Determination of traction and dynamic qualities of the electric train with operated pneumatic suspension

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S u m m a r y. The purpose of this article consists in research of traction and dynamic indicators of an electric train with operated pneumatic suspension. The object of research is pneumatic suspension of a high-speed railway transport. Work is performed by a method of theoretical research of control systems of pneumatic suspension. In article the algorithm of work of a control system is considered by pneumatic suspension. And traction and dynamic indicators of an electric train with operated pneumatic suspension are also defined. The developed control system is recommended for use on passenger high-speed railway transport.
K e y w o r d s : pneumospring, sensor, servomotor, GPS navigator, dynamic indicators.

INTRODUCTION

The future of control systems is connected by pneumatic suspension with control of geometry of a way and parameters of interaction of a wheel and a rail [1, 2]. Therefore the management development of systems with using of GPS is the actual task demanding the decision [18]. Proceeding from told above, the control system of pneumatic suspension which differs from standard ER-200 established on an electric train was developed. The offered system allows to make management of damping of fluctuations, to regulate floor level depending on a static deflection, from the speed of movement and a condition of a way, using GPS system data [12, 17]. It represents the module in structure of which three classical subsystems enter: measuring, decisive (managing director) and executive. The measuring subsystem consists of the sensor of height of level of a floor, a global system of positioning, the switchboard and the analog-digital converter [19]. The decisive subsystem is presented to the computer. It has the external (system) interface. The executive subsystem consists of two electric air gates. And also from a servomotor and a three-stage throttle which regulate air supply from the additional tank in a pneumospring. The object of management is the pneumospring [20].

The algorithm of work of system is described as follows, at the movement of the vehicle there is a vertical relative movement of a magnet along a plate to gerkonov's sensors [14, 15]. At a deviation of a magnet of rather initial situation the signal Δ which arrives on the computer(up-down) is formed. In a case excess of level it is necessary to turn on dumping electric air gate which will let out a quantity of the compressed air, and at level reduction, it is necessary to turn on the electric air gate of the forcing highway via which the compressed air in a pneumospring moves. Set turn of a shaft of a servomotor establishes the section of a throttle necessary for damping [13].

For definition of traction and dynamic indicators of an electric train AYR 200 with the developed control system the software developed on chair of railway transport of VNU of V. Dahl and adapted for the solution of problems of this work was used. The system consists of 27 bodies (bodies 1, sides 4, cross beams of carts 2, ATED 4, an anchor of ATED 4, wheel steam 4, and rails 8), each of which has six degrees of freedom [13]. Rails under each wheel have two degrees of freedom (the discrete model of a way is considered). Dynamic indicators of an electric train were determined for the range of speeds of movement from 5 to 45m/s with in a draft mode by a direct site of a way. The settlement scheme of an electric train of ER-200 is submitted in (fig. 1.)

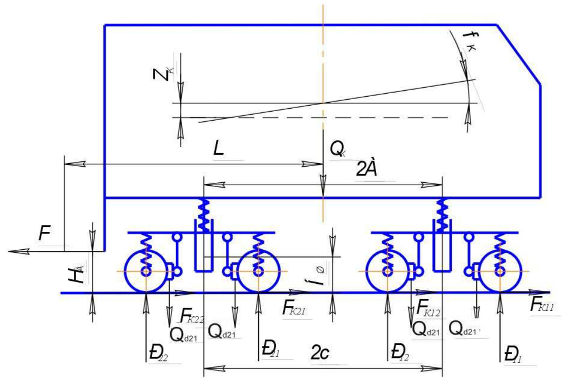
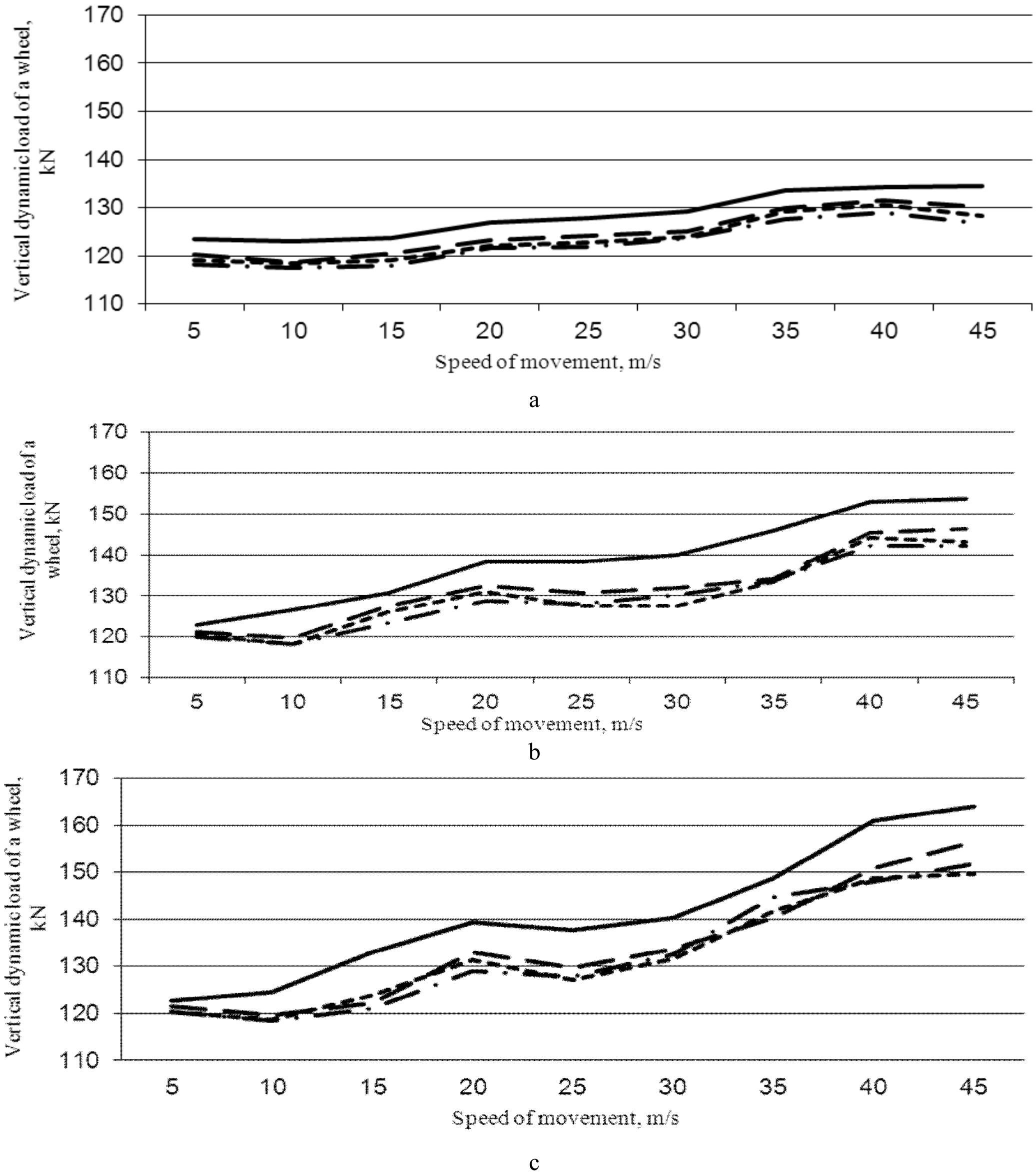


Fig. 1. Settlement scheme of an electric train of ER200

Calculations were carried out for four options of a rigidity of the second step of spring suspension: for spring 5518 kN/m, for pneumatic 3200, 3400, 3600 kN/m. And also for four conditions of a way: excellent, good, satisfactory and unsatisfactory which in the program are characterized by amplitudes of vertical roughnesses, respectively 0.01, 0.014, 0.02, 0.025 m (fig. 2) [6, 7].



rgidity of spring suspension 5518 kN/m
rigidity of pneumonic suspension 3600 kN/m
rigidity of pneumonic suspension 3400 kN/m
rigidity of pneumonic suspension 3200 kN/m

Fig. 2. Theoretical dependences of dynamic vertical loading on a wheel on a rail from the speed of movement and rigidity of suspension for an electric train: a) excellent condition of a way; b) satisfactory condition of a way; c) unsatisfactory condition of a way

As showed calculations for mathematical model of movement of an electric train application of pneumatic suspension allows to reduce dynamic influence from a wheel by a rail in the range of speeds from 5 to 45 m/s twice in comparison with spring suspension with 17,3 to 9,8%.

Deterioration of a condition of a way leads to increase in dynamic loading from a wheel on a rail: at a speed of 20 m/s for PS (pneumatic suspension) to 3%; for a spring set to 4,2%; at a speed of 40 m/s for PSS to 5,6%; for a spring set to 8,5% (fig. 2).

With change of vertical rigidity of pneumatic suspension with 3200 to 3600 kN/m the increase in dynamic loading from a wheel on a rail to 2% for a way in an unsatisfactory condition is observed.

Proceeding from told above, it is possible to draw the following conclusion that pneumatic suspension application with possibility of regulation of its rigidity allows to reduce dynamic impact on a way in comparison with spring RP and to increase the speed of movement of the rail vehicle with preservation of satisfactory qualities on indicators of vertical dynamics [9, 10]. We carried out an assessment of change of indicators of dynamics from regulation parameters. The virtual site of movement (5000 m long) is generated for this purpose. The site is randomly broken into 6 pieces, to each of which the condition of a way corresponds there. For the set way a series of calculations in the range of speeds of movement from 5 to 45 m/s was carried out.

As results of calculations showed, at speeds of movement up to 30 m/s spring suspension rather well carries out vibroprotective function. However at movement over 30 m/s are desirable to regulate rigidity of suspension that allows to do pneumatic suspension.

In order that on all generated site the coefficient of vertical dynamics didn't exceed an indicator with level "well" it is offered on each of sites of a way to regulate rigidity. Recommended parameters of regulation of rigidity of the second step of suspension are presented in table 1.

Table 1. The control parameters of pneumatic suspension

The indicator bumps, m	0.01	0.014	0.02	0.025
The rigidity of the 2nd stage spring suspension, kN / m	3600	3400	3400	3200

Results of regulation are presented in fig. 3 and they show that at movements of a rolling stock with a speed over 30 m/s improvement of coefficient of vertical dynamics at regulation of rigidity of pneumatic suspension on the average for 25%, in comparison with spring suspension, for 5% in comparison with unregulated pneumatic suspension is observed.

Thus regulation of rigidity of pneumatic suspension in the range from 3200 to 3600 kN/m allows us to achieve indicators of dynamic qualities with level "well" on way pieces with various limit parameters of roughnesses. While for traditional spring suspension the dynamic indicator corresponds to an assessment badly.

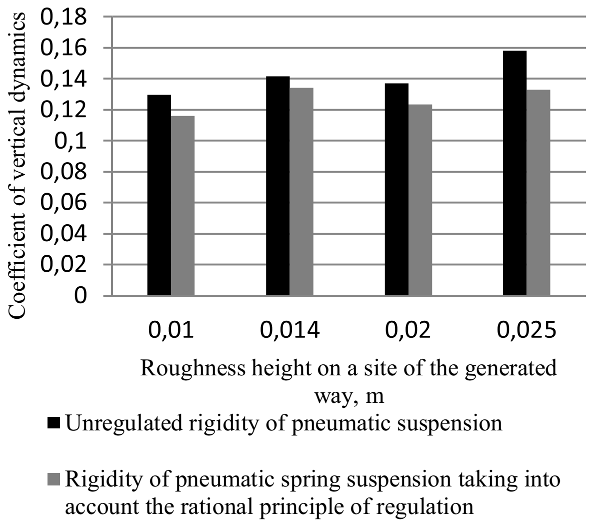


Fig. 3. Change of coefficient of vertical dynamics depending on a condition of a way at a speed of 40 m/s

In design and design practice as criterion of an assessment of traction properties of the locomotive the concept use of coupling weight is accepted η_u [3, 8]. The coefficient η_u qualitatively characterizes change of vertical loading of wheel couple at development by the engine of force of draft. For the biaxial engine of value of coefficient of unloading of wheel couple are defined by base of a body and full wheel base and don't depend on height $h_ш$. We carried out an assessment of application of pneumatic suspension for regulation of traction indicators of an electric train. The design of a pneumospring provides placement in a rubber-metal element, or a metal spring. Vertical rigidity of these elements is higher, than pneumosprings [11]. Therefore for increase in efficiency of coupling weight we offer to adjust at the time of start-off pressure in a pneumospring so that the body of the locomotive leaned on springs or rubber-metal elements. It allows to reduce turning moment of a body in the vertical plane and more ravnovnomerno to distribute loading between wheel couples. For an assessment of influence of such redistribution on efficiency of coupling weight a series of calculations is carried out [16].

For calculations the Mathcad package was used. Calculations showed that regulation of rigidity of pneumatic suspension allows to improve efficiency of coupling weight at the time of start-off on the average to 2,5%.

CONCLUSIONS

The analysis of calculations for mathematical model of movement of an electric train showed that application of pneumatic suspension allows to reduce dynamic influence from a wheel by a rail, in the range of speeds from 5 to 45 m/s of two in comparison with spring suspension (with 9,8 to 17,3 %)

At deterioration of a condition of a way the increase in dynamic loading is observed at a speed of 40 m/s for pneumatic suspension to 5,6%, for spring to 8,5%.

With change of vertical rigidity of pneumatic suspension with 3200 to 3600 kN/m the increase in dynamic loading to 2% for an unsatisfactory condition of a way is observed.

At movement of a rolling stock with a speed over 30 m/s improvement of coefficient of vertical dynamics at regulation of rigidity of pneumatic suspension on the average for 25% in comparison with unregulated spring suspension, for 5% in comparison with unregulated pneumatic suspension is observed.

The principle of regulation of rigidity of pneumatic suspension for the purpose of improvement of traction characteristics is offered at start-off. That allowed to improve efficiency of coupling weight for 2,5% in relation to a standard electric train.

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ОПРЕДЕЛЕНИЕ ТЯГОВО-ДИНАМИЧЕСКИХ КАЧЕСТВ ЭЛЕКТРОПОЕЗДА С УПРАВЛЯЕМЫМ ПНЕВМАТИЧЕСКИМ РЕССОРНЫМ ПОДВЕШИВАНИЕМ

Краснобрыжева Юлия

Аннотация. Цель данной статьи заключается в исследовании тягово-динамических показателей электропоезда с управляемым пневматическим рессорным подвешиванием. Предметом исследования является пневматическое рессорное подвешивание скоростного железнодорожного транспорта. Работа выполнена методом теоретического исследования систем управления пневматического рессорного подвешивания. В статье рассмотрен алгоритм работы системы управления пневматическим рессорным подвешиванием. А также определены тягово-динамические показатели электропоезда с управляемым пневматическим подвешиванием. Разработанная система управления рекомендуется для использования на пассажирском скоростном железнодорожном транспорте.

Ключевые слова: пневморессора, датчик, серводвигатель, трехступенчатый дроссель, электропневматические вентили, GPS-навигатор, динамические показатели.