Marcin Kowalski
dr inż.
P.U.T. Graw sp. z o.o.
kowalski@graw.com

DOI: 10.35117/A_ENG_16_12_02

TEP Rail Head Profile Trolley - test results of the laser measurement system

Abstract: The article describes the results of research and development undertaken to develop a compact, optical measurement system for measuring the elements of track infrastructure. The article describes the main features of the optical measurement systems and the results of the research project. The author presents two examples of the implementation of this technology in the portable diagnostic devices: electronic trolley and in the toll for the creation of 3D models of turnout crossings.

Keywords: Electronic trolley; Laser measurement of rail head; Measurement optics

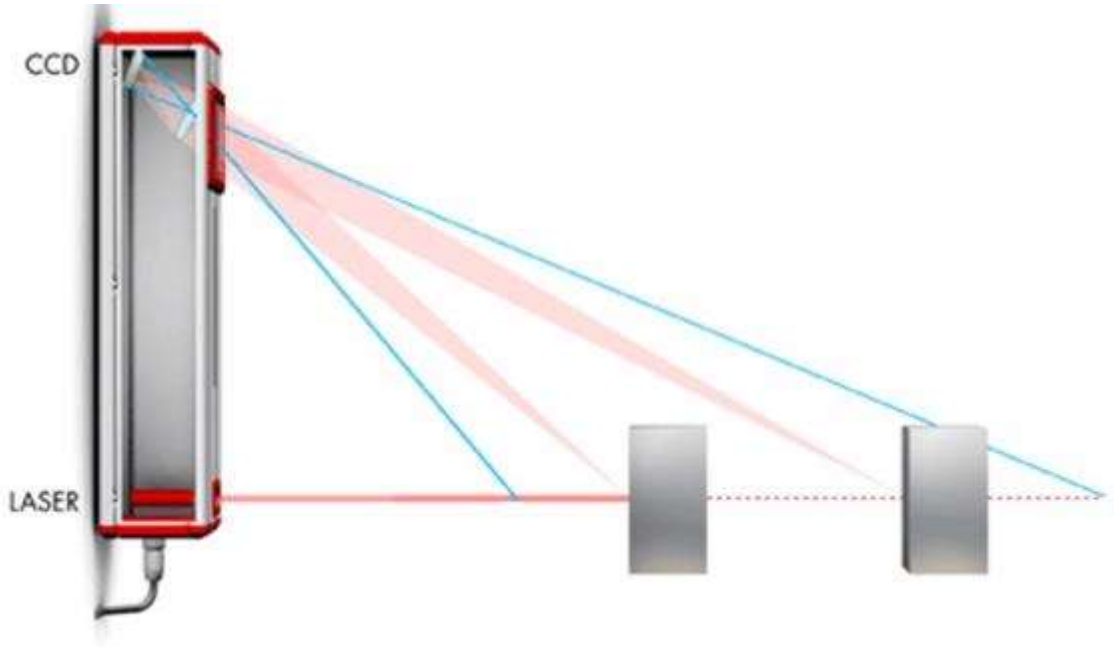
Introduction

In diagnostic studies of track status it is necessary to evaluate not only basic parameters such as the geometry of the track cant with width and inequality of track course but also to control the size of the fuel rail head. The control of the size usage of the rail head can be carried out manually using templates or profile touch or laser measurers (Figure 1).

1. Profile measurement tool XY produced by GRAW

Manual measurement methods allow checking the amount of wear in any chosen by diagnostician the cross-section of rail. It is quite natural that it is demanding to replace such

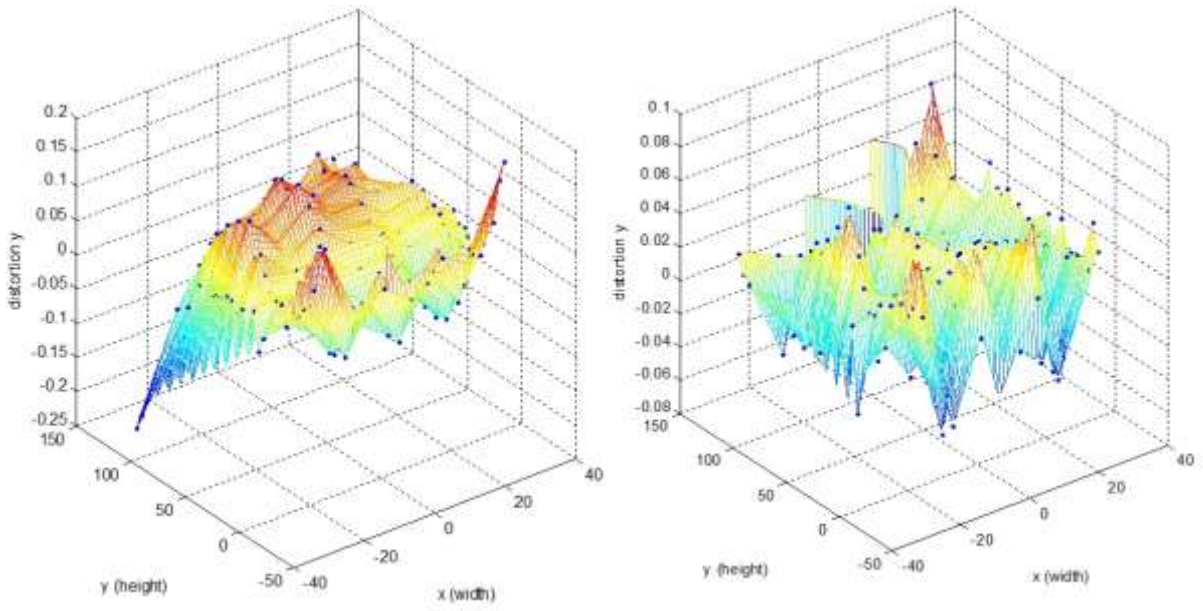
point information, by continuous measurements with the possibility to present the results of analyses in the form of charts, tables and ratings for selected sections of the track similarly for the basic parameters of the track state. The continuous measure the wear of the rail head can be done with the use of laser measurement systems installed on vehicles. Such systems are usually optional equipment in modern measurement vehicles. The diagnosis of the basic geometric parameters of the track can be also widely carried out by auto-registered track trolleys TEC produced by GRAW. They enable continuous measurements of the track which fills the gap between hand-held, point-measurements and measurements performed by simple trolleys. Technical progress in the field of image processing techniques and increasing range of small-sized components make possible to use them for the construction of 2D laser systems (Figure 2).



2. Visualization of profile laser head

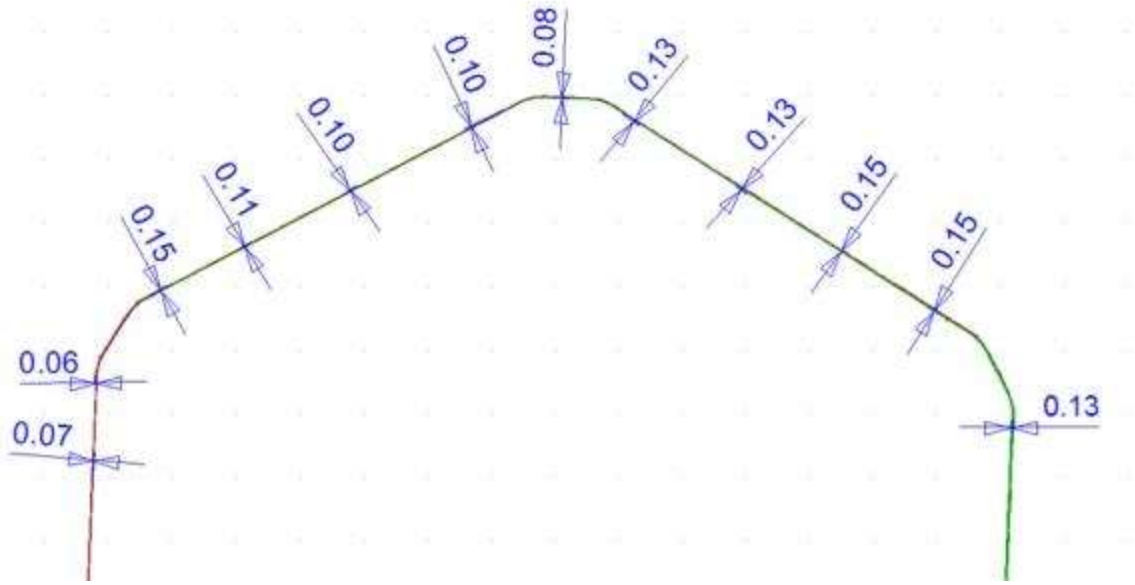
Results

The state of technique allowed to start in GRAW sp. O.o. a research and development work on the construction of the 2D head specialized to measuring the rail head profile. Financial resources for the realization of this work were obtained from the Fund Innovative Economy. In the initial stages of the project were chosen low-cost components with low power consumption and researches were carried out on their metrological and exploitation properties. A very important part of the work was the elaboration of calibration procedures for the 2D heads. This significantly improved the catalogue performance of low-cost components used to build heads. The sample results of their linearization are shown in Figure 3.



3. The example of error distribution for reconstruction of profile in the working space of camera before (right) and after (left) linearization of measuring head

Correctness of operation of the complete measure heads is checked for patterns with the known shape and dimensions by comparing the profile measured by 2D head with the master profile (Figure 4).



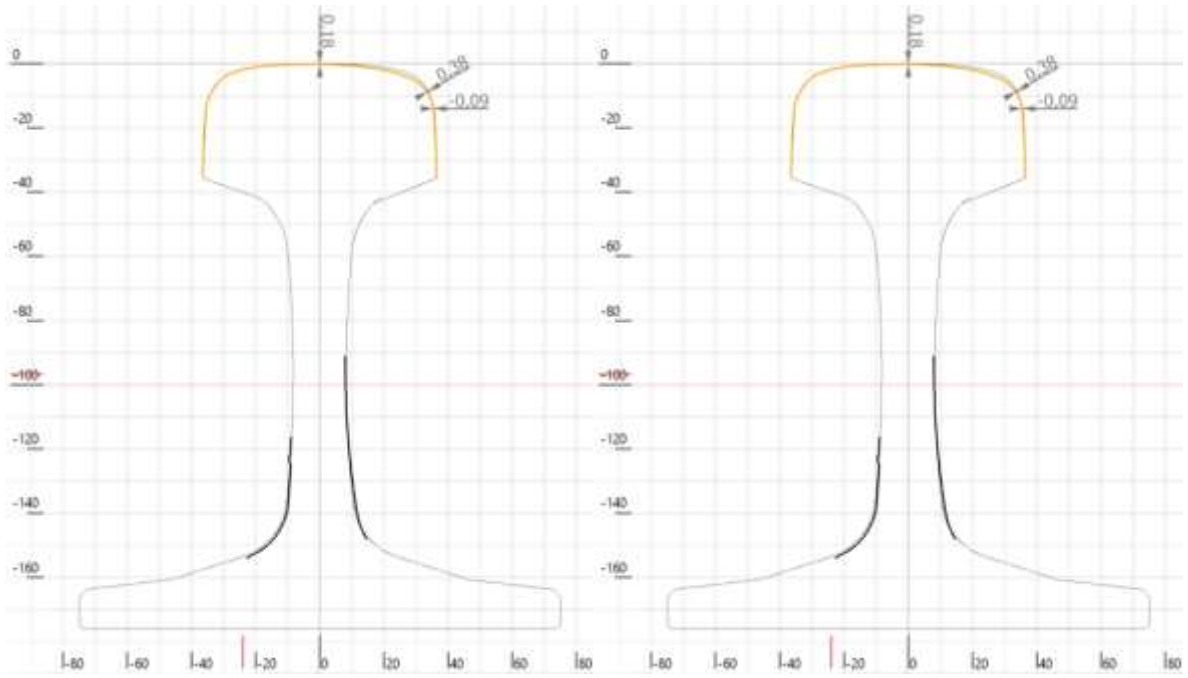
4. Results of comparing the measured profile with a certified standard measurement. The reproducibility of the measured profile was < 0.10 mm, the reproducibility of 10 measurements was < 0.15 mm

The 2D heads developed in the project are offered as profile additions to trolleys TEC in a single-head -TEP2.1 and two-head TEP2.2 versions, which allows simultaneous measurement of the rail head profile on both rail tracks (Figure 5).

5. Profile trolley TEP2.2 (production version)

The functionality of the TEP trolleys desktop is analogous to a typical functionality of TEC trolleys (Figure 6), so in the time of profile measurements are recorded geometric parameters of the track. Therefore, the diagnostician has a possibility to record in the file noticed failures of the track. Simultaneously, the measured transverse profiles of the rail head are recorded in the same file (figure 7). The software supplied with the trolley TEP enables the presentation of the measured values of wearing the rail head in the form of graphs in a manner analogous to charts for geometric parameters of the track.

6. Control panel of TEP2.2 trolley



7. The example of measurements of wearing rail profile: in the left is the distribution of wear on the running surface before polishing; in the right is the measure of basic wearing values of rail head.

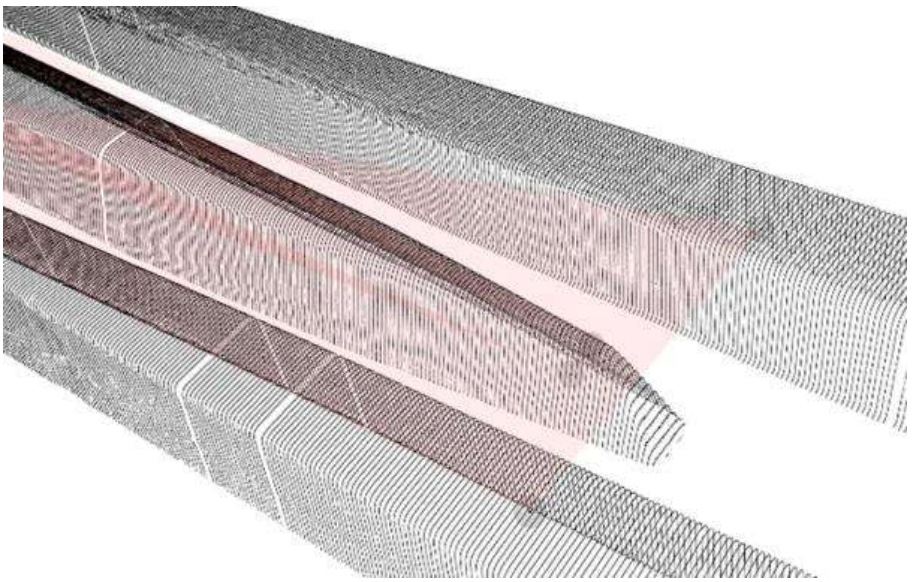
The TEP trolley can also be used for measuring of wearing needle of crossovers. For this purpose, a special software and library listing the number of parameters, e.g. the reduction of the needle relative to the stock rail in the whole area of adhesion, were developed.

In the frame of stress tests were also conducted studies on the application of 2D heads for the evaluation of wear of frog turnouts. The typical approach assumes to assess the wear of the beak of crossing in the relation to the rail wing. The comparison and evaluation of the shape of the beak is made in such cases using hand profile measures (Figure 1) and mechanical rulers. Such an assessment, carried out in the field, has a lot of flaws, and does not guarantee high accuracy during both the assessment of the frog condition and the acceptance of repaired works.

In order to eliminate the above problems, it is proposed placing the 2D head on an independent frame (Figure 8). In this solution, the measuring head moves over the measured object along a straight track, which is a reference line for assessing the longitudinal shape of the frog beak.

8. Scorpion – a toll for 3D measurements

The fully calibrated device allows creating a full 3D model of the frog (Figure 9) with an accuracy of better than ± 0.1 mm, including the beak and wing rails to the length of 1.2 m and the measuring step with the length of 1 mm.

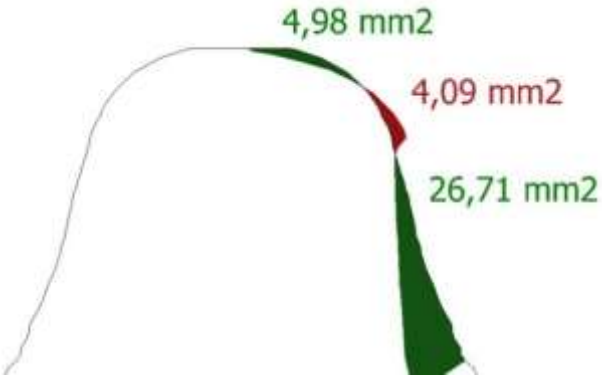


9. The example 3D model of frog crossover with the selected reference surface mounted on wing rails (red area)

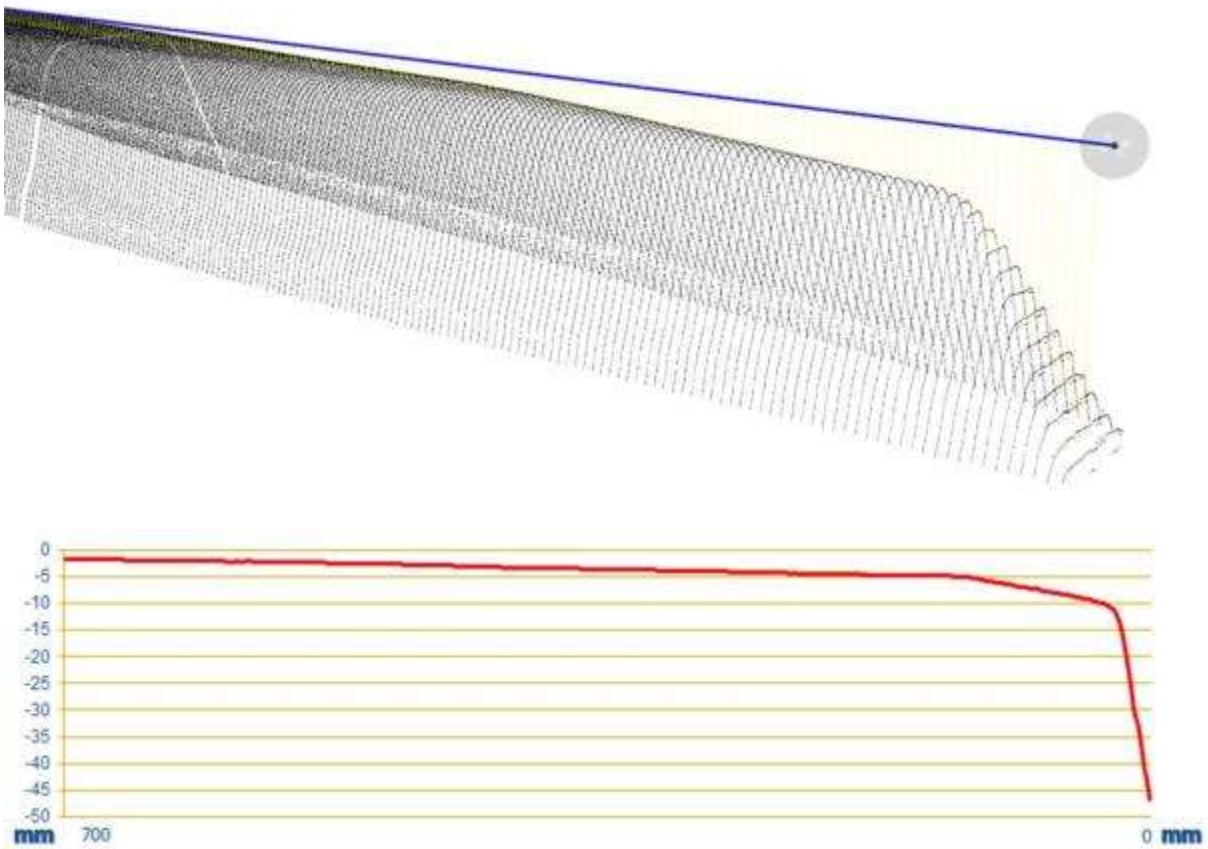
In order to improve the assessment of frogs, in the framework of development researches, collaboration with the branch of DB System Technique, conducting extensive research on the

life of the crossings turnout, was initiated. During the two years, sophisticated software was developed that automates among other things, the process of evaluating the consumption of frogs in time. Built-in functions allow additionally for: the overlapping each other 3D measurement of frogs made in different periods, generate arbitrary cross-sections with the analysis of wearing (Figure 10), and a precise evaluation of the longitudinal profile of the frog beak (Figure 11).

Great possibilities offered by the system caused that the current device Scorpio (Figure 8) is used to test the durability of frogs turnouts by PKP, DB and more recently also on the railways in Asia.



10. The comparison of the cross profile of the frog beak with the analysis of wearing



11. The example of evaluation of a longitudinal profile of frog beak (in the top is the 3D model of the frog with the selected direction of the evaluation, at the bottom is the profile of the frog beak along the defined direction of evaluation)

Summary

Studies conducted within the framework of the project has shown a great potential based 2D heads systems, as well as the limitations of this method. The main disadvantages include poor resistance in functioning of the system in bright sunlight. In order to minimize the negative impact of sunlight, one can use different methods, including various types of curtains, optical filters and algorithms, but the perfect solution does not exist. Therefore a very important stage project is evaluation the measurement environment and every adjustment of tools dedicated to it to increase the stability and quality of the results. The conducted tests showed also that it is possible to create a low-budget measuring heads with very high precision in measurements, but it requires the use of multi-step calibration process and the appropriate parameterized software responsible for the development of measuring profiles.