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ANALYSIS OF THE FAILURES OF BOGIES TYPE T73-AD AND Y32 FROM OF BULGARIAN STATE RAILWAYS

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Abstract *– The paper presents the results of a study on the operational status of a without cradle type of passenger bogies from the Bulgarian State Railways (BDZ) park. The designs of a swininging type passenger bogie in the operation of the Republic of Bulgaria is presented. Referred are most likely common faults of T73-AD and Y32 passenger bogies. Common failures, probable causes probably for the occurrence of failures and ways to minimize them, have been successfully identified using Pareto diagrams. By the finite element method, characteristic zones with probability of failures are determined.*

Keywords – Railway vehicles, passenger cars, bogies, failure.

1. INTRODUCTION

To ensure the design reliability, the appropriately selected materials, the strength stock, the reservation scheme, etc. are of particular importance. The systems ensuring the reliability cover the entire life cycle of the machines, from design and manufacture to operation. Reliability methods are specific to each stage of the life cycle.

2. WITHOUT CRADLE TYPE OF BOGIE FOR PASSENGER CARS - QUALITIES, REQUIREMENTS AND DEVELOPMENT OPPORTUNITIES

In recent decades, the increasing use of without cradle type bogies for passenger cars has been observed as one of the most characteristic trends. The principal feature of this type of bogies is that the necessary elasticity of the connection between the car body and the bogies in the horizontal-transverse direction is not provided on the basis of the properties of the physical pendulum by the so-called swing device, and without such a device based on the elastic deformations of the spring elements in the horizontal-transverse direction under the action of the respective forces [1]. Without cradle type of bogies offers special conveniences with the most widespread spring elements in the secondary spring suspension - the cylindrical coil springs. The cradleless principle has also been successfully applied to pneumatic springs, which are becoming more and more widespread.

3. BOGIE CONSTRUCTIONS WITHOUT CRADLE IN OPERATION OF THE REPUBLIC OF BULGARIA

3.1. T73-AD bogie

The bogie T73-AD (Fig. 1) is the construction of Bulgarian bogies for passenger cars B-84 type "Seagull".

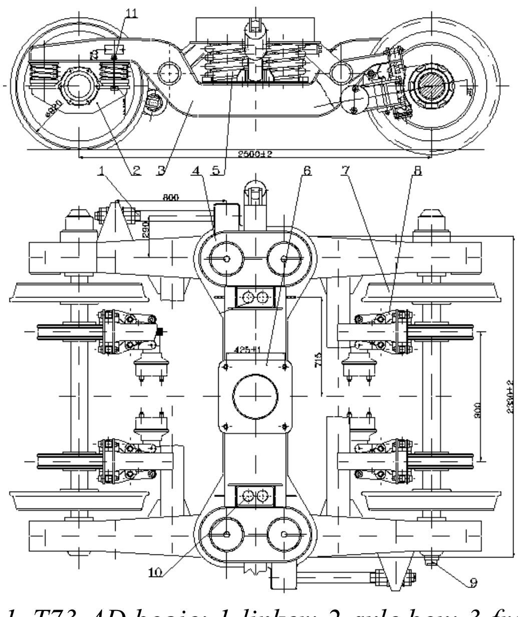

Fig.1. T73-AD bogie: 1-linker; 2-axle box; 3-frame; 4- bolster; 5-secondary spring suspension; 6-center pivot; 7-wheelset; 8-brake system; 9- system against dragging; 10- side bearer; 11-grounding.

The bogie is a without cradle type [2] and is equipped with a disc brake. Its construction allows the

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installation of a magnetic rail brake, as well as an automatic regulator of the braking force, depending on the load of the car. The base of the bogie is 2.5 m, design speed 160 km/h.

The wheelsets have wheels, monoblock type with a diameter in the rolling circle of 920 mm and are for axle load not exceeding 16.5 t/axle. Between the wheels of individual hubs are pressed two brake discs having internal ribbing to remove heat from the brake. The bearing of the axle in the socket has two single-row cylindrical roller bearings with standard dimensions ϕ120x240x80.

The frame is an "H" - shaped (i.e. open type) welding structure consisting of two longitudinal side beams (sides) with a box-shaped cross section, connected by two transverse steel pipes. The shape of the longitudinal side beams is specific for the common in other European countries swing less bogie constructions - type "swan neck" or "Seagull".

The spring suspension of the bogie is two-stage made entirely of springs. The static sag of the spring suspension is significantly larger than the other bogies considered; at maximum payload (12 t per wagon), it is 320 mm, of which almost 80% falls on the secondary spring suspension. The primary spring suspension for each axle box is made of two sets of double-row coil springs lying on vibration-insulating rubber rings attached to the "wings" of the axle box body.

The axles are guided by spindles, and between the spindle and the taller there is a radial clearance of 7 mm, providing self-steering of the wheels (radial location in a curved section of the road). It is possible to install a odometer on one of the bogie axles.

The secondary spring suspension consists of four elastic sets of concentrically arranged coil springs with a rubber sleeve in them. The rubber bushing provides a bilinear characteristic of the secondary spring suspension, being switched on when the bogie load exceeds the normal one (when the car is overcrowded). In this way, the wagon is protected against loss of lateral stability under heavy overloads and does not violate the condition of not exceeding the maximum permissible difference of 80 mm between the height of the buffers in the loaded and empty state. The transverse elastic mobility (elastic connection) between the wagon car body, respectively the over sprung beam of the bogie and its frame is realized by the transverse horizontal elasticity of the central springs (swing less device of the secondary spring suspension). On top of each elastic set of the secondary spring suspension, between it and the over sprung beam there is a taller and a rubber disk; moreover, the diameter of the rubber disc is much smaller than the diameter of the outer spring, in order to increase the hinge effect of the rubber disc supports and hence to reduce the horizontal stiffness of the springs of the secondary spring suspension. When the horizontal deformation of the set or the transverse displacement of the spring beam exceeds 20 mm, the elastic deflector is deformed, which has a strong progressive characteristic.

3.2. Bogie Y32

The Y32 type bogie (Fig. 2) [3] was designed for SNCF's Corail wagons by De Dietrich. The company De Dietrich (now Alstom) has produced more than 6,000 bogies used in France, Belgium, the Netherlands, Portugal, Romania, Turkey, Morocco and since April 2013 Bulgaria (30 sleeping cars type WLABmz).

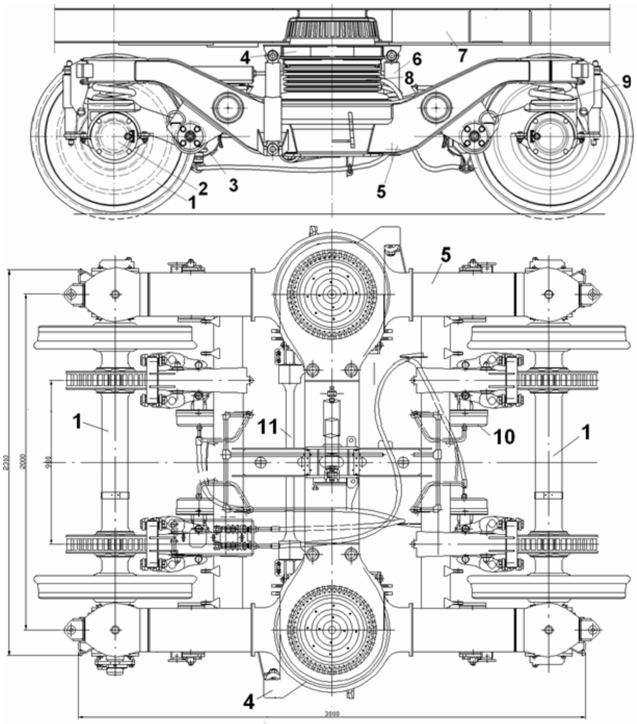

Fig.2. Y32 type bogie on WLABmz sleeping cars
1- wheel; 2- axle box; 3 - connection "axle box-frame"; 4 -bolster; 5 - frame; 6 - damping system; 7 - car frame; 8 - secondary spring suspension; 9 - primary spring suspension; 10 - braking system; 11 – traction.

Wheelbase - 2560 mm; Distance between pages - 2000 mm; Wheel diameter - 920 mm; Bogie tare - 6000 kg; Maximum design speed - 160 km/h.

The primary and the secondary spring suspensions have a two-row cylindrical coil spring.

The frame of the bogie type Y32 consists of two longitudinal side beams, two steel pipes and a middle part with a box-shaped section.

The overrun beam of the bogie type Y32 consists of an upper leaf, a lower leaf, a middle part and two conical upper supports of the springs from the secondary spring suspension and two brackets.

4. ANALYSIS OF INDIVIDUAL ELEMENTS AND ASSEMBLIES FROM PASSENGER CARRIERS BOGIES

Here will be considered only those of the elements and units of the bogie, which require increased attention due to coincidence of circumstances related not only to operational factors, but also to those of organizational and administrative nature:

A) In the first place - are the object of sharpened attention - the joints between the sides and transverse beams (pipes). These are the corners that represent welds. In the prescriptions of the institute (NITIZHT) the requirement for obligatory defectoscopy of the welds in this knot is set.

B) Secondly, the consoles (ears) through which the longitudinal lenkers are connected to the bolster and the sides of the bogie frame, in and around the places of their connection, are the object of sharpened attention. To reduce the high stresses resulting from different train conditions for the T73-AD bogie, it is recommended to increase the radius of curvature at the base of the brackets and improve the quality of the welds connecting the latter to the spring beam or the page and recommendations. of the linker rubber "hinges".

C) Thirdly, cracks can be expected under certain conditions in the lower sheet of the spring beam around the places near the edges of the brackets, perceiving the transverse forces as reactions of the rubber pads. In these places, cracks occur in bench fatigue tests at 6 million cycles and recommendations for rib welding are given.

4.1. Operational observations of passenger bogie type T73-AD

For the period from 01.01.2017 to 31.12.2018 in the repair shop of the depot "Nadezhda" arrived wagons B'84 with bogies T73 AD and the percentages of failures which are shown by Pareto-diagram (Fig. 3).

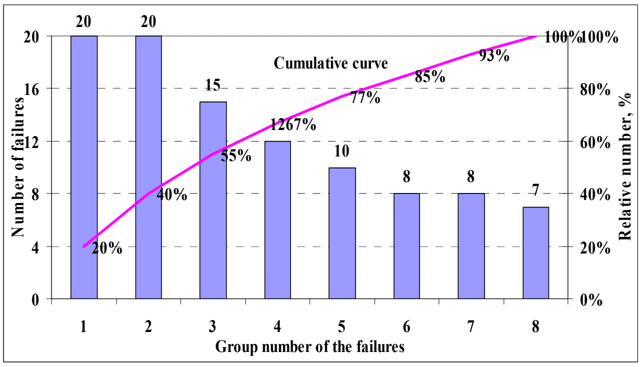

Fig.3. Failures to elements of bogie T73-AD. 1- frame; 2- bolster; 3- brake system; 4- wheel axles; 5- side bearer; 6- dampers; 7- spring suspension; 8- centre pivot

4.2. Operational observations of passenger bogie type Y32

For the period from 01.01.2018 to 31.12.2019 in the repair shop of the depot "Nadezhda" have arrived sleeping cars type WLABmz, whose bogies type Y32 needed repair or repair of failures, the percentages of failures of which are shown by a Pareto diagram (Fig.4).

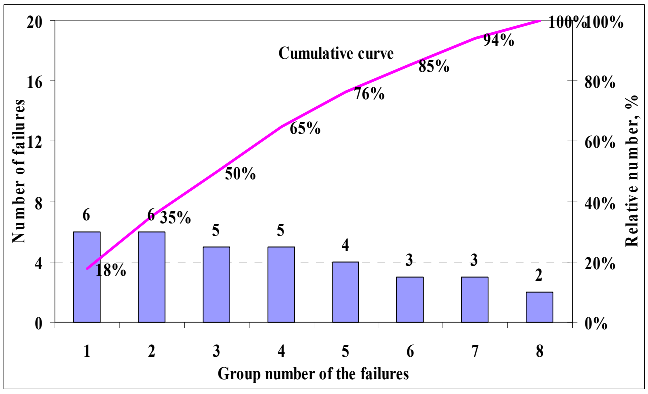

Fig.4. Failures to Y32 bogie elements. 1- frame; 2- overhead spring beam; 3- brake system; 4- wheel axles; 5- connection "axle box-frame"; 6- dampers; 7- traction; 8- spring suspension

5. ZONES WITH PROBABILITY FOR FAILURE

5.1. Stress condition of frame and bolster for bogie type T73-AD

In fig. 5 shows the stress state of the bogie frame, the maximum value being 80.46 MPa obtained in the axle box support. In fig. 6 shows the stress state of the bogie oversprung beam, the maximum value being 359.8 MPa obtained in the vertical support of the left slider. The obtained stresses and strains are within the permissible limits, but under cyclic loading cracks can occur due to fatigue of the material.

5.2. Stressed condition of frame and spring beam for bogie type Y32

In fig. 7 shows the stress state of the bogie frame, the maximum value being 80,654 MPa obtained in the central and axle supports. In fig. 8 shows the stress state of the bogie oversprung beam, the maximum value being 225.5 MPa obtained in the connection of the middle part of the spring support from the secondary spring suspension and the connection with the brackets. In conclusion of the present studies, the recommendation for monitoring the operational condition of:

- the frames of the two bogies in the area of the spinton connection, the middle conical part and the "page-cross links" connection;
- a spring beam from the two bogies in the area of slides, the spring supports of the secondary spring suspension and the connection of the beam with brackets

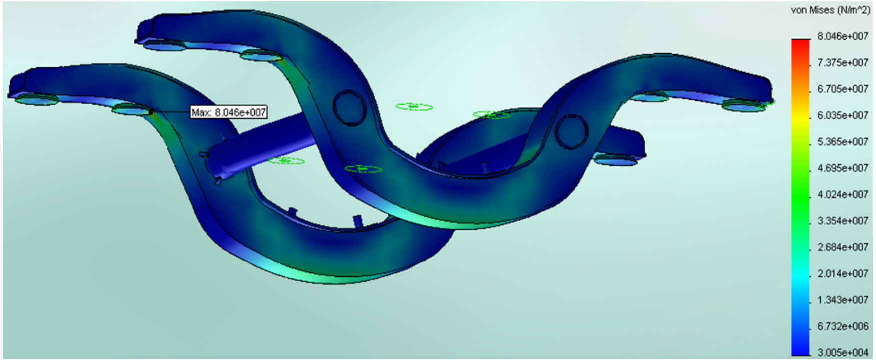

Fig. 5. Stress state of the frame on bogie T73-AD

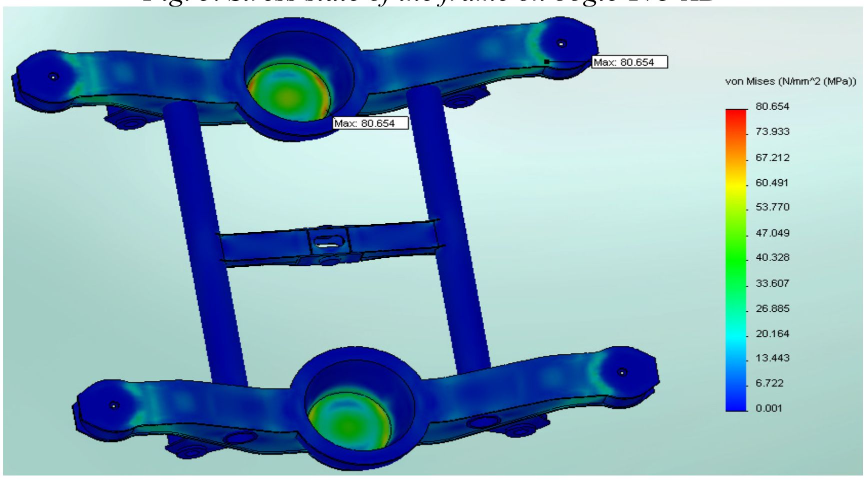

Fig. 7. Stress state of the frame on the Y32 bogie

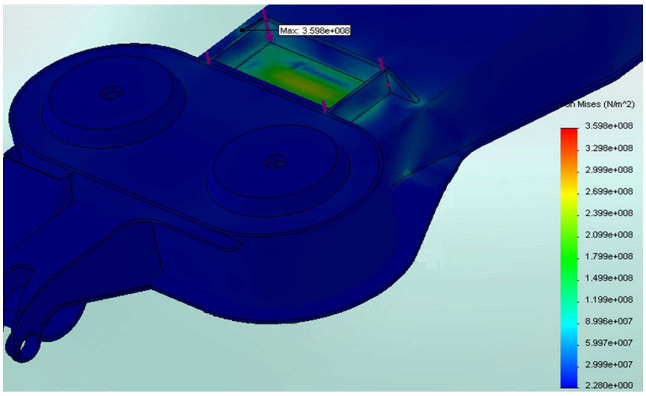

Fig. 6. Tension condition of the bolster of the bogie T73-AD

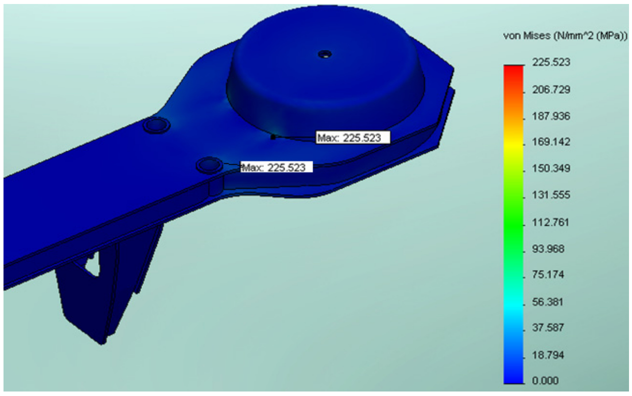

Fig. 8. Stress condition of spring beam of the bogie Y32

6. CONCLUSION

The publication presents the constructions of passenger bogies without swininging in the operation of the Republic of Bulgaria - the passenger bogies type T73-AD and Y32. The most common faults of the passenger bogies of the swininging type are indicated. Pareto diagrams show failures of the specified bogie structures from their operational monitoring. By the finite element method, characteristic zones with probability of failures are determined.

As a result of the research in design, production and repair the object of sharp attention should be:

- the places of connection between the sides and the cross beams (pipes). From the frame;
- spindle connection area, middle and axle support part of a page of the frame;
- the brackets for connection of the longitudinal linkers with the spring beam and the sides of the bogie frame;
- the upper and lower leaf of the oversprung beam in the area of the sliders and around the places near the edges of the brackets.

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