Computers in Railways VI

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Rail head and wheel profile geometry measurement

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Abstract

Fast and accurate measurement of the profiles of surfaces of rail head, switches, and wheels features an indispensable element of the technological process of their manufacturing and maintenance. Rails are the crucial elements of the track, so requirements regarding their mechanical properties and geometrical accuracy are very high. On the other hand, train wheels have to be checked on a regular basis to make it possible to determine when repair or replacement is needed, due to their excessive wear resulting in improper geometry. All presented results were obtained using the novel handheld gauges developed and field tested by the authors.

1 Introduction

The measurement process of wheel and track geometry is a tedious task, error prone, and requiring skilled staff to be done reliably in the field conditions (Bałuch[1], Królikowski[2]). Automatic portable devices with a programmable measurement zones, described in the paper, make it possible to take measurements of the transverse profiles of rail head and train wheels, and log the results for further detailed analysis using the dedicated computer software. Processing of data may be carried out in field conditions using a rugged industrial grade portable or handheld PC computers, or else later in the office environment where the latest measurement data may compared with previous readings to detect any eventual potentially dangerous trends (P.U.T. GRAW[3-5]). Some of the data collected are required by expert systems assisting track maintenance (Bałuch[6]).

The measurements may be carried out both by the rail and wheel manufacturers in the rolling mills and by the railways personnel inspecting the rails and cars in the track. The paper presents results of the thorough investigations of the track and sample units of the rolling stock operated on it. The results reveal specific details that may add to making the maintenance procedures more specific to the operation conditions investigated - Figure 1.

Rail head profile is a very sensitive feature of the rail - it keeps changing all the time during rolling, straightening, operation in the track, and during its repairs. Rail head shape features a decisive factor affecting the magnitude of contact stresses between the train wheels and the running surface of the rail (Adamiec[7], Bałuch[8]).

Laser rail head profile measurement gauge is indispensable in many distinct areas - all of them vital for the rail and track quality. According to current standards, customers - railways - must be allowed to verify the rail manufacturing process by the rail manufacturer (Feldman[9], Richter[10]). As one of the significant rail geometrical factors is the transverse section of the head, the railways' inspectors must have the necessary tools that will permit them to check correctness of the rail profile. The same holds true during commissioning of the rails - certain portion of the batch may be, and should be, carefully checked to confirm the product quality. Rail head profile, albeit a secondary factor when deciding repairs or other corrective measures, should be available to the railways' maintenance services. In certain cases - when third party service providers are called to do the job, e.g. during grinding of the track, it is desirable to be able to verify the quality of the work done (Świderski[11], Towpik[12]).

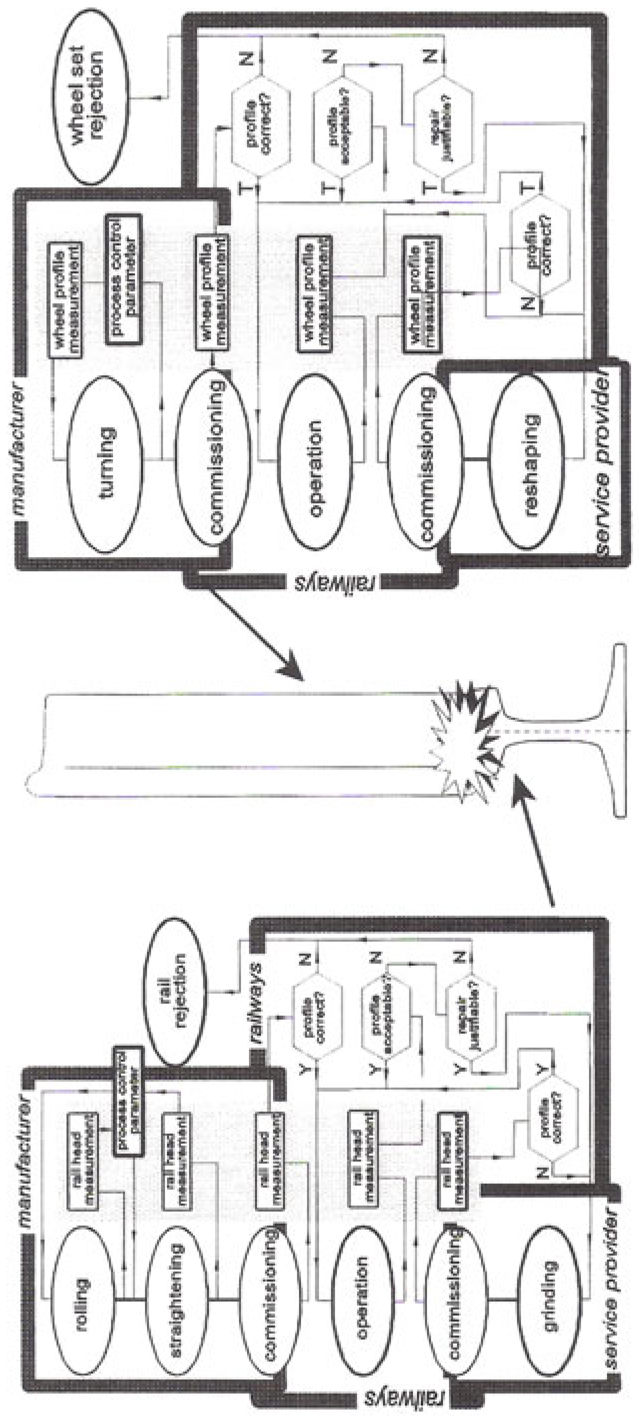

Figure 1: Manufacturing and maintenance related decisions requiring information about the rail head and wheel profiles

Profiles of the wheel sets of the rolling stock should be also regularly checked. It depends only on the specific needs if the user needs the full information about the wheel surface profile or only the values of its standardised geometrical parameters. Gauges to satisfy both these needs have been developed. All areas of application of the profile measurement gauges are presented in the scheme above along with some crucial considerations requiring reliable data depicting the rail head and wheel profiles.

2 Rail Head Profile Measuring Gauge

Complex rail head shape should be easily and precisely measured both on the manufacturer's shop floor and in the field conditions - on the track. It is essential from the economical- and safety of operation points of view that the decision of grinding the track is made based on sound technological assessment of the track condition after analysis of the results of measurements of rails' straightness and deterioration of the rail head shape. Thanks to the unique design principle, the accuracy of readings collected by the gauge is not affected by precision of the worker carrying out the measurement. In fact, real measurement of the rail head is carried out using a PC system into which all measurement data are downloaded. It is possible to store as much as 70 profiles in memory. Any gauge positioning errors are eliminated at this stage allowing user to take any measurements, perform zooming and annotating of the measured profile (Grabczyk[13], P.U.T GRAW[14]).

The gauge system consists of the mechanical measuring module, control and data logger module, and the proprietary software. The key element of the gauge is a laser measurement probe travelling around the rail head taking readings of its transverse profile - Figure 2. Whenever geometry of the rail head has to be measured in the track, the gauge is used with the additional measurement base positioning it properly in regard to the other rail of the track. The measurement sector may be freely defined according to the actual needs - its range may incorporate full head shape starting from its fishing surface.

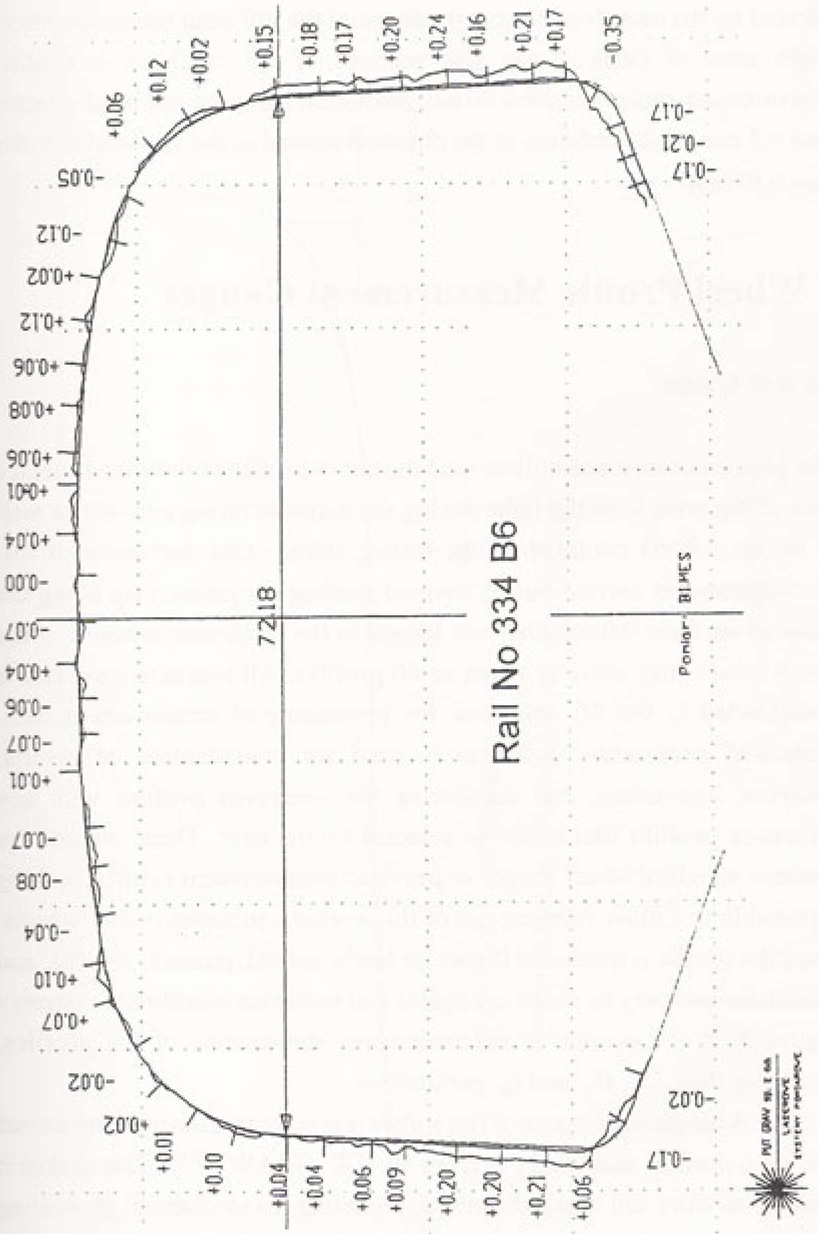

Figure 2: Example of the proper shape of the UIC 60 rail head with the error plot

Figure shows a new UIC60 rail nominal head profile, measured profile and labelled error plot with error values indicated at angular coordinates selected by the user. Note the proper shape of the rail head running surface, slight error of slope of the side surfaces of the rail head is visible. Measurement cycle was about 20 sec, resolution along the rail head is better than 0.5 mm, and resolution in the direction normal to the rail head is better than 0.05mm.

3 Wheel Profile Measurement Gauges

3.1 A-B Gauge

The device makes it possible to read the entire profile of the wheel surface both of the wheels on the lathe during the manufacturing process as well as of the wheels mounted on the rolling stock - cars and locomotives. Measurement is carried out by manual guiding the contact tip along the checked surface. All readings are logged in the electronic memory of the gauge which may store as much as 40 profiles. All measurement data is downloaded to the PC computer for processing of measurement data. Dedicated proprietary software is used for visualisation of results, analyses, annotating, and comparing the measured profiles with any reference profiles that might be selected by the user. These include for instance standard wheel shapes or previous measurement results, making it possible to follow wearing out of the working surfaces of the wheels. Once the profile is measured it may be freely zomed, panned, rotated, and measurements may be made in angular and cartesian coordinate systems - Figure 3. It is possible to determine any dimensions of the profiles, including their O_w, O_g, and q_R parameters.

A unique application of this software is juxtaposition of the measured rail head profiles and wheel profiles (P.U.T. GRAW [15,16]). This makes it possible to carry out detailed analyses regarding the mechanism of wearing out of the particular surfaces of the mating elements. Measurements may be made of particular profiles, their fragments or superimposed profiles.

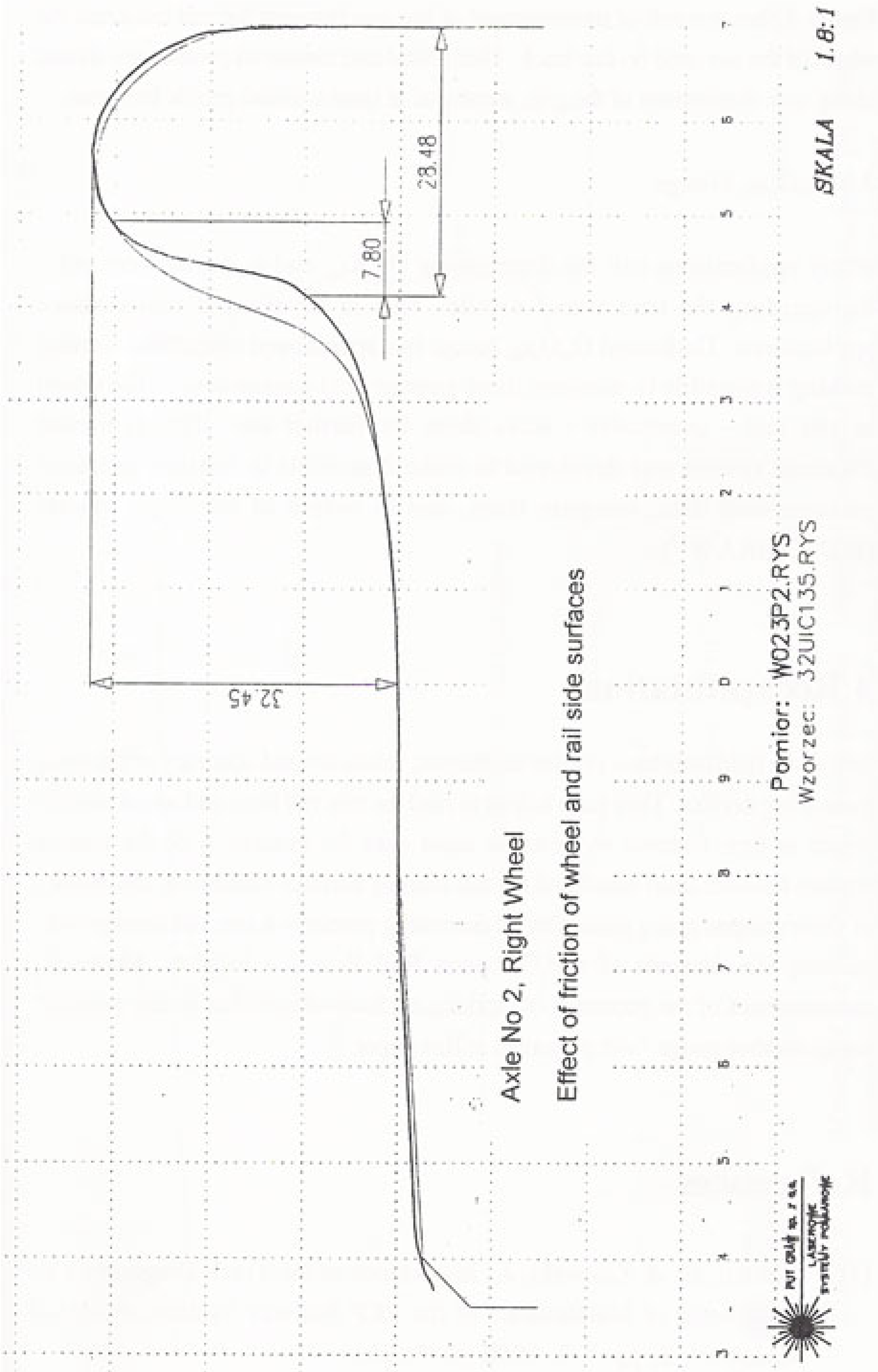

Figure 3: Worn out wheel running surface profile; dimensions were added in user selected locations

Figure 4 shows result of measurement of the gap between the rail head and the wheel of the car used on this track. Theoretical and measured profiles are shown along with dimensions of the gap, measured at used selected profile locations.

3.2 $O_wO_gq_R$ Gauge

Many applications call for determining O_w, O_g, and q_R parameters only, disregarding the true wheel profile. This is so in most maintenance applications. Dedicated $O_wO_gq_R$ gauge is a specialised electronic vernier making it possible to measure these geometrical parameters of the wheel in site and - eventually - store them for further use. The dedicated database system was developed to make it possible to retrieve previous measurement data, compare them, and to output of hardcopy reports (P.U.T. GRAW[17]).

4 Recapitulation

Extensive field tests have proven usefulness, reliability and accuracy of the novel measuring devices. They have helped to read the true rail head and wheel profiles which in turn featured an accurate input data for evaluation of the contact stresses between train wheel and the rail running surface. Measuring capabilities of these gauges, give a possibility of describing precisely a true rail head profile, meeting the demands of the European Rail Research Institute. Moreover, measurement of the geometry of working surfaces of switches is also possible using another gauge - not presented in this paper.

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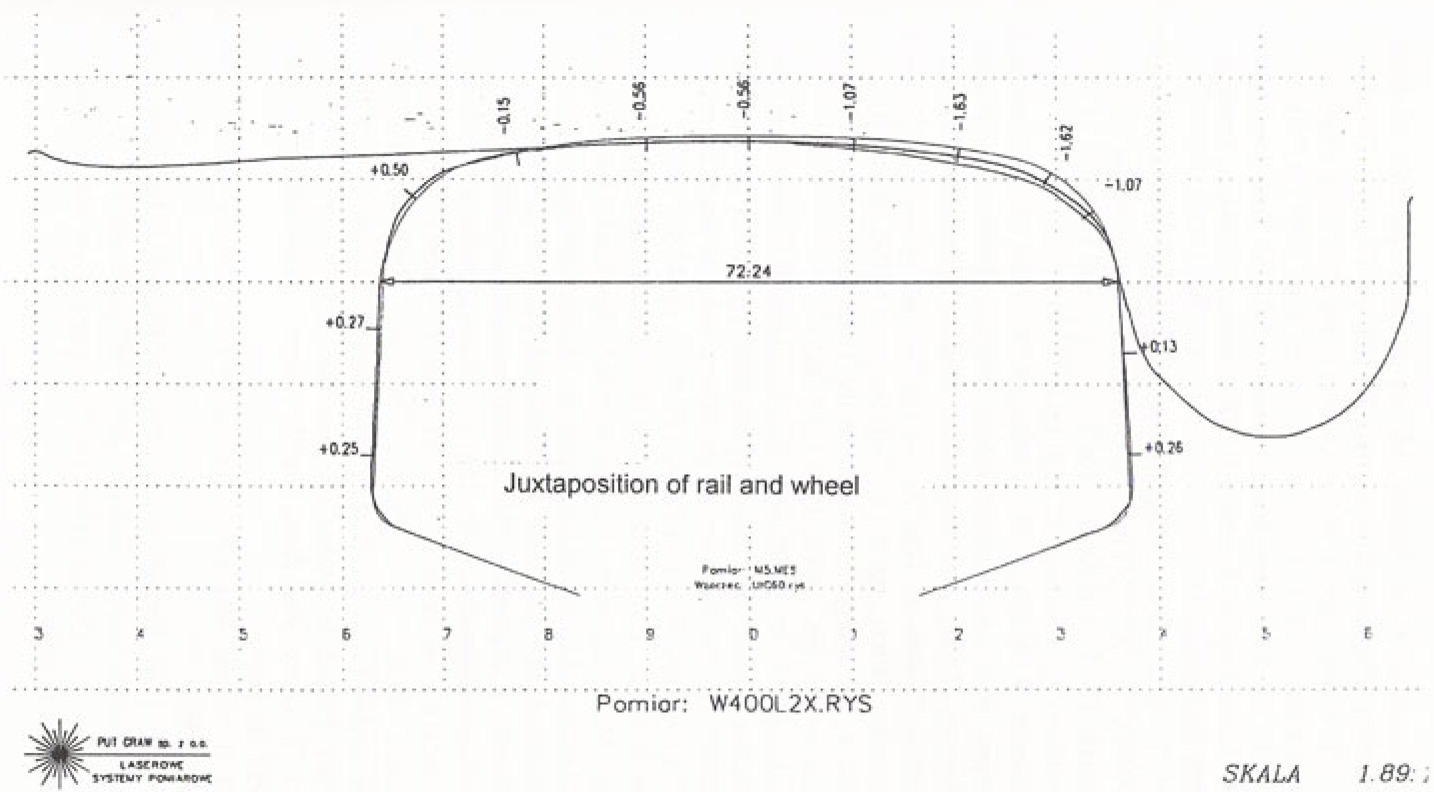

Figure 4: Mating of the rail head and wheel profiles - improper two point contact occurs; note gap size dimensions, theoretical profiles and error plots for rail head and wheel running surface

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Computers in Railways VI
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Computers are now being used in every facet of railway activity from initial feasibility studies to the actual construction of the track and rolling stock, and the ultimate operation of the network.

Following the success of the five previous international conferences on Computer Aided Design, Manufacture and Operation in the Railway and other Advanced Mass Transit Systems, the sixth meeting in the series was convened in Lisbon, Portugal in September 1998. Its purpose was to report on progress in the use of computer-based techniques within the railway industry and other advanced passenger and freight transit systems and to promote a general awareness of these.

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