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Efficiency Evaluation of Freight Cars Perspective Draft Gear Coupler

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Abstract

The main task of a draft gear coupler (shock absorber) installed on its movable part is to reduce the longitudinal forces in the formation of the train on the humps and at transient modes of the train. Its serviceable and effective action ensures the safety of the train itself as well as that of the goods transported. In the study of the longitudinal loading of a carriage the problem of improving and introducing new high-performance couples becomes urgent. We designed the constructions and mathematical models of advanced shock absorbers PMC-RBP-120, PMC-RBE-120, AVC-120P, AVC-120E, PA-120 and PA-120M. We managed to obtain a statistical distribution of the longitudinal forces affecting the movable part of the train through the automatic coupler of the carriage equipped with promising devices, under various loading conditions. The results of the calculations of the statistical distributions were used for the calculation and evaluation of performance effectiveness indicators of draft gear couplers as well as the assessment of the likelihood of parametric failure of the devices.

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Keywords: draft gear coupler; absorbing device; mathematical modeling; criteria of economic efficiency.

1. Introduction

The longitudinal forces arising in the rolling stock during the maneuvers and collisions while moving in a train have very negative impact on the safety of rolling stock construction, its equipment and cargo carried. The task of reducing these forces can be effectively solved by draft gear couplers of the rolling stock. The development of new and the modernization of previously existing constructions are the most important goals in the study of the longitudinal loading of freight train cars.

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These objectives are closely related to the conduct of a large number of theoretical and experimental problems. Experiments to assess the strength and durability of the machine elements are money and time-consuming. Mathematical modeling can significantly reduce the amount of experiments. Well-designed calculation model gives an adequate idea of the characteristics of the simulated object, allows us to identify the most promising technical solutions [1].

2. Methods

The most complete assessment of the properties of the draft gear coupler from the point of view of its main purpose can be obtained by using the criterion of economic efficiency, taking into account repair costs of the freight cars damaged by longitudinal loads of freight cars damage from uncoupling and downtime of cars as well as emergency situations arising from its poor performance. The research made by Keglin B.G. and Boldyrev A.P. [2].

For the newly created device the evaluation of the economic efficiency criteria is a difficult task of forecasting the relation between costs and the shock-absorber properties. This problem is related to the definition of the interrelation between the shock absorber properties and the longitudinal loading of carriage in the process of operation and with the establishing of connections between the loading of the carriage and repair and other costs. The solution of the problem as well is also complicated by the difficulty of differentiation of the damage caused by longitudinal or other forces, interrelation of various physical damages; the stochastic nature of the relationship between load and the damage caused by it, as well as different frequency of load composition, technological deviations and volatility properties of the material at the same loads affecting different samples of the cars belonging to one and the same type due to different duration of their service or environmental temperature.

Considering the above mentioned factors, it is difficult to establish the relationship of longitudinal loads and damages caused by them. Therefore, the criteria for the effectiveness of the draft gear couplers are limited to mathematical models that reflect the most important aspects of the fracture process [3].

The efficiency of the coupler can be associated with determined and stochastic indicators, which include:

- energy capacity and fullness of power characteristics ;
- maximum forces (accelerating force);
- reliability indexes;
- blocks of spectrum of longitudinal loads;
- efficiency criteria related to various types of failures.

To compare the work and assess the impact of the parameters of modern shock absorbers on the loading of cars such criteria effectiveness criteria as J_r (generalized criterion of efficiency of freight car shock absorber), J_f (criterion of fatigue damage of the carriage components), J_{cd} (conditional criterion of damage to the carriage from single overload), J_{gd} (conditional criterion of damage to goods from single overload), as well as the probability of parametric failure.

The generalized criterion of the efficiency of freight carriage shock absorber is determined by:

$$\begin{cases} J_r = J_f + \gamma_{cd} J_{cd} + \gamma_{gd} J_{gd}; \\ J_f = \sum_{i=1}^{r} P_i^{m'} n_i; \\ J_{cd} = \sum_{i=1}^{r} (P_i - P_p)^2 n_i \sigma_0 (P_i - P_p); \\ J_{gd} = \sum_{i=1}^{r} (j_i - j_p)^2 n_i \sigma_0 (j_i - j_p); \end{cases} \quad (1)$$

where J_f , J_{cd} , J_{gd} – components of the generalized criterion relating to the different types of failures, n_i - the number of load from longitudinal forces P_i; m' – fatigue curve parameter; P_p – the threshold force of the blow, the excess of which leads to a shift of cargo; σ_0– Heaviside unit function; j_p – threshold acceleration of the carriage, the excess of which leads to a shift of cargo; γ_{cd}, γ_{gd} – weighting coefficients determined experimentally for different types of cars [3].