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ASSESSMENT CARTS STRENGTH INDICATORS WAGONS WITH EXPIRED SERVICE LIFE

Currently, a significant number of units of specialized cars of 1520 mm gauge in Ukraine has a service life that exceeds that assigned by the manufacturer. At the same time, many years of experience in diagnosing and analyzing the operation of carts of these cars by specialized organizations, shows that their technical condition after long operation shows that the specified service life specified in the technical conditions in most cases far from the limit. This is largely due to the significant margin of safety, which is laid down in the design, and the peculiarities of the operation of a particular type of car. The paper considers the issues of assessing the operation of such cars on the example of the carriage of the weighing car, bogie model 18-102, and the carriage of the passenger car model KVZ-TsNII used in the track economy for transportation of workers. The average daily mileage of such cars is 60-70 percent less than the average mileage that is laid down when calculating the service life assigned by the manufacturer. The evaluation and methods of determining the strength of the frames of carriages of special cars are performed. Conclusions are made based on the results of the analysis of the strength of the carriages of special cars.

Keywords: *bogies, control tests, resource, technical diagnostics, safety margin, resource estimation, strength.*

Introduction. Currently, a significant number of units of bogies of special cars of 1520 mm gauge in Ukraine has a service life that exceeds that assigned by the manufacturer. At the same time, many years of experience in diagnosing the technical condition of freight, passenger and weighing carts after long operation show that the service life specified in the technical conditions is far from the limit. This is largely due to the significant margin of safety, which is laid down in the design, and the peculiarities of the operation of a particular type of car. Ensuring safe and timely freight transportation is one of the main tasks of railway transport. In this regard, when at the end of the last century began to show a shortage of freight rolling stock, including specialized, as well as taking into account the technical and economic difficulties of its renewal after the appointed period, it was decided to partially abandon the regulated service life for rolling stock units, the individual resource of which allowed to solve their further trouble-free operation.

In recent years, there has been a significant aging of the operational fleet of specialized carriages. The fleet of weighing cars has more than 50% of cars that have served one and a half or more years and a half of service life.

To address the issue of the possibility of further operation of weighing cars with a service life exceeding not only the intended, but also one and a half, their technical diagnosis and control tests are carried out.

Analysis of recent research and problem statement. To date, insufficient attention has been paid to the study of the residual life of the load-bearing structures of bogies of special wagons with a service life exceeding that set by the manufacturer. Thus, in [1] the results of researches of bearing capacity of gondola cars of model 12-9745 are given. However, the purpose of such research was to find structural reserves to reduce the material consumption of this model of cars. Accordingly, the load-bearing capacity of the body structure with the simulation of wear typical of 1.5 service life has not been studied. The article [2] presents the prospects for improving the design of gondola cars, including by increasing the service life. However, it is proposed to increase the service life of gondola cars by improving their design properties, for example through the introduction of materials with improved characteristics. Analysis of the properties of structural materials of car bodies of the new generation is given in [3]. The advantages of using new progressive materials for separate components of car constructions are indicated in the work. However, the issue of extending the implementation of this direction when extending the service life of gondola cars is not paid attention. Measures to improve the load-bearing structure of the gondola body in order to ensure the reliability of its attachment to the deck of the railway ferry are given in [4, 5]. The calculation was performed in the software environment MSC Adams. The study of resistance against overturning the car was carried out when it fits into a curve with a radius of 250 m, taking into account different speeds. The issues of estimating the accuracy of the capacity of railway networks intended for transportation of raw materials and finished products of the mining and metallurgical industry are given in [6, 7]. The design features of the car for intermodal transportation are considered in [8]. The car has a lowered middle part, and the presence of the reversible part makes it possible to load / unload vehicles on / from it by scooter. In [9] the results of researches on definition of character and level of influence of various freight carts on durability of bearing systems of cars are resulted. However, the task of such a study did not include the question of determining the appropriate impact on bodies that are operated outside the standard period. Studies [10, 11] analyzed the features of the movement and interaction of units of new rolling stock. And the corresponding researches for units with indicators reflecting operational wear are not carried out. Summarizing the results of the above analysis, it can be noted that at present the issue of the possibility of extending the service life of the load-bearing structures of weighing cars has not been fully resolved. Taking into account the above, we can conclude that the results of the analysis of information sources on the subject indicate the lack of sufficient methodological and practical materials to determine the residual life of the frames of bogies special cars.

The purpose and tasks of the study. The purpose of the work - to solve the scientific and practical problem of creating theoretical provisions on the features of the assessment and determination of the residual life of the frames of carts of special cars.

The purpose of technical diagnostics and control tests is to study the residual life and justify the possibility of continuing the operation of carriages of special cars with exhausted assigned service life, establishing the value of the extended service life.

The task of running strength tests of bogies 18-102 and KVZ-TsNII is to determine the stress (strain) in the studied sections and points of the elements of the bogie.

Features of carrying out a complex of works on definition of a residual resource of weight-calibrating cars are:

the average daily mileage of special cars is 60-70% less than the mileage of freight and passenger cars on the basis of which the test cars are made;

differences in the features of operation of special cars.

The above features must be taken into account when determining the residual life of the bearing metal bogies models 18-102 and KVN-TsNII.

Materials and methods of research. The objects of research were the bogie of the model KVZ-TsNII (Fig. 1) of 1974 and the bogie of the model 18-102 (Fig. 2) of 1955, which were operated with special cars.

Fig. 1. **Experimental bogie model KVZ-TsNII**

Fig. 2. **Experimental bogie model 18-102**

To develop a scheme for the installation of strain gauges, the normative calculation of the bogie model KVZ-TsNII by the finite element method was performed to determine the most loaded places. The calculations were performed for the most unfavorable possible combination of simultaneously acting regulatory forces in accordance with the established calculation regime III.

Mode III – operating mode, which takes into account the forces acting on the cart during the movement of the car as part of the train on straight and curved sections of track and turnouts with the allowable speed up to design speed with periodic service braking, periodic moderate jerks and shocks, regular operation of mechanisms and car components.

The plots of stresses arising in the frame of the cart are shown in fig. 3, 4.

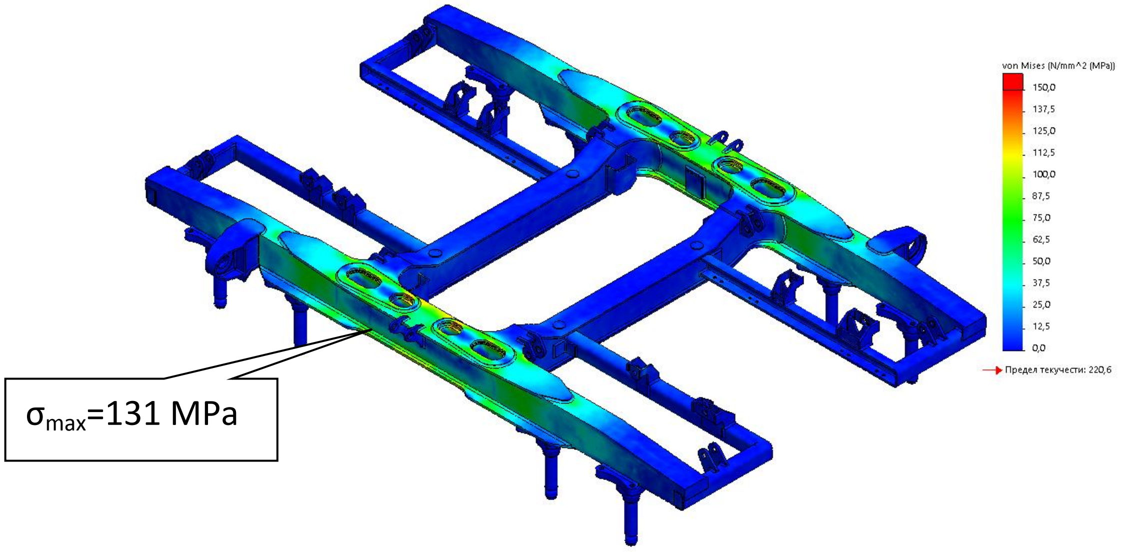

Fig. 3. **Example of a diagram of stresses arising in the frame of the bogie**

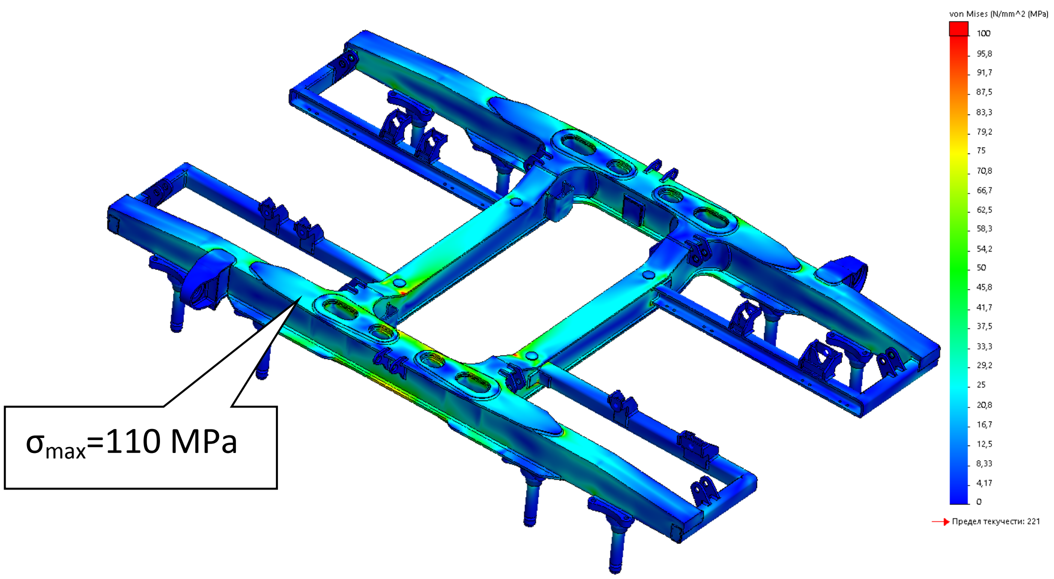

Fig. 4. **Example of a diagram of stresses arising in the frame of the bogie**

The maximum stresses are 110-131 MPa, which is less than the allowable $[\sigma_d]$ = 150 MPa.

When conducting running strength tests of bogies of the KVZ-TsNII and 18-102 models, the stress (deformation) in the investigated sections and points of the bogie elements is determined.

Running strength tests, bogie model KVZ-TsNII and 18-102, with the determination of stress (deformation) in the studied sections and points of the elements are carried out on straight and curved sections of track, turnouts in the modes of traction, run and braking. The tests are performed in the actual operation of the car.

In fig. 5, 6 shows a simplified diagram of the installation of strain gages on the cart during the running strength tests.

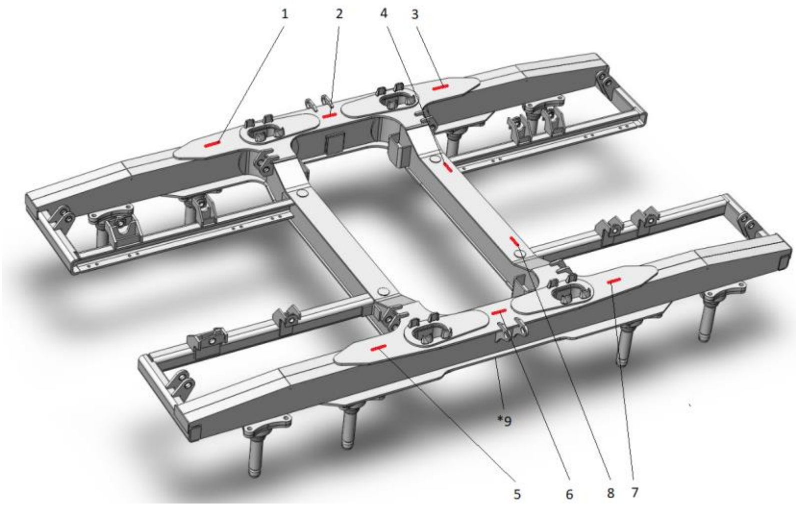

Fig. 5. **Simplified scheme of installation of strain gages on the bogie KVZ-TsNII**

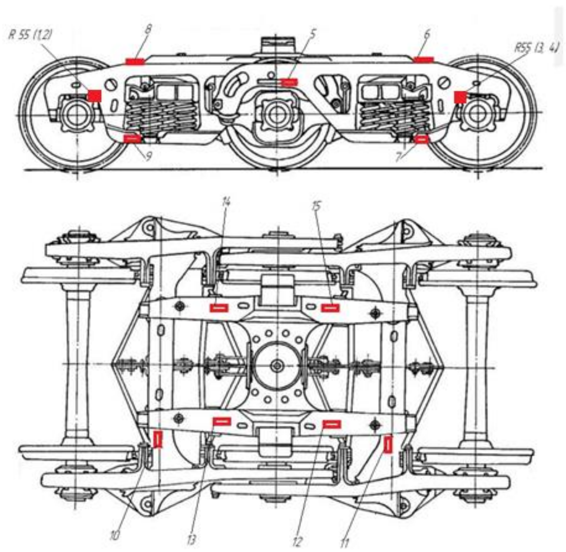

Fig. 6. **Simplified scheme of installation of strain gages on the bogie 18-102**

The following is a calculation of the fatigue resistance of the bogie frames.

Based on the processing of running strength tests, the experimental data are grouped by ranges of speeds, characteristic features of the road section (straight, curve, arrows, etc.), modes of movement (acceleration, braking) of the car and determines the amplitude-frequency composition of the stress-strain state in structural elements in the range from 0.3 Hz to 30.0 Hz, in order to estimate the coefficient of fatigue resistance according to the formula:

$$n = \frac{\sigma_{a,N}}{\sigma_{\text{а,э}}} \geq [n], \qquad (1)$$

where $\sigma_{a,N}$ – endurance limit (according to the amplitude) of the full-length part according to the symmetrical cycle and the set load mode;

$\sigma_{a,э}$ – the calculated value of the equivalent amplitude of the dynamic voltage in the real mode of operational random loads for the design life of the structure;

[n] – allowable coefficient of fatigue resistance.

The results of the assessment of the coefficient of fatigue resistance for bogies KVZ-TsNII and 18-102 are given in table. 1, 2.

Table 1. **The smallest calculated values of the coefficient [n] of the bogie 18-102**

Loaded wagon (wagon weight 121 tons), maximum speed - 81 km / h	Fatigue resistance margin, *n*		
	zone 1-4 (transition radius R55 axle boxes)	zones 5-9 (upper and lower belts of side frames)	10-15 zone (over-spring beam)
	1,75	> 3	1,79

The recommended value of the coefficient of fatigue resistance for new bogie frames is [n] = 1,8. It is allowed to reduce the n - coefficient of fatigue resistance, depending on the accuracy of determining the parameters by calculation and experimental methods.

At speeds of 70 and above km / h the level of stresses in the most loaded zones of carts increases: for a zone R55 of lateral frames in 1,5… 1,8 times, for overspring beams to 2 times. The most loaded zone is the zone R55 of the last in the direction of movement of the axle section of the cart.

Given the running dynamic tests in real operating conditions (actual technical condition of trucks and tracks, which corresponds to the operating conditions) in a fully loaded condition, n = 1.75 with an estimated service life of 60 years inclusive (61 actual year) is satisfactory for further operation.

Table 2. **The smallest calculated values of the coefficient [n] of the bogie KVZ-TsNII**

Wagon weight 60 tons, maximum speed - 120 km / h	Fatigue resistance margin, *n*		
	zones 1–3, 5-7 (upper plane of the longitudinal beam of the frame)	zone 4, 8 (upper plane transverse beams of the frame)	zone 9 (lower plane of the longitudinal beam of the frame)
	3,37	1,7	1,85

The allowable value of the coefficient of fatigue resistance of the load-bearing structures of the bogie is [n] = 1,7. The smallest value of the coefficient of fatigue resistance corresponds to zone 4 (transverse beam of the bogie frame) and is equal to 1.7 with an estimated service life of 53 years. All other values of the fatigue resistance margin are 1.85 and higher.

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Conclusions. The input of theoretical research to determine the possibility of extending the service life of carriages of special cars operated on the railways of Ukraine, it was determined that the condition of the load-bearing metal structures of cars after long operation does not approach the limit. After analyzing the value of the average daily mileage of special cars, it was found that it is 60-70% less than the mileage of freight and passenger cars on the basis of which special cars are made. Given the above differences in the design of cars, features of operation and lower mileage, they must be taken into account when estimating the residual life.

During the calculations of the coefficients of the fatigue resistance of the frames of the carts, the following is established:

the lowest value of the coefficient of resistance to fatigue of the cart 18-102 in areas R55 is 1.75;

the smallest value of the coefficient of fatigue resistance of the cart KVZ-TsNII in zones 4, 8 is 1.7 with a permissible value of 1.7,

Thus, the obtained theoretical and practical results will allow to develop a set of works and measures to assess the residual life of the frames of bogies KVN-TsNII and 118-102, which are operated on the railways of Ukraine.

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ОСОБЛИВОСТІ ОЦІНКИ ПОКАЗНИКІВ МІЦНОСТІ ВІЗКІВ СПЕЦІАЛЬНИХ ВАГОНІВ З ЗАКІНЧЕНИМ ТЕРМІНОМ СЛУЖБИ

В даний час значна кількість одиниць спеціалізованих вагонів колії 1520 мм в Україні має термін служби, який перевищує призначений заводом – виробником. У той же час багаторічний досвід діагностування та аналіз експлуатації візків цих вагонів спеціалізованими організаціями, показує, що їх технічний стан після тривалої експлуатації показує, що зазначений в технічних умовах призначений строк служби у більшості випадків далекий від граничного. Багато в чому це пов'язано, як з істотним запасом міцності, який закладений при проектуванні, так і з особливостями експлуатації конкретного типу вагонів. В роботі розглянуті питання з оцінки експлуатації таких вагонів на прикладі візка вагоповірочного вагона моделі 18-102, та візка пасажирського вагона моделі КВЗ-ЦНИИ який використовується у колійному господарстві для перевезення працівників. Середньодобовий пробіг таких вагонів на відсотків 60-70 менший за середньо експлуатаційні пробіги які закладені при розрахунку терміну служби призначеного заводом виробником. Виконано оцінку та описано методи визначення показників міцності рам візків спеціальних вагонів. Зроблено висновки за результатами проведеного аналізу з оцінки показників міцності візків спеціальних вагонів.

Ключові слова: *візки, контрольні випробування, ресурс, технічне діагностування, запас міцності, оцінка ресурсу, міцність.*