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Simulating the Operation of the Pantograph-type Current Collector

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Abstract

The usage of electricity to increase the safety and environmental friendliness of transportation is a very important issue. The common feature in the work of different types of electric transport is the dependence on reliable contact with the conductor from which it receives power. The reliability of the constant movable contact between the conductor with current and electrical equipment depends on the precise operation of the pantograph complex mechanism. To simplify the planning calculations and approbation of structures, a pantograph model with two degrees of freedom is proposed. It gives an adequate description of the real system and improves the mathematical apparatus while calculating the forces and dynamic displacements of the pantograph mechanisms for electric transport.
KEY WORDS: *electric transport, pantograph, model, transportation, safety*

1. Actuality

Modern transportation requires safe environmentally friendly [1, 2], material-saving [3, 4], energy-efficient transport [5-7]. The priority of the modern transport strategy is to ensure the replacement of transport with hydrocarbon emissions by "green" transport. It is not only railway transport that is changing from diesel to electric locomotives. Leading automobile companies have also started the testing of freight electric vehicles using their own electrified lines. This improves logistics and reduces transportation costs.

2. Introduction

Safety has always come first for carriers. Recently, much attention has been focused on preserving the environment and saving energy resources [8, 9]. This concerns not only traditional types of electric transport (Fig. 1, a, b), but also automobile ones (Fig. 1, c) [10, 11].

a b c

Fig. 1 Interaction with the contact wire of a pantograph on: a – electric locomotive; b – tram; c – car

What these vehicles have in common is their dependence on reliable contact with the conductor from which they receive electrical energy. A complex mechanism of the pantograph-type current collector is used to transmit electric current from the contact wire to the traction equipment of electric vehicles.

Symmetric pantographs (Fig. 2, a, b) are mainly used on direct current freight electric locomotives. On DC electric locomotives in the conditions of heavy freight trains current collectors of T-5M1 type (Fig. 2, a) are used. T denotes heavy series, 5 – model number, M – with copper overlays, 1 – placement category number. Current collectors of the L-13U1-01 type (Fig. 2, b) are used on alternating current electric locomotives and electric multiple units. L denotes light series, 13 – model number, B – with carbon overlays inserts, 1 – placement category number, 01 – design number. The kinematic schemes and the principle of operation of both types of symmetrical current collectors are identical (Fig. 2 a) [12].

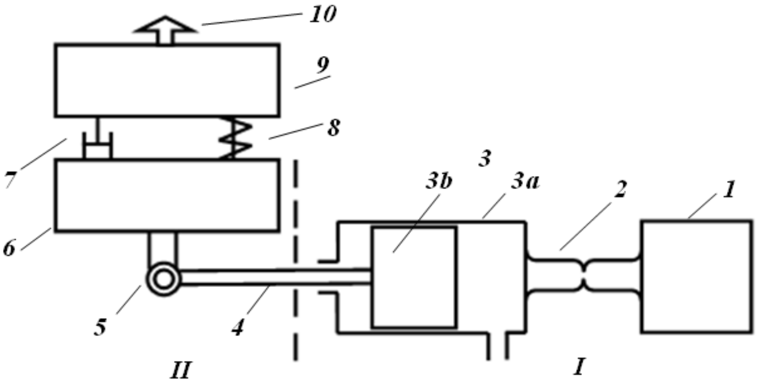

Fig. 4 The pantograph model with two degrees of freedom: I Pneumatic part of pantograph: *1* – air tank (P_O, V_O, T_O), *2* – pipeline concise air (F_O), *3* – pneumatic drive for pantograph lifting: *3a* – pneumatic cylinder, *3b* – piston (M_r, η); II Mechanical part of pantograph: *4* – piston rod, *5* – the main shafts and levers, *6* – kinematics of pantograph mechanism (pantograph frames and metal tubes), *7* – equivalent elasticity of contact wire, *8* – equivalent stiffness of the system, κ , *9* – equivalent mass of skids, *10* – point of interaction of the elements of the pantograph and the contact wire

This model is simplified in its design, since the branched multi-link mechanism is replaced by a sequence of the four-link chain. The number of lever mechanisms is decreased by combining them in the third link. All equivalent springs, considering the elasticity of the system as a whole, were reduced to one equivalent spring in the fourth link. This model gives the average value of displacements for the three links. In the model, changing the parameter's impact on external factors allow minimal deviation to predict the operation of the pantograph mechanism and optimize its design.

6. Conclusions

Pantograph – a catenary system is utilized to supply electric energy to vehicles. With the priority of low emission transportation, it is utilized not only in railway transport systems, but is being tested in the automotive industry also. New applications of using pantographs same as continual demand on increasing the speed of railway transportation bring also new demands on pantograph design and its' optimization. A pantograph is a rather complex pneumo-mechanical system. To simplify the planning calculations and approbation of structures, a simplified pantograph model with two degrees of freedom is proposed. It gives a sufficient description of the real system and simplifies the mathematical apparatus for calculating forces and dynamic displacements of the pantograph mechanisms of electric transport.

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