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Determination of fouling level change in the railway ballast layer during machine cleaning process by measuring changes of relative permittivity using GPR technology

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Railway, as one of the most used mode of transportation, requires high demands on its maintenance. This maintenance should be performed on the basis of comprehensive and accurate diagnostics. Current diagnostic methods require high costs associated with their destructive nature as well as financial losses caused by traffic constraints and related complications. Railway infrastructure managers aim at the reduction in the time of diagnosis and subsequent repairs, in order to minimize the financial costs associated with it. For these reasons, Ground Penetrating Radar (GPR) as a relatively new, non-destructive tool for diagnostics of the railway body, is being used recently. This technology is still not the most typical way to control the state of the railway body (ballast and sub-ballast layers), but it is gradually being applied because of its various advantages, such as the speed of diagnostics, the possibility of continual measurement of large sections, non-destructive nature and achievable depths.

Upon cyclic loading of trains and through weathering processes, railway track ballast deteriorates by time. Ballast fouling, i.e. contamination of ballast takes place when voids in the ballast are filled because of ballast breakdown and infiltration of other materials from the ballast surface or infiltration from the base of the ballast layer. To remove debris and dirt from spent ballast, machines called ballast cleaners and/or undercutters are commonly used. These devices perform continuous cleaning of the existing worn-out materials with the possible addition of new fresh ballast. This essential process, followed by tamping, is both costly and time-consuming, therefore it is necessary to accurately determine at what stage of track ballast life cycle, and degree of pollution, this activity is needed and most economically advantageous. To obtain this information, a long-term and repeated monitoring of the track ballast condition is necessary to carry out.

In the present study, a series of in-situ surveys were performed to obtain track ballast relative dielectric permittivity (RDP) values in several stages of selected railway track lifecycle. The measurement took place on several track sections at different conditions/stages of ballast i) before cleaning process, ii) in between cleaning and tamping stage iii) and after final tamping step. Also, earlier GPR data from 2014 and 2017 obtained from state railway administrator - Správa železniční dopravní cesty (SŽDC) were used to assess changes in RDP values in time. Moreover, ground truth data were obtained from opened trenches. The study also includes a series of laboratory tests performed on collected track ballast material samples and tests on newly added aggregate. Based on RDP values, fouling levels of ballast were set and determined, and changes were assessed in between all stages of survey series. The results show change of railway ballast RDP in time, a dependency of ballast fouling level on RDP and the RDP change during cleaning process, thus the efficiency of machine cleaning process performed by two different undercutters.

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