sciendo

PRODUCTION ENGINEERING ARCHIVES 22 (2019) 11-15

PRODUCTION ENGINEERING ARCHIVES

ISSN 2353-5156 (print)
ISSN2353-7779 (online)

Exist since 4th quarter 2013
Available online at www.pea-journal.eu

An analysis of the causes of track twist at high speed of driving

Andrzej Pacana[1], Dominika Siwiec[2]

[1] Rzeszow University of Technology, The Faculty of Mechanical Engineering and Aeronautics al. Powstańców Warszawy 8, 35-959 Rzeszów, ORCID ID: 0000-0003-1121-6352, app@prz.edu.pl
[2] Rzeszow University of Technology, The Faculty of Mechanical Engineering and Aeronautics al. Powstańców Warszawy 8, 35-959 Rzeszów, ORCID ID: 0000-0002-6663-6621

Article history
Received 04.02.2019
Accepted 08.03.2019
Available online 15.04.2019

Keywords
track twist
operational tests
quality management techniques
railway logistics
mechanical engineering

Abstract
The research of railway track surfaces is aimed at improving the quality of railway infrastructure and providing the chance of improving the safety of driving. Therefore, it is advisable to constantly monitor track surface, but the research itself is not innovative because it is based on a known procedure. The crucial element are the techniques that allow to delve into the sources of problems. The aim of the article is to use the selected instruments of quality management to analyze the causes of track twist at high (180 km/h) speed of driving. The analysis of the causes of track twist was done on the basis of results from the measurement of one kilometer track section of the Krakow Glowny - Medyka route, which was made by using the TEC measuring device in April 2018. It was inferred that it is impossible to reach 180 km/h without track twist. In order to identify the causes of track twist it was proposed to use the selected sequence of quality management instruments, i.e.: brainstorming, Ishikawa diagram and the 5Why method. The identified causes of track twist include the abrasion of rail, scratches and exploitation point. The analysis and conclusions drawn from it may be useful in the analysis of other problems in railway transport as well as production and service industries.

DOI: 10.30657/pea.2019.22.03 JEL: L23, M11

1. Introduction

The accomplishment of correct diagnostics of a railway vehicle track is sometimes a big problem due to changes in steel grades from which rails and wheelsets are produced, as well as due to the speed and power of vehicles and the process of improving their construction. One of the conditions to maintain the surface of track is the track twist, i.e. the ratio of the difference between the height of rail tracks in two adjacent cross-sections to the distance between these cross-section (Bałuch et al., 2015; Horodecka et al., 2017; Nowakowski, 2007). The unit of track twist is millimeters [mm] or promiles [‰]. Track twist can be caused by geometric factors, which can occur on its trajectory, i.e. inclinations of the incline ramp, which is on the curve of the track with a cant amounting maximally 2‰. The track twist can also be caused by unevenness in height that occurs in the mutual arrangement of rails, where the maximum deviation of the highest point, which is found on one of the rails from the plane designated by the next three points equals 15 mm (Sobaś, 2017). The basis tool, which is used for assessment of the condition of track surface, are the geometrical measurements of the track. The geometric measurement of the track can be made by using a measuring device. In practice, this device does not identify the causes of track incompatibility, so it is necessary to perform visual analysis of the area on the track on which the fault was described and then to use additional tools to identify the causes of this incompatibility.

In the article the results of the performed geometric measurement of the track of one kilometer section of the route from Krakow Glowny to Medyka was analyzed. The measurement was made in order to check the condition of the track and to analyze whether the track twist will be identified at the speed of 180 km/h. After the analysis, it was inferred that there occurred track twist at the speed of 180 km/h. It was proposed to conduct the analysis of the causes the track twist by using the Ishikawa diagram and the 5Why method, because these tools are pertinent tools to identify the causes of the problem. In the empirical part the measuring device and the method of measurement were analyzed. The Ishikawa diagram was drawn so as to identify the main causes of track twist i.e. abrasion of rail and headchecks. Then the causes of track twist were analyzed by using the 5Why method, by means of which it was inferred that the source cause of track twist was the located operating point.

2. Experimental

The analysis of the causes of track twist was done on the basis of the results from the measurement of a selected track section on the Krakow Glowny – Medyka route, made in April 2018. The measurement was done by using the measuring device the aim of which was to check the condition of the track surface and to check if it is possible to achieve higher speeds (180 km/h) on the selected track section, without creating a track twist. The length of the selected track section which was analyzed was 1,1270 km, where the initial point where the measurement started was at the 128,627 kilometer of the route, and the end point where the measurement was completed was the 127,421 kilometre of the route. The step of the measurement equaled 0,50 meter, which allowed to collect more measurements and acquire more accurate results.

The measurement of the track was made on the measuring device TEC-1535 N3 (fig. 1).

Fig. 1. The measuring device TEC-1535 N3. Own study

During the measurement the measuring device TEC-1535 N3 was based on a three-point construction and an extended driving system, which allowed for stabilization of the device and increased the accuracy of the measurement. The device had a locking mechanism for the expansion rollers; thanks to this they did not fall out from the track on the railroad switch. The measuring elements of this device included the inductive sensor of linear displacements, which allowed for the measurement of width and inequalities of track. The analysis of driving was displayed on the device screen and all the results from measurement were saved on the internal device memory, which allowed to archive the results and to provide further analysis.

The methodology of track measurement was developed according to the instruction for device TEC-1435 N3. After setting the device in the initial section, where the measurement was initiated (128, 627 km), the handrail G-clamp was relinquished. After lifting the bracket, the screw clamps on the support wheels were removed; then the beams of the device were put on and the screw clamps were screwed in. The device recorder was positioned and the longitudinal beam of the device was pushed away from the rail course. Then the device was separated from the longitudinal side of the measuring beam on the track. The device was started, after which the superelevations were reset and the measurement was started along with recording of the measurement to the internal memory of the device.

During the measurement and analysis of the results the values of admissible deviations for the track twist of the track position were taken into account, thanks to which it is possible to provide a quiet train travel (fig. 2).

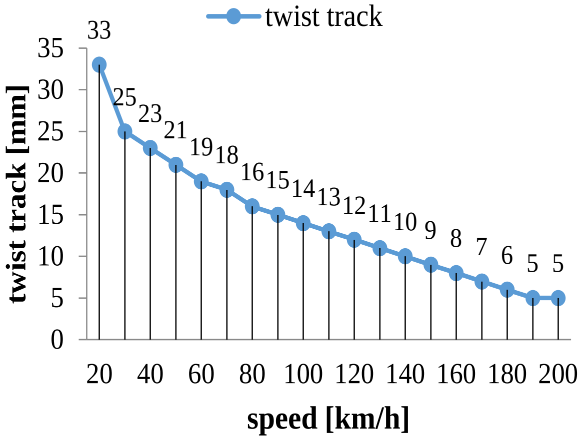

Fig. 2. The values of admissible deviations for the track twist in relation to the speed of the rail vehicle. Own study based on the instruction, 2005.

During the analysis of the track twist according to the norm PN-EN 13848-5:2017-10 it was assumed that the value of admissible deviations for the track twist is 6 mm by the speed of 160 km/h <V≤200 km/h) (Horodecka et al., 2017; PN-EN 13848-5:2017-10).

The Ishikawa diagram and the 5Why method were used to analyze the causes of track twist at the speed of 180 km/h. The analysis was done by using these instruments because their aim is to identify the causes of problem. In order to identify the potential causes of the problem the Ishikawa diagram was used. The other name of this diagram is the fish bone diagram. The factors which were included during the analysis of the problem were: man, method, material, machine, management and environment, or the principle of 5M+E (Harmol, 2017; Pacana 2010; Pacana et al., 2018). For each factor the potential causes of track twist were described, and then the main causes were selected from among them. At the same time, in order to identify the source cause of the track twist the 5Why method was used. For each cause, the question "why" was asked until the source cause of the track twist was identified (Sęp et al., 2006).

3. Results and discussion

After analyzing the results from the geometric measurement of the track in the case of achieving the possible speed of 180 km/h the track twist was identified (fig. 3). Three values occurred that were not within the tolerance limit of the admissible deviation of track twist. The first value, which was not within the upper tolerance limit (UTL) amounted 6,25 mm and it occurred on the measuring section at the point of 127,5120 km. The second and third value, which was not within the lower tolerance limit (LTL) of the admissible deviation of track twist amounted respectively -6,05 mm and – 6,09 mm and they occurred on the measuring section of, respectively 127,6240 km and 127,5900 km.

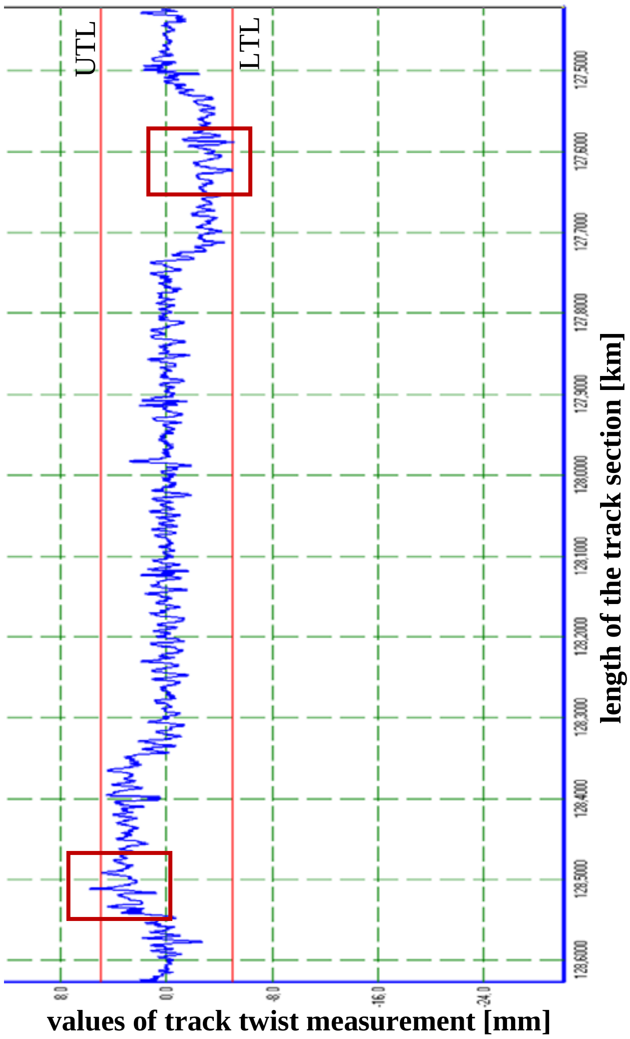

Fig. 3. An example of a chart for twisted track at a rail vehicle speed of 180 km/h for the total measurement performed on a 1,1270 km section. Own study

The first of the track (from 128,5470 km to 128,3400 km) was characterized by the values of track twist significantly close to the upper tolerance limit of the admissible deviation of track twist (6 mm). While the second section of the track (from 127,7130 km to 127,5350 km) was characterized by the values of track twist significantly close to the lower tolerance limit of the admissible deviation of track twist (-6 mm). It was concluded that in the case of achieving the possible speed of 180 km/h on the section track which was analyzed, the track twist occurred and it could be problem in the view of safety and the comfort of driving a rail vehicle. In order to identify the potential causes of the problem (the track twist) the Ishikawa diagram was drawn up (fig. 4).

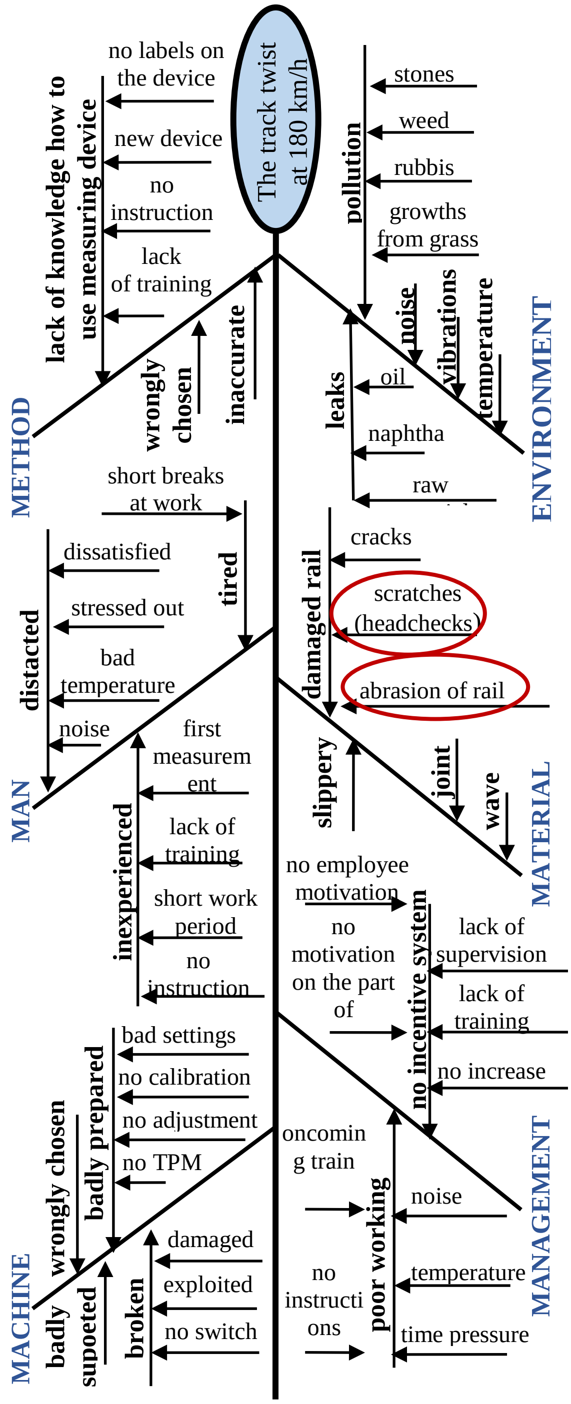

Fig. 4. An example of Ishikawa diagram for the analyzed problem. Own study

After analyzing the problem (the track twist at the speed of 180 km/h occurred) by using the Ishikawa diagram it was concluded that the main causes of the problem are scratches (the so-called headchecks) and abrasion of rail. These inconsistencies occurred locally on the rolling surface and both side surfaces of the head of the rails (Guide, 2017). The scratches, or headchecks, developed mainly in the arches with radius of 600 – 1000 m. The abrasion of rail appeared as local wipe-down of rails, which resulted from start of heavy trains. These faults occurred at the depths ranging from a fraction to a few millimeters from the surface of the rail (Bałuch, 2009; Grulkowski, 2014; Stencel, 2016). In order to identify the source cause of the problem (the track twist) the 5Why method was applied (fig. 5).

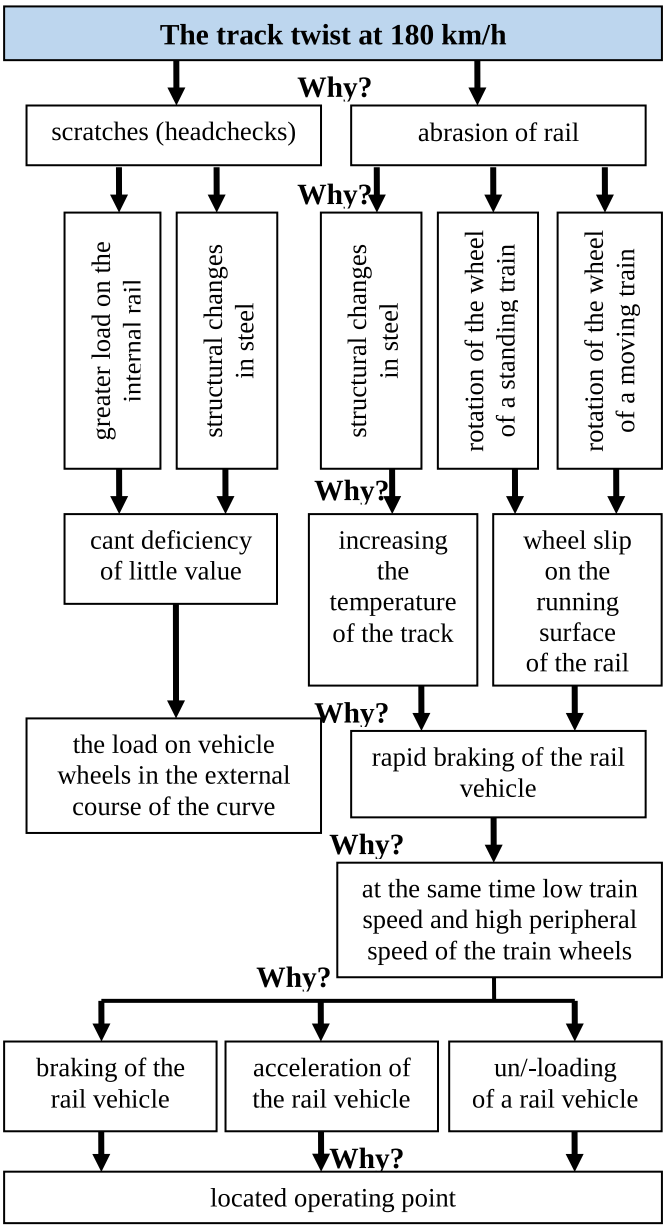

Fig. 5. An example of 5Why diagram for the analyzed problem. Own study

Analysis of the problem of track twist at possible speed of 180 km/h of a rail vehicle using the 5Why method allowed to identify the source cause of the problem which was a located operating point, i.e. railway station or level crossing.

4. Summary and conclusion

The use of the TEC measuring device allowed to analyze the condition of the course surface of track on a selected section of the route of Krakow Glowny – Medyka, and allowed to analyze the causes of occurrence of track twist at 180 km/h. Three values were identified that were not within the tolerance limits of admissible deviations for the track twist, as they were equal to ~ 6 mm. Therefore, it was concluded that it is impossible to reach 180 km/h without track twisting. The applied sequence of the selected quality management instruments allowed to identify the reasons for the track twist at the speed of 180 km/h, which were abrasion of rail**,** scratches and the exploitation point (railway station or rail-road crossing). The analysis and conclusions drawn from it may be useful in the analysis of other problems related to track surface, as well as to solve quality problems in other industrial and service areas.

Reference

Bałuch, H., 2009. *Derailments of train connecting with track condition and methods of their investigations*. XXIV Scientific and Technical Conference, construction failures, 26-29 May, Szczecin-Międzyzdroje, 29-44.

Bałuch, H., Bałuch, J., 2015. *Working time of broken rails*. Notebook Scientific and Technical SITK RP, Krakow, 2(106), 7-16.

Grulkowski, S., Kędra, Z., 2014. *Diagnostic problems of railway rails in tracks and crossovers.* Marine Engineer and Geotechnics, 5, 497-504.

Guide, 2017. *Guide for railway commissions, tracks, turnouts and crossroads.* Warsaw.

Harmol, A., 2017. *Management and quality engineering.* PWN, Warszawa.

Horodecka, A., Wolniak, R., 2017. *Tool for valuing non-conformities in an industrial enterprise.* Quality problems, 1, 13-21.

Instruction, 2005. *Instructions on making measurements, tests and assessing the condition of tracks,* Warszawa., https://www.plksa.pl/files/public/user_upload/pdf/Akty_prawne_i_przepisy/Instrukcje/Podglad/Id-14.pdf [access, 18.10.18r.]

Nowakowski, M.J., 2007. *Computer aided planning of current repairs on the railway surface.* Doctoral dissertation, University of Technology, Gdańsk.

Pacana, A., 2010. *Analysis of the implementation of 5S practices using brainstorming and Ishikawa diagram.* Organization Overview, 6, 11-14.

Pacana, A., Siwiec, D., 2018. *An Analysis of Factors Affecting the Choice of Medicines.* Humanities and Social Sciences, HSS, XXIII, 25 (2/2018), 183-194 , DOI: 10.7862/rz.2018.hss.28.

PN-EN 13848-5:2017-10. Railways. Track. Geometric quality of the track. Part 5: Levels of geometric quality. Trail.

Sęp, J., Perłowski, R., Pacana, A., 2006. *Techniques of quality management support.* Rzeszow University of Technology Publishing House, Rzeszow.

Sobaś, M., 2017. *Safety aspects of driving freight wagons on 1XTa bogeys with leaf springs when travelling in quasi-static conditions on warped track.* Rail Vehicles, 4, 45-56.

Stencel, G., 2016. *Evaluation of Running Surface of Rails by Measuring Corrugation.* Railway Problems – Notebook, 170, March, 87-93.

Wolniak, R., Skotnicka, B., 2008. *Quality management methods and tools. Theory and practice.* Scientific Publisher of the Silesian University of Technology, Gliwice.

高速行駛時軌道扭曲原因分析

關鍵詞
跟踪扭曲
運行測試
質量管理技術
鐵路物流
機械工業

摘要
鐵路軌道表面的研究旨在提高鐵路基礎設施的質量，並提供提高駕駛安全性的機會。因此，建議不斷監測軌道表面，但研究本身並不具有創新性，因為它基於已知的程序。關鍵因素是能夠深入研究問題根源的技術。本文的目的是使用選定的質量管理工具來分析高（180 公里/小時）行駛速度下的軌道扭曲的原因。軌道扭曲原因的分析是根據克拉科夫 Glowny-Medyka 路線的一公里軌道段的測量結果完成的，該路線是在 2018 年 4 月使用 TEC 測量裝置製作的。據推測它是沒有軌道扭曲，不可能達到 180 公里/小時。為了找出軌道扭曲的原因，建議使用所選擇的質量管理儀器序列，即：頭腦風暴，石川圖和 5Why 方法。軌道扭曲的確定原因包括軌道磨損，划痕和開採點。從中得出的分析和結論可能有助於分析鐵路運輸以及生產和服務業的其他問題。