THE INFLUENCE OF OPERATING PARAMETERS ON BRAKING PRECISION OF METRO TRAINS

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Abstract
In the paper, the basic function of an Automatic Train Operation (ATO) called target braking has been discussed. The most important assumptions of this function have been discussed in detail. The authors’ simulation model, which was developed to study the impact of the propulsion systems on the precision of train braking, has been described. The adopted model of movement of rail vehicles and the methodology of determining the braking precision of target metro trains have been described. Subsequently, simulation results of the investigation of influence of operating parameters on braking precision and braking time have been presented. The simulation model verification and the preliminary statistical elaboration of the measuring results have been presented.

Introduction
Traffic conditions present in the underground are unique because the distance between trains is short, they move with a high speed (v~90 km/h) and platforms are short. Therefore, it is required to apply specialized systems which can provide traffic safety, which in terms of speed restrictions, is ensured by Automatic Train Protection (ATP) system. Once the system has been provided with appropriate data, it can calculate safety speed for each train or all trains travelling along the same line. By executing a specified algorithm, ATP devices do not allow to exceed safety speed as it includes control of the power transmission and braking system. The ATP system is initiated only if the driver exceeds permissible speed e.g. signaled by a semaphore. Automatic Train Operation (ATO) is an example of systems which can be of help in the underground. This one is responsible for supporting the driver of the train. Target braking is one of the functions performed by an ATO system. It relies on automatic train stopping at the stations, where braking process is fully controlled by an on-board device. Precision braking is an important stage of underground train ride as it is required to stop a train in a platform with limited length. The average length of the subway train is about 100 m, length of the platform for reasons of space savings in the tunnel is very similar. At

the 1st line of Warsaw underground, traffic safety provides a system commercially called SOP-2 [1]. It is a type of an ATP system which is enriched in the ATO system function – the target braking of train in the platform. The system performs its tasks by a continuous data transmission, which is achieved by using a wire loop placed between the rails. There are used two basic types of rolling stock: type “81” trains driven by a DC motor and type “Metropolis” powered by an AC motor. In the literature, there is no information about a simulation model which cooperates with a braking controller and which was developed to carry out calculation of precision braking [2, 4, 5, 6, 9, 10, 11]. Therefore, a simulation model (in the text also called the Simulator) dedicated to study the impact of the propulsion systems on the precision of train braking has been created and positively verified. The scope of research presented in this paper relies on calculation of the influence of operating parameters on target braking, for the selected type of rolling stock. The results allow for an analysis of static and dynamic parameters of the target braking process performed in subway conditions.

Conclusions
As part of the work, following general conclusions can be proposed:
- From the examined operating parameters, the reduction of available braking force and the addition of resistance to motion have the greatest impact on the precision of braking. The obtained outcomes can be generalized to most kinds of rolling stock operating with an ATO system,
- Supreme precision has been obtained for the initial braking speed $v_p$ in the range of 50÷90 km/h (mean values of the train speed),
- Conducted studies can support existing ATO systems by improving the accuracy of automatic train stopping on the platform. The increase of accuracy of target braking improves the safety of passengers e.g. by minimizing the risk of falling on the tracks. For platforms with double doors (so-called closed platforms), exact
stopping of the train will play a key role in the evacuation of passengers in case of fire or a terrorist attack,

- The created tool can be used to support the process of designing automatic train operation systems,
- A software recreation of target braking is possible,
- The major effect of the work is the developed target braking model. The model allows for performance in dynamic conditions the target braking process and it provides the ability to calculate braking accuracy,
- The research results of braking accuracy are consistent with a normal distribution,
- The simulator allows calculating the quality factor, which makes possible the assessment of generated braking curve, which is an additional research interest.

References


