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Analysis of the occurrence of headchecks in rails

Abstract: The article concerns the problems of the headcheck defects occurring in the outer rail on curves. Basic features of these defects are presented, as well as detection and diagnosis methods. Based on the measurements made by the author, conclusions regarding the possible causes of defects have been formulated.

Keywords: Defects in railway rails; Headcheck

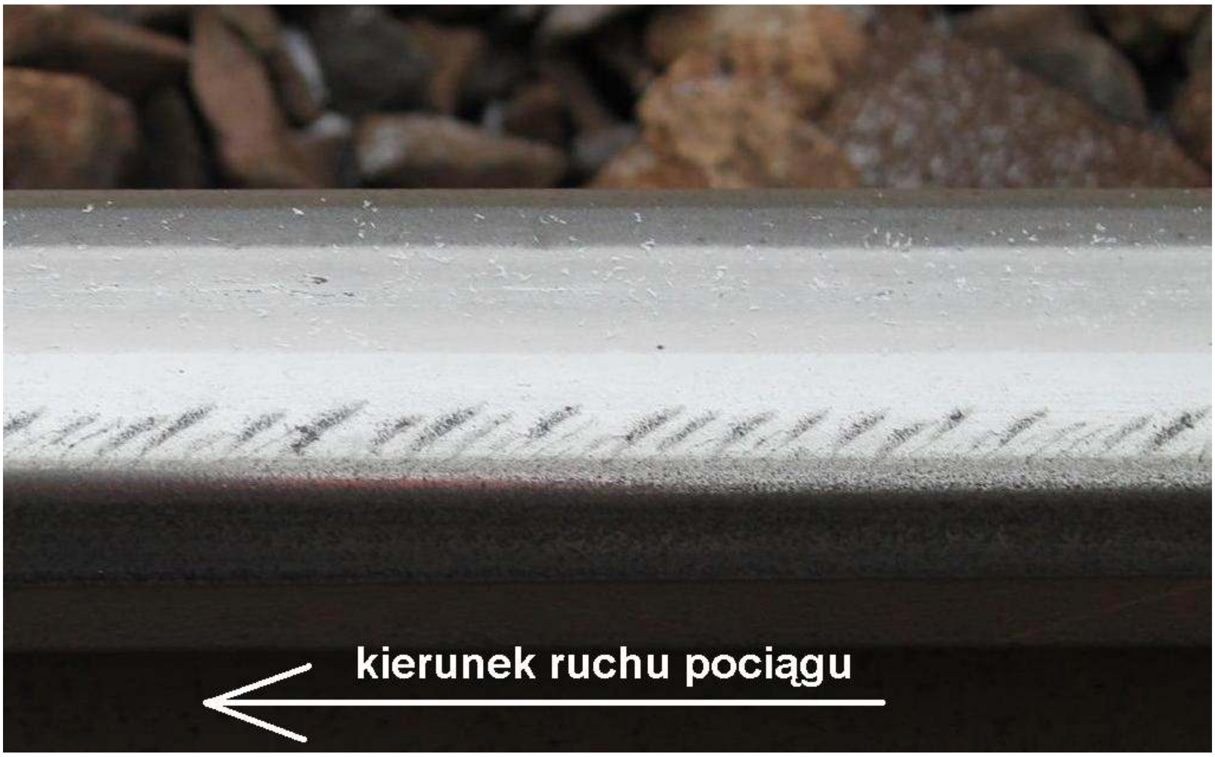
Introduction

Headcheck defects (also known as scratches) are a well-known phenomenon occurring in railroad track rails, but due to the many difficulties that their diagnosis gives them, as well as the variability of the factors that cause them, until now has not fully described the genesis that would facilitate the prevention of their occurrence.

The article presents the characteristics of this type of defects enriched with measurements made by the Author on the Polish railway network. The first conclusions from these measurements and observations are also presented.

Basic features of headcheck defects

Headache defects, in addition to curbs and squat defects, are currently the most frequent contact-fatigue defects on the running surface of the rails [1, 2]. It is assumed that headcheck defects occur on arcs with a radius below 1500 m, however, the smaller the radius of the arc, the more serious the problems with these defects [2].



1. An example of a headcheck defect

In the catalogue of rail defects, the head checking phenomenon is described as slots or scales on the inner edge of the head (outer rails) and marked with the symbol 2223. According to the catalogue, 3 forms of headcheck defects are accepted:

- Homogeneous and regular headcheck (Figure **1**);
- Headcheck with scales;
- Headcheck looking like long cracks ending on the surface.

It has been observed that the crack occurs at an angle of 20-25 ° into the rail. Figure **1** shows a picture of defects on the rail, which carried about 150 Tg of the gross load over a period of 13 years. Under current operating conditions, this load intensity is typical of the so-called medium-loaded lines. The size (depth) of defects in this section was approx. 2 mm, which meant the need for intervention by profiling the rails.

However, the rate of defect growth varies. Observations made on railway lines in Poland show that one of the basic operational factors affecting the rate of development of headcheck defects is driving two-way traffic. In "medium loaded" tracks, where two-way traffic was carried out even for a few weeks, there are headcheck defects, which should be removed (over 1.5 mm) after only 3 years of operation.

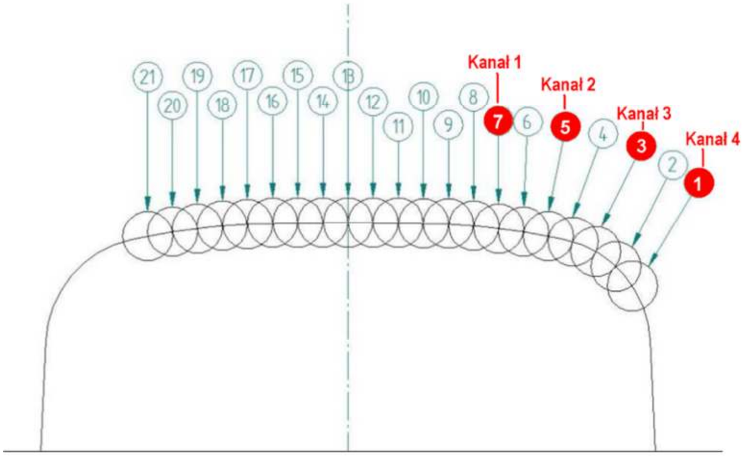
In order to prevent defects, when profiling rails on curves, it is desired to obtain profiles whose shape allows to limit the contact of the wheel flange with that surface of the rail edge where defects develop, and also apply grinding strategies that most often predict rail profiling from the beginning operation [3, 4, 6].

Detection methods for headchecks

The basic method of detection is observation. Although there is no relationship between the length of cracks and their depth, the experienced eye of an experienced diagnostician is able to estimate the depth of defects with accuracy to a few tenths of a millimeter.

In the case of deeper defects (few millimeters) scratches are also detected by ultrasound heads [1, 5], however, the detection of defects of only such a size is characterized by a small diagnostic value. The other techniques used to measure the running surface of the rails turned out to be of little use in this area [7]. Therefore, the dominant method in the detection of headchecks is the eddy current method [8].

The Railway Institute conducts research on headcheck defects with the GF04 eddy current device. The device allows continuous measurement of headcheck defects with the determination of their number (per 1 linear meter) and depth (mm). Four probes (with adjustable settings) - devices operating on the basis of eddy current - scan the surface of the tested rail. The probe settings that are most commonly used are shown in Figure **2**.



2. Probe setting when measured with GF04

The first probe is placed in station 7, the second in station 5, the third in station 3, and the fourth in station 1.

The measurement results are displayed continuously on the machine's computer. The measured data is presented in real-time on the graph as a function of the road. During measurements, the operator can sign specific areas in the measurement results using markers.

Defects in the graph are marked in different colours depending on their depth. The meaning of colours is as follows:

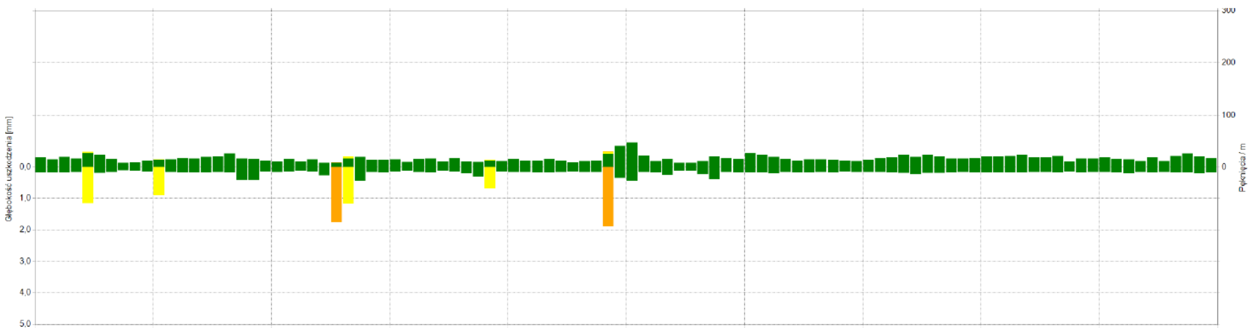
- green - 0 ÷ 0.5 mm depth,
- yellow - 0.5 ÷ 1.5 mm depth,
- orange - 1.5 ÷ 2.7 mm depth,
- red - 2.7 to 5 mm deepth,
- brown - depth over 5 mm.

Due to the limitations of the method, measurements of defects with a depth of more than 3 mm are subject to a large error. Therefore, it is often not analyzed in detail of this type of defect, only specifying that these are defects with a depth of more than 3 mm.

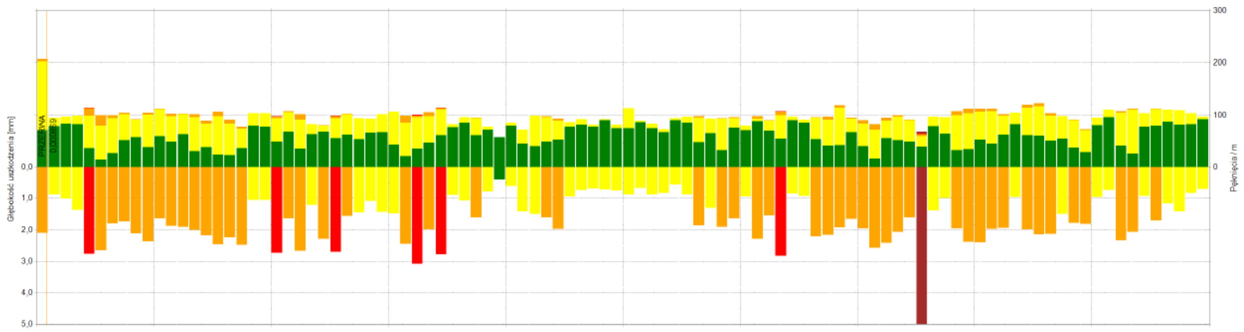
3. Eddy current device GF04

Examples of measurements made on sections of headcheck defects

Figures **4** and **5** present the results of measurements made on track sections, where 3 years earlier rails (60E1 R350HT) have been replaced in external ones. The sections are located on neighbouring tracks, so the traffic structure is similar, while on section 2 the load is about 30% bigger. Each of the graphs shows the occurrence of headcheck defects over a 100 m section. Bar charts over the X-axis represent the number of registered defects of a certain size (defined in colour) in individual meters of the segment, while diagrams under the axis inform about the maximum depth of the defect in a given rail meter.



4. Headcheck defects in section 1 (R~800 m, 30 Tg)

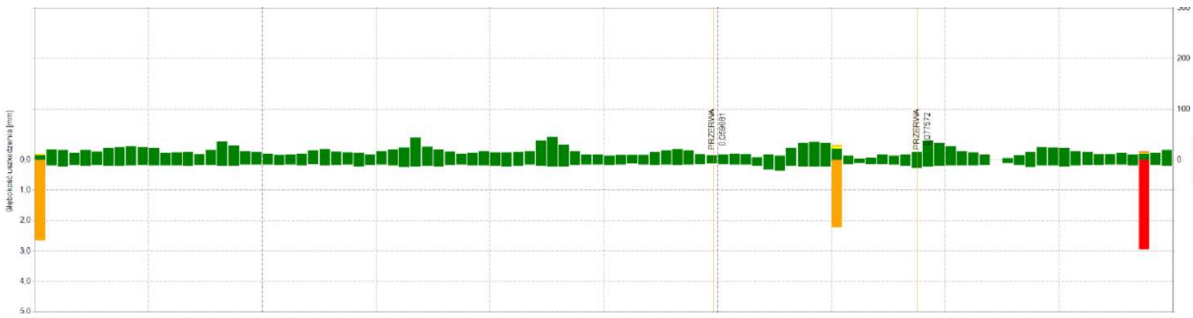


5. Headcheck defects in section 2 (R~800 m, 40 Tg)

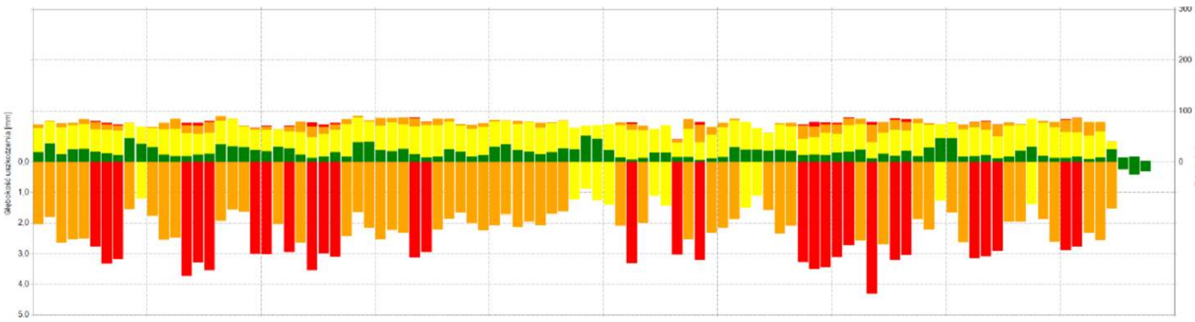
The graphs clearly show the differences in the development of defects in very similar operating conditions. On section 1 there are only a few cracks per 1 meter, and their depth in the predominant majority does not exceed 0.5 mm. Meanwhile, in the neighbouring track, almost 100 defects have been registered in almost every meter of the rails, of which almost half reach about 1 mm deep into the rail. The maximum depth of defects in particular meters of the rail reaches 3 mm, so the condition of the rail tends to carry out profiling in the repair mode.

In the graphs from sections 3 and 4 one can also observe a large difference in the development of defects on rails with a similar operational load. However, these are sections from different lines, so in this case the traffic structure is different. The cases of sections 1-2 and 3-4 are connected by the fact that on the sections where the defect development is much larger, two-way traffic was conducted.

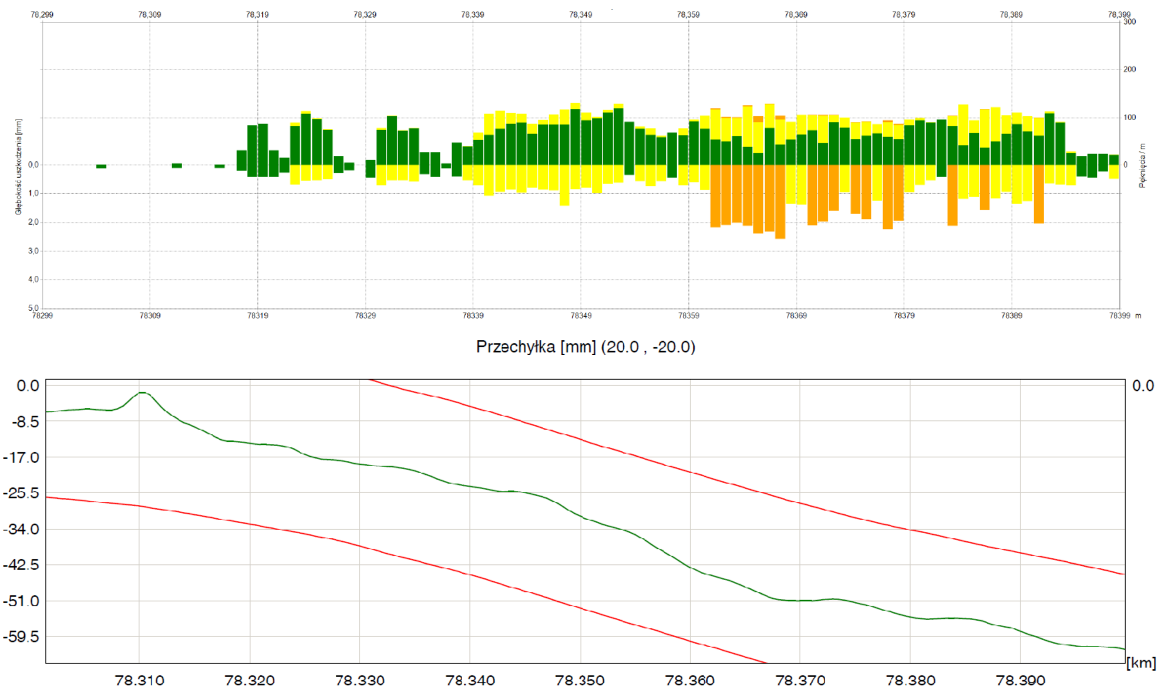
In the graphs from sections 3 and 4 it is also clearly visible that the occurrence of cracks is of wave nature, i.e. every 10 meters, both the number of defects and their size is noticeably greater. As you can see, this phenomenon occurs in every stage of defect development.



6. Headcheck defects in section 3 (R~500 m, 40 Tg)



7. Headcheck defects in section 4 (R~600 m, 45 Tg)



8. Headcheck defects in section 5 (curve transition to the arc R~800 m, 150 Tg)

Figure **8** shows the results of measurements of headcheck defects and the results of cant measurements on the section of the transition curve with the superelevation ramp, which connect the straight line to the arch with a radius of 800 m with a cant of 80 mm. The development of defects can be noticed already after a few meters from the beginning of the transition curve, which means that in the case of profiling on sections of tracks located in the arch, the necessity to perform works also on rails located on the sections of the track in the transition curves should always be taken into account.

Summary

The research indicates that the development of headcheck defects does not depend solely on structural and geometrical factors, but to a large extent on operational factors. As a result, the sections which are similar in terms of the radius of the arc, the rail type, the structure of the traffic and the size of the transports develop defects at a completely different pace.

Despite the increasing availability of eddy current devices, in the diagnosis of headaches, it is still necessary to rely largely on the observations and knowledge of people who deal with maintaining the railway surface on a daily basis.

Source materials

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