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ANALYSIS OF DESIGN OF PASSENGER CARS BOGIES FOR HIGHSPEED MOVEMENT

Abstract. This paper gives an overview of the existing models of passenger cars bogies for high-speed movement, both Ukrainian production and production of other countries. As a result of this analysis it were determined the main tendencies to improve the design of running parts of passenger cars for high-speed movement. Also it were made a classification of bogies of passenger cars on different criterias.

АНАЛИЗ КОНСТРУКЦИЙ ТЕЛЕЖЕК ПАСАЖИРСКИХ ВАГОНОВ ДЛЯ СКОРОСТНОГО ДВИЖЕНИЯ

Аннотация. В работе приведен обзор существующих моделей тележек пассажирских вагонов для скоростного движения, как украинского производства, так и других стран. В результате анализа определены тенденции совершенствования конструкции ходовых частей пассажирских вагонов для скоростного движения. А также выполнена классификация тележек пассажирских вагонов по различным признакам.

1. INTRODUCTION

In the modern world passenger rail transportation are an integral partof human life. At the same time with the development of high-speed rail passenger transport a lot of attention is paid to creation of wagons' running gear, that provides high rates of smoothness, stability of motion and reducing force influence onthe track. Design of bogies based on the latest theoretical and experimental data in the dynamics of rolling stock. Along with the creation of special bogies for high-speed movement it is being developing new and improving existing bogies of rolling stock for operation with standard driving speed. Thus, the creation of new constructions of bogies for high-speed passenger cars as well as improving of existing bogies is an actual scientific and applied problem for railway transport.

2. BOGIES FOR PASSENGER WAGONS IN RUSSIA AND UKRAINE

First passenger cars for Russian railways were built in 1846 with two-axle bogies [1], and in 1850 appeared a bogie with two-stage spring suspension. In the 70-ies of the XIX century it were using bogies of American firm Pullman with two-stage spring suspension and single longitudinal equalizer. At the beginning of XX century the Fette bogie with two-stage spring suspension were very common on many railroads of Russia. In 1931, the Leningrad plant named after Egorov created a new design of bogie, that were characterized by the absence of equalizers. It welded metal frame rested on the axle box, located in the guides, with the help of springs. Advantages of nonequalizer bogie compared to previous types were low weight , simplicity of design and accessibility for inspection and repair of

swing link and brake rigging. However, during the operation it were observed an increased wear of axle slots and axlebox guides. Therefore, in 1937, the building of non equalizer bogie were stopped.

From 1957 to1962 it were tuned up aserial production of bogies KVZ-5, that were equipped with frictions hock absorbers in axle box suspension and hydraulic shock absorbers in central suspension. Equipment of wagons by bogies KVZ-5 allowed to increase train speeds up to 140 km/h. Further improvement of the designed to the creation of bogie KVZ-CNII in two versions - KVZ-CNII-I and KVZ-CNII-II. The serial manufacturing of these bogies was started in 1962 [2]. Bogies type KVZ-CNII-I is a typical model and rolled up under the carbodies of passenger wagons with a gross weight of up to 60 tons, while bogie type KVZ-CNII-II rolled up under the carbodies of passenger wagons with a gross weight from 60 to 72 tons [3]. Bogies KVZ-CNII types I and II have the same structure, but differ in the number of hydraulic shock absorbers: KVZ-CNII-I has one shock absorber on the each side, and KVZ-CNII-II has two. According to this, they have different location of brackets for mounting of shock absorbers on the frame and bogie bolster. Key elements of the frame of bogie type II strengthened compared with bogie type I. Bogie KVZ-CNII-II has a more rigid spring suspension. Furthermore, in the bogie type II it is redesigned safety device of suspension bar.

Evolvement of bogie KVZ-CNII became a swing-hanger bogie model 68-875 (68-876) and 68-4065 (68-4066), that ensure normal operation of wagons at speeds up to 160 km/h. All these bogies are designed for passenger wagons with a gross weight of up to 72 tons. However, bogie 68-4065 (68-4066) has different design of brake block suspension and use separate vertical and horizontal dampers in central suspension for oscillation damping. Also gear of undercar generator of bogie 68-4066 has increased power (32KW) and is made from the middle part of the axis [4].

Since 2006 JSC "TVZ" has developed and produced new designs of bogies that meet modern requirements for running gear of passenger rolling stock. It is rigid bolster bogies model 68-4075 (68-4076) designed for rolling up under wagons with gross weight up to 62 tons and speeds up to 200 km/h, as well as the rigid bolster bogies model 68-4095 (68-4096) designed for speeds up to 160 km/h The main structural difference of these bogies placed in the very title - rigid bolster bogies, due to changes of the central secondary suspension [4].

It should also bemention the workof "Krukov Carbuilding Plant" in the field of creation of bogies for high-speed rolling stock. In the periodfrom 2002 to2003 it were developed and produced rigid bolster bogie model 68-7007, that is designed for use with speeds up to 200 km/h. And in 2009, it were represented the bogie model 68-7041 for speeds up to 160km/h, the distinguishing feature of whichis the use ofair springsas a secondary suspension. On the basis of bogie model 68-7041 were developed a number of models of bogies, such as: 68-7044 that is intended for the high-speed passenger trains with track gauge 1435 mm and speeds of up to 200 km/h, with three brake discs and magnetic track brake; motor rigid bolster bogie model 68-7072 that is designed for rolling up under wagons of electric trainand operated with design speed of160-200 km/h; model 68-7049 that is designed for rolling up under intermediate wagons of electric trains and passenger wagons with locomotive traction on railways with track gauge 1520 mm and speed up to 200 km/h.

Comparative characteristics of described above bogies are shown in Table 1.

Characteristics	Model of bogie								
	KVZ-5	KVZ-CNII-I	KVZ-CNII-II	68-875/ 68-876	68-4065/ 68-4066	68-4075/ 68-4076	68-4095/ 68-4096	68-7007	68-7041
Permissible speed, km/h	140	140	160	160	160	200	160	160	160
Bogie weight, kg	7000	7100	7200	6900/ 7400	6900/ 7400	7250/ 7300	6800/ 7540	6850	6700
Bogie wheel base, mm	2400	2400	2400	2400	2400	2500	2500	2560	2560
Type of spring suspension	Two-stage: central swing link and axle-box suspension					Two-stage: central rigid bolsterand axle-box suspension			Two-stage: centralrigidbolster with air springsandaxle-boxsuspension
Total static deflection from gross weight, mm	150	190	162	221/ 233	233	260/ 280	280	405	405
Gauge	03-VM	03-VM	03-VM	02-VM	02-VM	01-VM	01-VM	02-VM	02-VM

3. BOGIES FOR PASSENGER WAGONS IN COUNTRIES OF WESTERN EUROPE

Since the mid of 60s National Railway Company of France under took extensive are search works aimed to develop running parts of bogies for high-speed movement. The result of this work was the creation of a number of bogies, which were extensively tested for several years. Basic design elements of new bogies in most cases were taken from the well-provenin service bogie Y28. Works on the bogies type Y was part of creation of high-speed comfortable wagons. These works allowed to identify the main ways of development of the rolling stock in order to increase speeds. In 1974 testing of the new design motor bogies Y226 were started. In the primary suspension it were used coil springs and hydraulic shock absorbers. Secondary suspension consists of coil springs with high flexibility, in which it were mounted a rubber cylinders of one horizontal lateral and four vertical shock absorbers. On the bogie Y226 originally were used a new electrodynamic linear brake that is based on the use of vortical currents. However, further tests showed that the use of vortical currents leads to significant heating of the rails that affects safety of movement. Bogies that were made taking into account indicated features received index Y229A and Y229B. On the base of bogies Y226 and Y229 were created bogies Y230 and Y231 designed to work with a maximum speed up to 300 km/h. Bogie Y231, as well as bogie Y226 in the secondary suspension has two sets of coil springs, but its flexibility is increased. Due to the significant growth in passenger traffic in the early 70s, it was decided to develop a new wagons with increased comfort. Specially for these wagons it were designed bogies Y32. The basic model of the bogie is designed for speeds up to 160 km/h There were also developed various modifications of this bogie. For example, bogie Y32E designed for speeds up to 200 km/h, and were additionally equipped with antihunting device. A bogie Y32B were tested with the use of air springs and rubber steel herringbone springs into the axle-box suspension. For double-deck suburban wagons it were created bogiesY30P [5].

On the Italian State Railways until 1963 for passenger cars were used bogies that had coil springs in the primary suspension and secondary suspension was swing link with leaf springs. However, as a result of researches under taken by increasing the comfort levelin 1965 was created bogie 7170, which served as a prototype for further development. This bogie was designed for speeds not exceeding 150 km/h, but during tests with speeds 180 km/h were obtained good results. Good results that were received using coil spring in combination with rubber cushion inthe secondary suspension of bogie 7170, led to the useof this system for designing a bogie for wagons with tilting carbody. This bogie was created in 1971 and received index Y0160. Simultaneously it were upgraded bogie type 7170, that received index7196. Bogie 7196 was designed for speeds up to 140 km/h. Each bogie has a structure distinguished from every other. For example, bogie type 7196 does not have vertical dampers in axle-box suspension and in horizontal dampers in central suspension. And bogies Y0160 has additional hydraulic dampers that prevent wabbling and torsion barsto eliminate rolling motion [5].

High-speed requirements were taken into account in the design of bogie, that received a designation Minden Deutz 36 (MD36) and were used on wagons of German railways. Bogies before MD36 allowed speed not exceeding 140 km/h This bogie has conventional design with cradle suspension and inclined hydraulic shock absorbers, which were later replaced by two vertical and one horizontal for separate weakening of vertical and lateral vibrations. Moreover, it were equipped by stabilizing supports to reduce rolling motion of car body and axlebox link. Simultaneously with the modification of existing bogies company Klockner - Humboldt - Deutz in 1975 started to work on bogie MD52, designed for operation at speeds up to 250 km/h The main structural feature of the bogie MD52 is flexible for torsion welded H-type box-section frame. Primary suspension consists of four sets of coil springs with mounted in parallel hydraulic shock absorbers. Secondary cradle suspension includes four spring kit (two on each side) and two vertical and one horizontal hydraulic dampers.In addition to the springs in the places of their bearing on the traysit were installed rubber elastic elements for soundproofing. Another bogie that were used on the German railways is bogie LD70, that were produced in two versions: bolsterless bogie with springs or with air springs in central suspension. Primary suspension of bogies LD70 performed on bell type rubber springs, providing the necessary communication parameters of wheelset and bogie frame in the longitudinal and lateral directions and do not require the use of special shock absorbers.

Since 1991, ICE trains on the German railways, which operate at speeds up to 280 km/h are using bogies MD523, MD524 and MD530 with central cradle suspension with decreased lateral stiffness. In 1999-2000, the company Bombardier tested and determined the suitability of bogie type TR400,

designed for speeds up to350 km/h. Axle-box suspension of this bogie consists of simple elastic elastomeric elements perceiving predominantly vertical dynamic load sand leashes of wheelsets with elastomeric bushings. In the central spring suspension it is mounted air springs fitted emergency springs.

4. CONCLUSIONS

Thus, it were made an analysis of structures of existing models of passenger cars' bogies for high-speed movement, both domestic production and other countries. As a result of analysis it can be concluded that there is a tendency to use bolsterless bogie and elastic elements in the axle-box spring suspension when speed increase up to 200 km/h and above. It can be also mentioned that air springs due to their advantages in comparison with coil springs are more preferred.

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