"Environmental Engineering" 10th International Conference
Vilnius Gediminas Technical University
Lithuania, 27–28 April 2017
http://enviro.vgtu.lt

eISSN 2029-7092 / eISBN 978-609-476-044-0

Article ID: enviro.2017.136
DOI: https://doi.org/10.3846/enviro.2017.136

Analysis, Research and Assessment of the Measures of Railway Protection from Snow

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Abstract. The research object of this paper are the railway switches. The paper studies the efficiency of the usage system of a stationary switch protection in the Lithuanian railways. The study consisted of observations and condition assessment, as well as a survey of the people whose work is directly related to the switch exploitation, in order to establish the specifics, advantages, disadvantages, and experience in the Lithuanian railway system. It was found that the system is an efficient technical solution to obtain maximum results with minimal costs because the system is efficient, necessary in Lithuania in consideration of climate conditions, does not require high maintenance, system installation is fast and simple, the system does not affect train traffic, but rather helps in protecting the most sensitive parts of a switch from snow, especially during a snow storm. During the use of the system, switch blades are not blown out or blown out to a lesser extent. As the electric switch heating is used, the use of electric heating system becomes more efficient because the stock rail maintains heat for a longer period. Furthermore, in consideration of the research carried out, this paper provides the recommendations of the system use.

Keywords: brush systems, railway switches and crossings, snow, climate conditions.

Conference topic: Roads and railways.

Introduction

According to Lindgren *et al.* (2009), climate-related events, especially floods and storms, are already among the factors most frequently causing disruptions for railways. However, the climate features that have a significant effect for the railway infrastructure depend on the region. For instance, snow and snowstorms are not characteristic of all regions but Lithuania may be classified as one of such territories. Train operation in winter conditions has always been a challenging task. From steam engines, with water freezing on its way to the boiler, to modern electrical locomotives with frozen pantographs and catenary, different winterly conditions has cost the railway undertakings and infrastructure managers much money and many man hours (Winter… 2017). All of these winter natural phenomena disrupt a safe and continuous railway traffic. However, an exclusive quality of the railway transport is the fact that 99% of the time they are properly exploited. When the snow falls on a railway, it creates an additional resistance to movement, demands additional energy and fuel costs, train speeds decrease, and section exploitation becomes more difficult due to the snow removal works. One study (Rossetti 2007) showed that the most railroad accidents and incidents in the US in 1995–2005 from December to March were caused by snow and ice.

In train stations four critical zones may be excluded, for which the protection from snow is of crucial importance. These zones are as follows: switches; station areas where the snow is not blown away; platforms. In case the snow is not properly and timely removed, trains may drive off railways (this may be caused by both ice and snow); trains may get stuck and lose time (train resistance to movement increases with the snow mass that affect running time. Sometimes snow mass may cause a train to get stuck); travellers slip and hurt themselves on platforms; snow gets in the rolling stock and their parts are broken; switches may not work (Xia *et al*. 2013).

Therefore, in order to remove snow and prevent it from accumulating on roads, various measures may be applied, such as follows: areas may be built where the snow could be stored; platforms may be heated (this would reduce the need for snow removal but that is truly expensive); the transverse road profile should be designed in the way that it would not be blocked by snow (e.g. in Japan, the transverse profile, i.e. road width is increased in the places where the layer of snow is relatively thick); ensure that the water is properly directed from the road; snow fences may be built in places where there is a possibility of snowstorms

This article further discusses in more detail the problems of switch protection from snow. The problems related to the switch maintenance in winter may be classified as the problems related to snow and snowstorms and freezing of switch parts.

Every railway network has a huge number of switches (on average about 200–400 switches per 100 km network). Major rail system problems in winter occur due to the malfunctioning of switches due to frost and snow. Countries in

Alpine regions and Scandinavia have already started to introduce protection such as heating, covers or brushes (Doll *et al.* 2014).

Use of measures of protection from snow

In modern times, a major part of switches are heated by electricity. The installed and exploited electric heating system must be optimal and properly functioning, i.e. when needed, the system must be turned on automatically or manually. However, the electric heating system alone cannot protect the switch from snow if it falls very heavily. In that case, manual or automatic cleaning measures are necessary. What is more, the infrastructure manager must include in their plan the solution of exploiting the line with a low number of functioning switches, if necessary (in case of heavy snowing). It is also necessary to install special devices in critical places, i.e. where the wind brings a lot of snow. Snow fences or snow spoilers may be used. In Sweden there are rubber spoilers used (see Fig. 1) that are lain along the zone of the track switch point. Their goal is to raise the snow in order to prevent it from getting between the switch point and the stock rail. V-shaped spoilers are used in Finland and placed at the beginning of a switch to reduce the amount of snow falling on the switch. Sweden widely uses brushes that are presented and analysed in detail in this paper. They are deemed to be very similarly effective as rubber spoilers.

Fig. 1. Rubber snow spoilers

A lot of focus in the world is dedicated to the maintenance of railways during winter, and especially a lot of attention is paid in attempts to improve the existing systems of switch protection from snow or design the new ones. A lot of specialists work in this field: scientists, road builders and various production organisations. For example, in Russian science centres, scientists, together with experienced railway specialists, explored the measures of railway protection from snow for many years and created a design system of railway road protection from snow. A new branch of science was created – snow engineering. Upon using this method, the mathematical statistic methods are used to process the meteorological data. That way it is established what optimal measures of railway protection from snow should be.

It was also found in the Russian railways that the electrical switch heating, regardless of the fact that it has many advantages, cannot fully change the manual works (as well as other equipment that protect a switch from snow), especially snow removal from switches. Because of this reason, it was decided to search for and select new measures that would neutralise the accumulation of snow in switches. Therefore, in 2011 in Russia there was implemented a Triple S system (triple S stands for safe, clean and economical in German). Instead of a traditional switch heating that uses electricity, the system uses geothermal energy. Upon using the geothermal energy, this system reduces the electricity consumption by 60%, compared to the traditional switch heating systems. In Germany, where this system was designed, there are 120,000 heated switches; one third of them apply the Triple S system (Innovatsionnyy daydzhest 2017; Sneider 2011).

In carrying out research in order to design effective devices used to remove snow from switches the USA was assisted by NASA. Midwest Industrial Pupply Inc. (MIS) is leading company in the USA that creates measures protecting railways from ice. In cooperation with NASA, two products were created (liquid) to fight ice. MIS offered new liquids in two commercial products: Third Rail Anti-Icer/Deicer ir IceFree Switch (NASA Spinoff 2012).

The other system created by a USA company (SPECTRUM) is RRSH Track Switch Snow Removers that is designed according to the principal of controlling power by three regimes that are as follows: blowing away, part-heating and full heating. The system includes both the heating system and the system of blowing cold air. It also includes the system snow detection with sensors.

In Lithuania the following measures are taken to efficiently protect the switches from snow (Instruction… 2008):

- electric heating of switches;
- the blowing away systems;
- Snow fences;

- Plantation;
- Manual cleaning of switches;
- Recently, the stationary brush system in switches has been applied.

Object of research

The stationary brush system in switches consists of the vertically collected brushes that are mounted in parallel to the stock rail, along the switch point. The brushes protect the switch from snow from the outside cap of the railway and at the same time it preserves the warmth coming from the place where the switch is heated. For that reason, the snow does not fall between the stock rail and switch point, and the snow that does fall there is melted faster (see Fig. 2) (Smith 2010).

The system is special and essentially advantageous in the way that this protection system is the first one and so far the only one suitable for use in both usual railway lines where the train speed is up to 160 km/h and high-speed railway lines with higher speeds. Hence, there is no threat that, after installing this system in lines with the speed below 160 km/h, it will not be suitable after a reconstruction, during which the train speeds will increase. What is more, the system does not require a removal. i.e. the brushes may be used all year round because they do not disrupt the inspection of railways or work of cleaning machines. The installation of the system is simple and does not consume much time (up to 2 hours).

The first section of brushes must be lain 1–1.5 m behind the peak of a switch point. The installation of brushes in the zones of switch points and crossings is illustrated in Figure 3.

Fig. 2. The protection system of brushes from snow installed in the switch of Šiauliai railway station: 1 – lower part of brushes; 2 – upper part of brushes

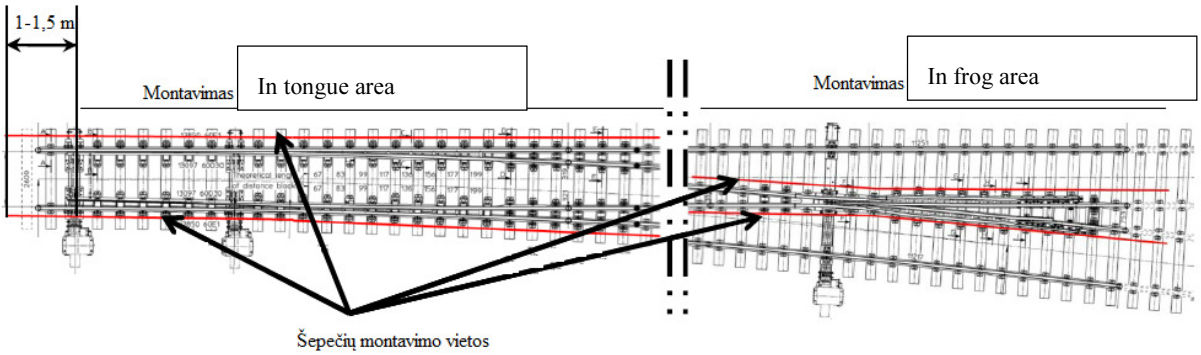

Fig. 3. Brush layout in a switch

Research of the system of protection from snow

One of the tasks of this paper is to carry out a research on the protection system from snow in switches by using the methods of survey, visualisation and comparison. Therefore, the study in this paper consists of two parts: survey carried out in order to find out about the experience of people whose work is directly related to the maintenance of switches upon exploitation of the system studied and the visual observation and condition assessment of the switches during snowing and a snowstorm. Further in the paper these studies are referred to as survey and observation.

The trial switch protection system in Lithuania is installed in the stations categorised as the infrastructures of Vilnius, Šiauliai and Klaipėda: Kyviškiai, Paneriai, Radviliškis, Šiauliai, Kužiai, Kuršėnai, Papilė, Viekšniai, Giruliai, Kretingalė, and Rimkai. The research was carried out on 30 switches. In all three switches there is an electric heating mounted and the system is applied in various frog angle switches (1/9, 1/11, 1/18). The types of railways used are R65 or UIC60, the system is installed in the switches with both sleepers of reinforced conrete and wooden sleepers.

During the observation study from January to April 2014, the conditions were unfavourable to the study because there was almost no snow nor snow storms. The research was intentionally planned during the months of winter when the snowstorms and heavy snowing are the most common, as well as on the first part of spring when the weather is also unpredictable. However, during the research period, winter was warmer than usually. However, after conducting a study it may be concluded that, even after snowfall without wind or snowstorm, the system is effective because there is basically no snow between the switch point and stock rail.

Table 1. Survey results

No.	Question	Score, %				Comments
		10	9	8	5	
1	Do you think the system is efficient in the switches installed?	40	33	7	20	
2	Do you think it is necessary to use the system in Lithuania, in consideration of the climate conditions here?	87	13			
3	Do you think the system installation is simple and easy, i.e. it does not require any special qualification?	60	40			
4	Does the system require a lot of time and consumables for its maintenance?	67	27	6		
6	Could you please name a few flaws of the system?	It is more difficult to remove snow between the switch point and stock rail that gets there because of a vertical snowfall. 80% of the survey participants answered that they did not notice any flaws.				
7	What type and number of maintenance works were needed to perform during the functioning period of the system?	No maintenance works were needed.				
8	When do positive change occurs: at what temperature, natural phenomena, etc.?	80% of respondents claimed that the positive change was noticed during a snowstorm, and half of the respondents added that also during snowfall.				
9	Does the system help protecting the most sensitive switch parts from snow?	All of the respondents provided a positive answer to this question.				
10	After installing the system, did the maintenance of switches became more frequent/became rarer/showed no change?	80% of respondents answered yes.				
11	Does the system help keeping the railway warm?	All answers were yes. The majority of respondents added that it is the biggest advantage of the system.				
12	What positive change did you observe in the exploitation of switches after installing this system?	Due to the use of the system, the electric switch heating becomes more effective (using both systems simultaneously); The railway remains warm for a longer period of time due to the lower brushes; The railways are less blown out, especially between the stock rail and the switch point; The switch operates in a more reliable manner during a snowstorm.				
13	In what tracks and switches (depending on the frog angle) did the use of the system seem the most effective and why?	Part of the answers (30%) was that this system should be used regardless of the intended use of tracks, road layout and switch frog angle. 30% mentioned that the most effective use is in the frog angle switches 1/18 that are in open places and where the side wind blows. 30% emphasise that the system is the most effective in areas where side winds and snowstorms are common, as well as on main roads that are in open areas without the protection from snowstorms.				
14	Were there any system breakdowns? If yes, what kind and how many?	All of the respondents answered that there were no breakdowns.				
15	Were there any incidents or trouble related to the use of the system?	All of the answers were also negative				

After analysing the survey results (the summary of questions and answers is provided in Table 1) it may be concluded that the system analysed is an optimal solution in order to obtain maximum results with minimal costs because of the following:

1. The system is effective;
2. Needed in Lithuania, in consideration of the Lithuanian climate conditions;
3. Does not demand any maintenance;
4. Easy, simple and fast system installation;
5. Does not affect the train traffic;
6. The system helps to protect the most sensitive parts of a switch from snow, especially when there is heavy snowing or a snowstorm;
7. As the system is used, the switch blades are not blown out or blown out less;
8. The electrical switch heating becomes more effective because the stock rail preserves the warmth for a longer time.

Conclusions

During the research, a survey of the people whose work is directly related to the switch exploitation was conducted, in order to establish the specifics, advantages, disadvantages, and experience of the system in the Lithuanian railways. After analysing the survey results, it may be concluded that the system is an optimal solution in order to obtain maximum results with minimal costs because the system is efficient, necessary in Lithuania in consideration of climate conditions, does not require high maintenance, system installation is fast, easy and simple, the system does not affect train traffic but helps in protecting the most sensitive parts of a switch from snow, especially during a snow storm. As the brush system is used, the switch blades are not blown out or blown out less and the electric switch heating becomes more efficient due to the fact that the stock rail preserves the heat for a longer period.

The system of brush protection from snow in switches must be used as an auxiliary measure next to the electric switch heating in order to achieve a maximum switch protection during snowfall and snowstorm;

It is recommended using the system in switches that are in open territories, that are not protected from a snowstorm in other ways;

The system is especially necessary in places where side winds with respect to a railway are dominant.

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