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## Simulation of Braking Processes in Freight Trains

L. Ursulyak<sup>1</sup>, K. Zheleznov<sup>2</sup>

<sup>1</sup>Ukrainian State University of Science and Technologies, Lazaryana St., 2, Dnipro, Ukraine, 49010,  
E-mail: [lydm.urs@gmail.com](mailto:lydm.urs@gmail.com)

<sup>2</sup>Ukrainian State University of Science and Technologies, Lazaryana St., 2, Dnipro, Ukraine, 49010,  
E-mail: [constantinz@i.ua](mailto:constantinz@i.ua)

### Abstract

The article presents the results of theoretical research of the processes occurring in the brake cylinders on freight wagons in trains of different lengths. A detailed analysis of the real time dependences of the forces of pressing the brake pads on the wheel for various braking methods (adjustment, full service and emergency braking), which were obtained during experiments with freight trains of different lengths, was carried out. Based on the analysis performed, approximating expressions for brake pad pressure diagrams on the wheel are proposed, which can be used to estimate the longitudinal dynamics of trains using mathematical modeling in real or accelerated time. The above dependencies are especially relevant when a train is controlled using a special onboard computer system. In this case, it is necessary to quickly estimate to what results, from the point of view of traffic safety and achievement of the control goal, the implemented control modes will lead to.

**KEY WORDS:** longitudinal dynamics, braking forces, brake cylinder, braking modes

### 1. Introduction

Sometimes, it becomes necessary to obtain the results of train motion simulation in real time or even in accelerated time [1-6]. For instance, one may need to evaluate the influence of the chosen running modes on running safety [7-9]. In such cases, the speed of simulation is the main demand to the modelling system. The most time-consuming subtask in the train longitudinal dynamics simulation is modelling of the train's braking system [10-15].

### 2. Model Description

Braking force depends mainly upon the braking mode, the place of the wagon in a train and running velocity [2, 10]. Two first mentioned factors influence the pressure in a braking cylinder and the speed of its filling. To study the processes of brake cylinders filling, the experimental dependencies for the trains of various lengths were obtained with the help of pressure sensors, installed in several braking cylinders distributed along the train length, for the trains with 60, 100, 120, 150 and 180 wagons [11].

Cylinder filling time depends on the train length and varies from one experiment to another. The piecewise-linear approximations of the obtained pressing processes in the 27<sup>th</sup> wagon, for the full service braking are shown in the Fig. 1.

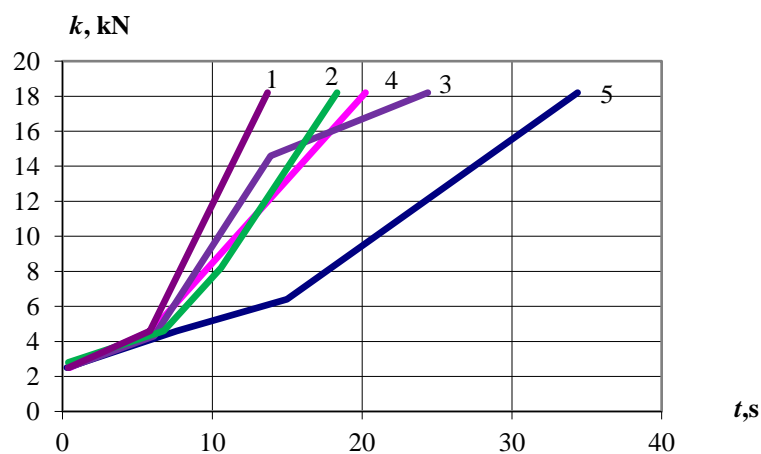


Fig. 1 Brake shoe pressing in the 27<sup>th</sup> wagon for the trains of different lengths

Here the lines 1, 2, 3, 4, 5 correspond to the train sets of 60, 100, 120, 150 and 180 wagons. As one can see from Fig. 1, brake cylinder's filling time increases with increasing of the train length, but some deviations are also possible. They are caused by unstable work of distributors.