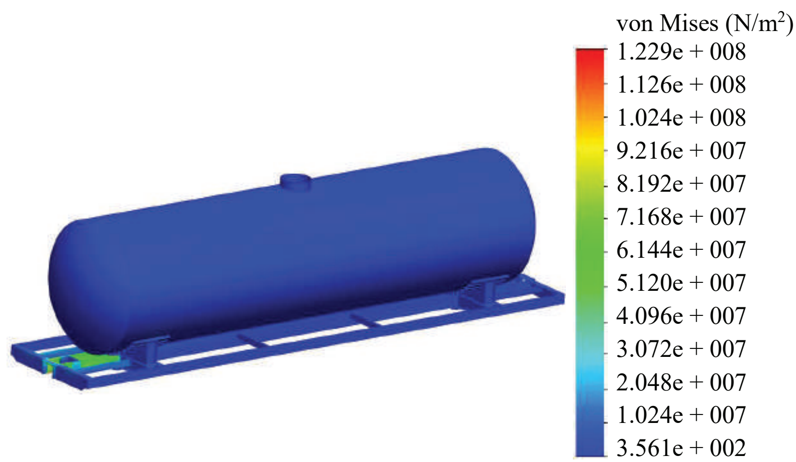


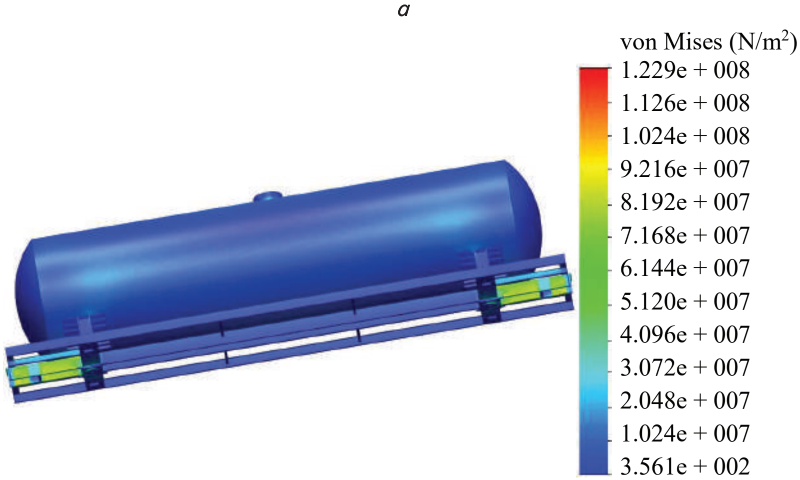
Fig. 10. Estimation scheme of the load-bearing structure of a tank car: P_l – longitudinal load on front stops; P_d – dynamic load

The estimation scheme of the bearing structure of a tank car is shown in Fig. 10.

The results of calculating the load-bearing structure of a tank car for strength are shown in Fig. 11, 12.



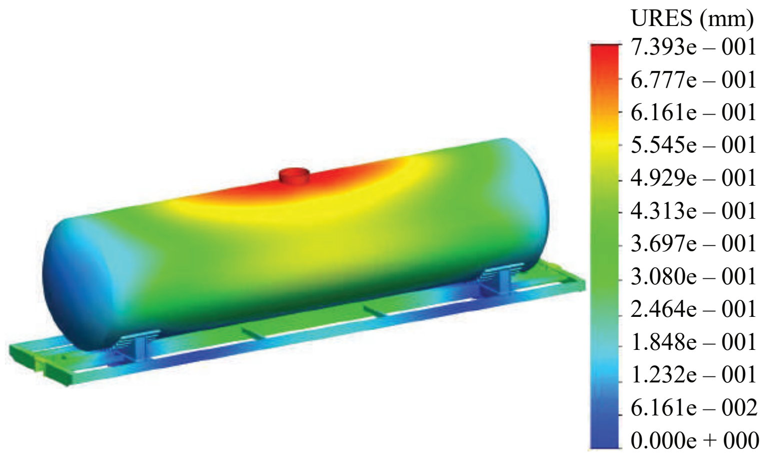
a



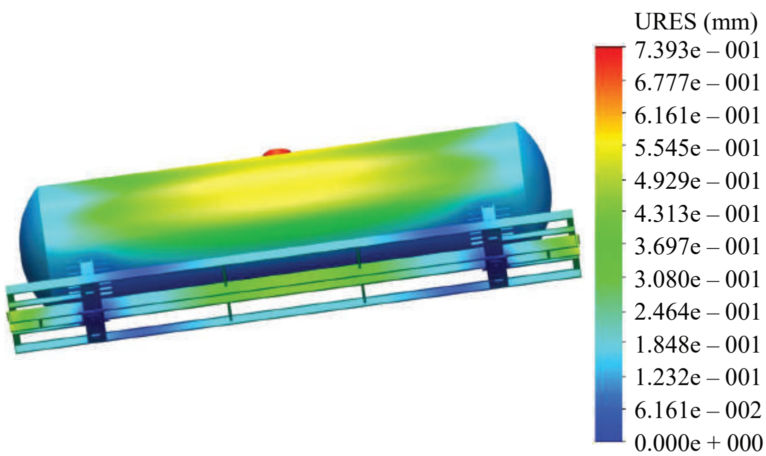
b

Fig. 11. The stressed state of the load-bearing structure of a tank car with rated dimensions under estimation mode I (jerk): *a* – side view; *b* – bottom view

The maximum equivalent stresses occur in the zone of interaction between the girder beam and the pivot beam, and are about 120 MPa: they do not exceed the permissible ones [25–27]. The maximum movements were about 0.7 mm. The resulting stress values are 18 % lower than the stresses acting on the load-bearing structure of a tank car equipped with 18–100 bogies.



a



b

Fig. 12. Displacements in the nodes of the bearing structure of a tank car with rated dimensions under estimation mode I (jerk): *a* – side view; *b* – bottom view

For the load-bearing structure of a tank car with actual dimensions, the maximum equivalent stresses were 156 MPa: they do not exceed the permissible ones [25–27]; and the displacement – 1.3 mm. The resulting stress values are 16 % lower than the stresses acting on the load-bearing structure of a tank car equipped with 18–100 bogies.

5. 4. Determining the design service life of the bearing structure of a tank car equipped with Y25 bogies

We determined the design service life of a tank car, taking into consideration the use of Y25 bogies under it, according to the following formula [24]:

$$T_s = \frac{\left(\sigma_{-1E} / [n]\right)^m \cdot N_0}{B \cdot f_e \cdot \sigma_{ds}^m}, \tag{10}$$

where σ_{-1E} is the average value of the endurance boundary; n is the permissible safety factor; m is the indicator of the degree of fatigue curve; N_0 is the test base; B is the coefficient that characterizes the time of continuous operation of an object in seconds; f_e is the effective frequency of dynamic stresses; σ_{ds} is the amplitude of equivalent dynamic stresses.

The amplitude of equivalent dynamic stresses was determined from the following formula

$$\sigma_{ds} = \sigma_{sw}\left(k_{vd} + \psi_\sigma / K_\sigma\right), \tag{11}$$

where σ_{sw} is the stress from a static weight load; k_{vd} is the coefficient of vertical dynamics; ψ_σ is the sensitivity coefficient; K_σ is the total coefficient of a fatigue strength decrease.

When determining the amplitude of equivalent dynamic stresses, the coefficient of the influence of side forces equal to 1.1 [28, 29] was taken into consideration.

The following input parameters were accepted in the calculations: σ_{-1E}=245 MPa; n=2; m=8; N_0=10^7; B=3.07·10^6 s; f_e=2.7 Hz; ψ_σ/K_σ=0.2.

To determine the stresses from the static weight load on the load-bearing structure of a tank car, strength calculation was carried out. The calculation results showed that the maximum equivalent stresses in the load-bearing structure of a tank car with rated dimensions are concentrated in the zone of interaction between the pivot beam and the girder beam, and are about 90 MPa. In the bearing structure of a tank car with actual dimensions, the maximum equivalent stresses were about 97 MPa.

Our calculations showed that the design service life of the bearing structure of a tank car with rated dimensions equipped with Y25 bogies is more than twice as high as that obtained taking into consideration the use of 18 100 bogies. The same results were obtained for the structure with actual dimensions.

It is important to note that the resulting value of the design service life should be refined taking into consideration additional studies into the longitudinal load of the load-bearing structure of a tank car and experimental (full-scale or bench) studies.

6. Discussion of results of justifying the prolonging of the service life of the bearing structure of a tank car

We have investigated the dynamic load of the bearing structure of a tank car with rated and actual dimensions. Mathematical modeling was carried out for the case of movement of an empty tank car over a butt irregularity. It was established that the use of Y25 bogies under a tank car with rated dimensions reduces the acceleration of its bearing structure by almost 39 % compared to the use of standard 18–100 bogies (Fig. 5).

The use of Y25 bogies under a tank car with actual dimensions could reduce the acceleration of its load-bearing structure by almost 50 % compared to 18–100 bogies (Fig. 8).

The obtained values of acceleration were taken into consideration in determining the stressed state of the bearing structure of a tank car. In this case, the maximum equivalent stresses in the load-bearing structure of a tank car with rated dimensions are about 120 MPa (Fig. 11). In the bearing structure of a tank car with actual dimensions, the maximum equivalent stresses are 156 MPa. Therefore, the use of Y25 bogies could reduce the stressed state of the bearing structure of a tank car with rated and actual dimensions by, respectively, 18 % and 16 % compared to the use of 18–100 bogies.

To determine the design service life of the load-bearing structure of a tank car equipped with Y25 bogies, appropriate calculations were performed. It was established that the design service life of the bearing structure of a tank car with rated dimensions equipped with Y25 bogies is more than twice as high as that obtained taking into consideration the use of 18–100 bogies. The same results were obtained for the structure of a tank car with actual dimensions.

It is important to note that the resulting value of the design service life should be refined taking into consideration additional studies into the longitudinal load of the load-bearing structure of a tank car. In addition, it is important to conduct experimental studies of the dynamics and strength of the bearing structure of a tank car equipped with Y25 bogies.

In further research, it is necessary to determine the dynamic load of tank cars at other types of oscillations.

Our research could contribute to devising conceptual principles for the restoration of the effective functioning of outdated freight cars, including tank cars.

7. Conclusions

1. We have mathematically modeled the vertical dynamic load of the bearing structure of a tank car with rated dimensions equipped with 18–100 and Y25 bogies. The calculations were performed for a speed of 80 km/h. It was found that the use of Y25 bogies under a tank car with rated dimensions could reduce the acceleration of its bearing structure by almost 39 % compared to the use of standard 18–100 bogies.

2. The vertical dynamic load of the bearing structure of a tank car with actual dimensions equipped with 18–100 and Y25 bogies has been mathematically modeled. The results showed that the use of Y25 bogies under a tank car with actual dimensions could reduce the acceleration of its bearing structure by almost 50 % compared to 18–100 bogies.

3. We have determined the basic indicators of the strength of the load-bearing structure of a tank car equipped with Y25 bogies with rated and actual dimensions. The calculation was carried out using a finite-element method in the SolidWorks Simulation software package. The maximum equivalent stresses in the load-bearing structure of a tank car with rated dimensions were about 120 MPa. The maximum displacement was about 0.7 mm. The resulting stress values are 18 % lower than the stresses acting on the load-bearing structure of a tank car equipped with 18–100 bogies.

4. We have determined the design service life of the bearing structure of a tank car equipped with Y25 bogies with rated and actual dimensions. The study has shown that the value of the design service life of the bearing structure of a tank car is almost doubled compared to the use of 18–100 bogies.

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