A new Eddy Current Instrument in a Grinding Train

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Abstract. The recognition of surface damage on rails is of critical importance in order to guarantee a high level of safety for normal train operation. Without early recognition systems, defect damage (e.g. cracks) in the rail, will increase in size and can eventually lead to fracture of the rail. Special grinding trains are in general use for rail maintenance and are employed to machine down worn rails and prevent surface damage in an early stadium.
The company SPENO INTERNATIONAL SA along with the BAM, DB AG and other partners have integrated an eddy current instrument into a grinding train. The equipment has been developed for detection of Head Check type defects and provides information on defect position and depth. Initial experiments were presented at the DACH-conference 2004 in Salzburg [1]. This system has been continually developed and as will be shown is ready for practical application. It is named HC Grinding Scanner.
The actual measuring system and results will be presented.

Introduction

The stress on rails has constantly increased during the last few years in-particular due to high train speeds and heavy axle loads. For this reason the relevance of near-surface defects in rails has been gaining in significance. The cause of such defects is usually rolling contact fatigue. One such defect is the so-called head check. Head check cracks occur at the gauge corner of the rail – mainly on the outside rail of a curve. Head check cracks initially run into the interior of the rail at an angle of 15-30°. They appear in a large number around the vicinity of the whole curve. The distance between the cracks amounts to 2-7 mms. Figure 1 shows a photo of a magnetic particle test and a micrograph of a typical damage caused by head checking.

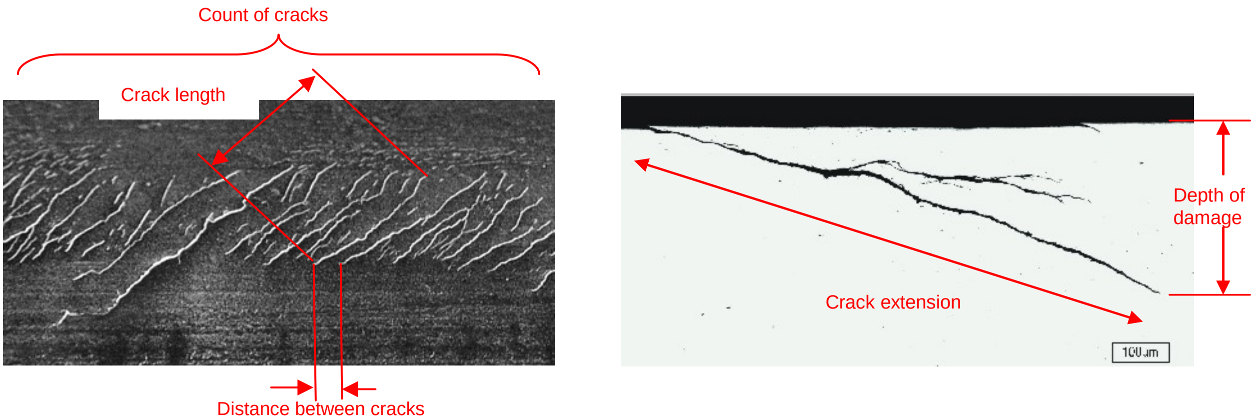

Figure 1: Head check cracks

If cracks are present, contact with liquids in conjunction with the passage of trains will cause cracks to grow. This entrapped liquid within the closed crack will introduce a very high-localised pressure at the crack tip [2]. This can be prevented if the cracks are removed at an early stage by rail treatment such as grinding or milling. An eddy current measuring system was developed some years ago by the BAM in collaboration with the German Railways and other partners to determine the extent of rail damage [3, 4] and to aid effective maintenance. At the moment this system is used in some rail test vehicles and manual rail test systems. The installation of a measuring system working upon the same measuring principles in a grinding machine from the company SPENO International SA had following objectives:

- Optimization of the grinding process by real-time monitoring of the depth of damage.
- Documentation of rail conditions before and after grinding.
- Validation of the eddy current measuring system.

For real-time analysis and monitoring of the measuring data a specialized program was developed. The user interface was customized to meet the requirements for rail grinding. The program developed for the grinding machine is called HC-Grinding scanner. Figure 2 shows the grinding machine train in which the measuring system was incorporated.

Figure 2: Grinding machine train

The Measuring System - Hardware

On the rail test vehicles there are four sensors positioned over each rail. Together it is possible to measure a surface range of approx. 25 mm. The four probes are mounted on a modular mechanism, which permits individual positioning on the measurement tracks. In order to detect head check damage the sensors in the grinding train and rail test vehicles are placed in the same positions for both vehicles. The sensors are mounted on a guidance device carried by a measuring trolley. With a special calibration device the sensors are fixed at a distance of 1 mm from the surface of a new profile UIC 60 rail. For worn rails the distance of the sensors can be varied according to the surface. The resulting change of sensor sensitivity can be compensated in the software by the analysis of the measuring data in a range of -1 mm to +2 mm.
An equipment cabinet with two four-channel eddy current devices is mounted under the train and in close proximity to the sensors. These are connected with the measuring computer in the engine driver's cabin using specially shielded cables. Figure 3 shows the components of the measuring system mounted under the grinding machine.

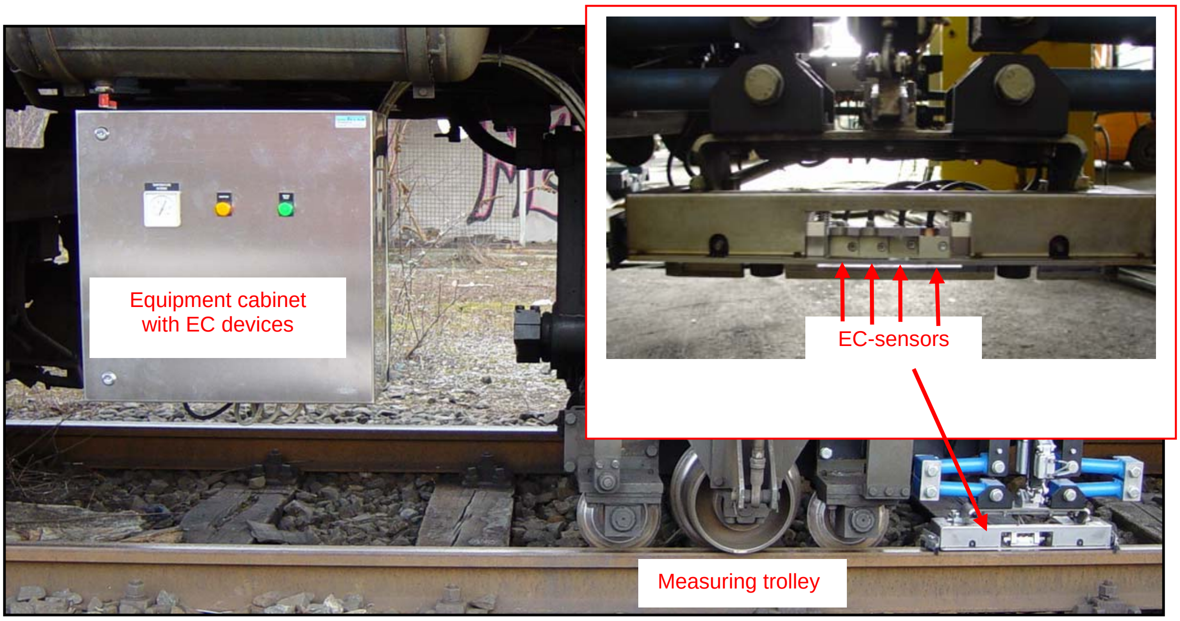

Figure 3: Measuring system under the grinding train

An extra small 19" touch screen and PC as well as a color printer are located for the documentation of the measuring results are located in the engine driver's cabin (figure 4). The touch screen is fastened to a swivel arm that can be constantly observed and operated by the engine driver.

Figure 4: Equipment in the engine driver's cabine

The Measuring System - Software

Central to the successful application of this device is the simultaneous recording, filtering and analysis of the eddy current signals for all eight probes in real time. The strongest signal per side is selected, converted and indicated on the screen. Data concerning the depth of defect, position and count of residual head checking is continuously available.
The program is organized in several pages. The Scan Data page represents the most important feature of the software for the operator. The configuration is aligned with the train position on the track. Both rails are displayed individually with their own field of results. Between them there is the symbolic image of the train with the measurement trolley at its extremity. As the train advances, the train image scrolls over the virtual grinding section and updates the results. Kilometre points can be set so that a full set of results per unit distance is provided and used to locate the affected sections of rail. The status of probes and eddy current devices are indicated continuously as well as the direction of train movement.
It is possible to choose a day or night display mode. For international staff and customers the language is adjustable. In figure 5 you can see an example of the Scan Data page, half of it displayed in the day mode in English and half of it in the night mode in Italian.

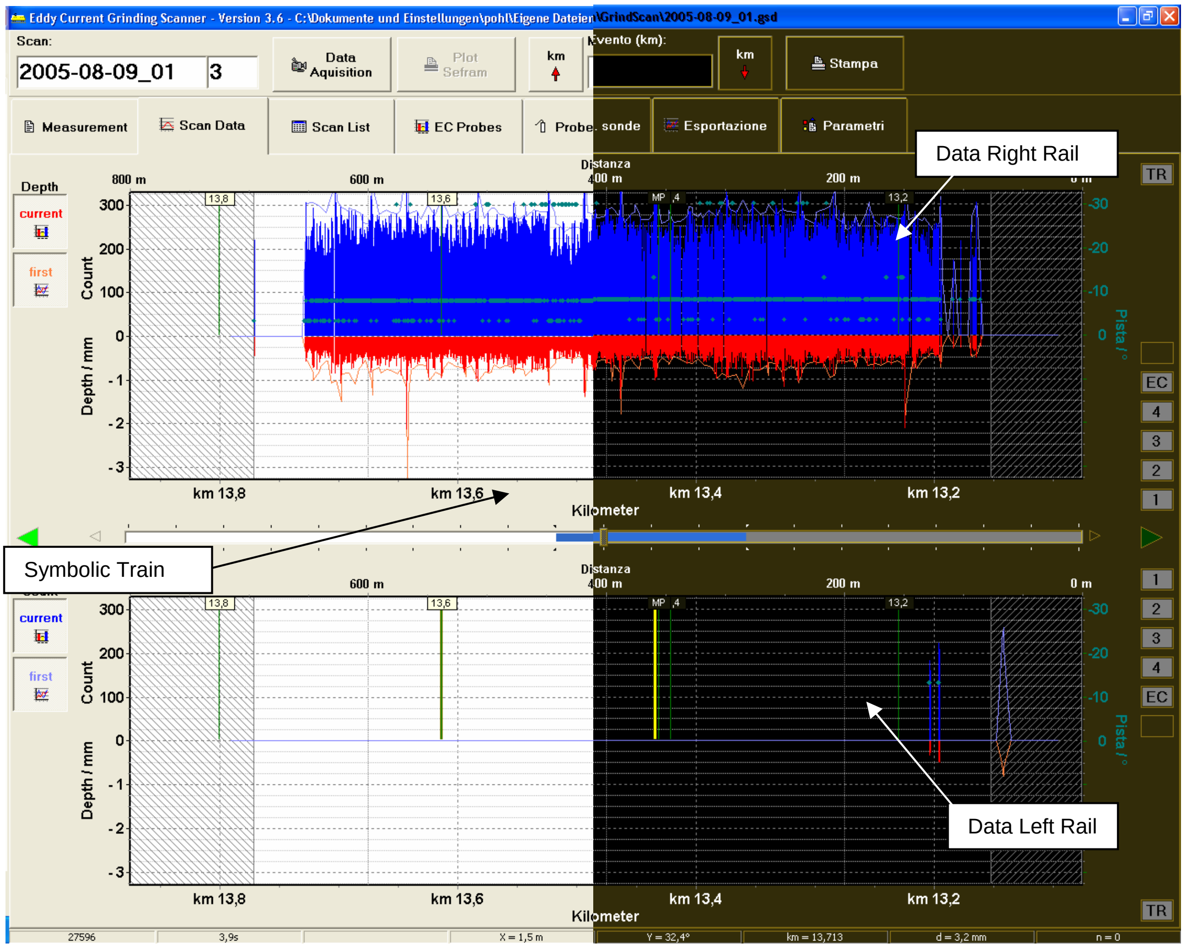

Figure 5: Scan Data page

On the EC-Probes page the status can be controlled in more detail. The distance from the rail surface, the measured depth and count of each of the eight probe signals are indicated for every meter run, whereby the depth of defect is provided for the crack with the largest depth. The correct functioning of the guidance device as well as the current mechanical configuration can be checked (figure 6).

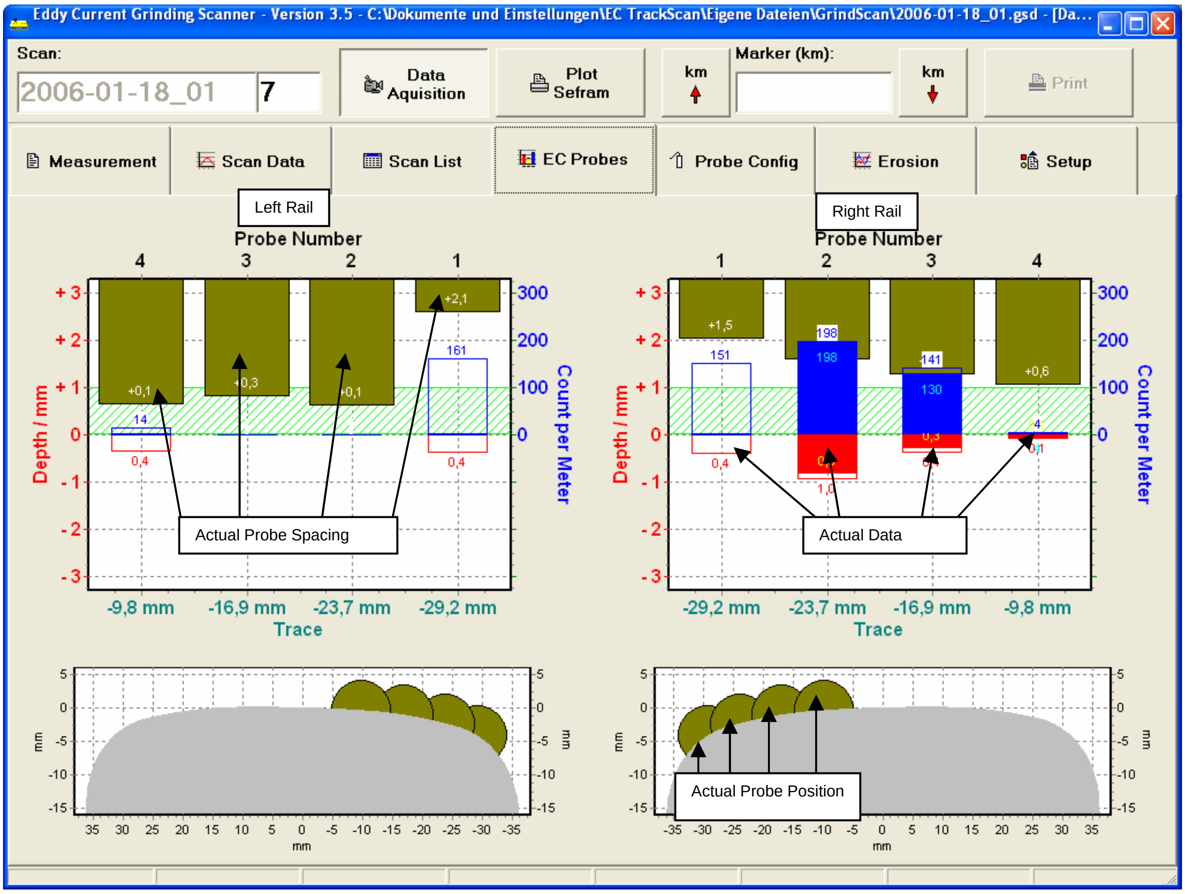

Figure 6: EC Probes page

The positions relative to the mechanical configuration of the probes in the guidance device are chosen in a table of probes on the Probe Config page. This information is permanently available wherever an indication of probe position is needed in the software.
The user language as well as the documentation language, colours, day or night mode and other settings are defined on the Setup page, which contains all options.
Information relative to the track section being ground can be entered at any moment during measurement.
Saved files can be loaded and overviewed for printing or completion with supplementary information. Results can be plotted as diagrams and retained for each grinding pass in the form of A4 colour printing. In addition to the grinding results, the documentation comprises all information relative to the section being ground in order to offer the user a complete and easy-to-handle document. It is possible for users to choose various options for printing to ensure consistent documentation (figure 7).

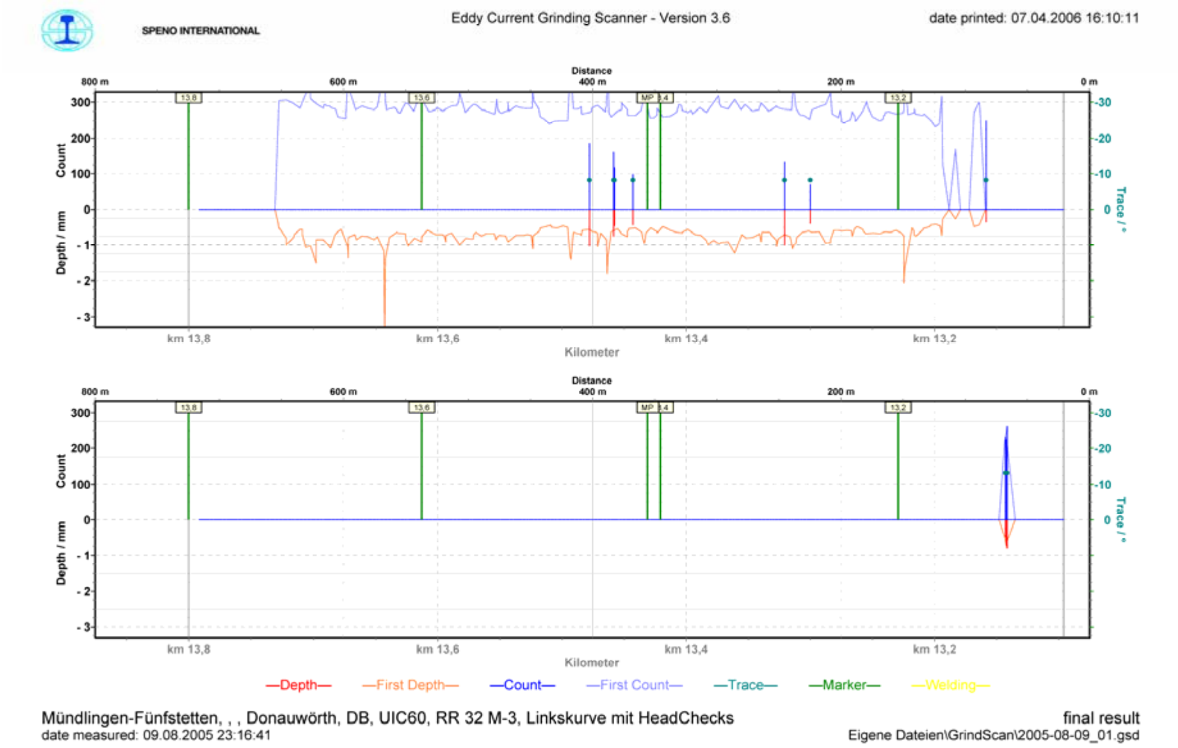

Figure 7: print example of a final result

Results

To check that the measuring system functions correctly, comparative measurements were carried out with the manual test system (B3HeadChecker) employed by German Railways. With this system several measuring tracks were measured during a grinding campaign in the capture range of the HC-Grinding scanner. A result is displayed in figure 8. The results correspond very well. Minor deviations can be explained by differences in the positions of the measuring tracks for both systems.

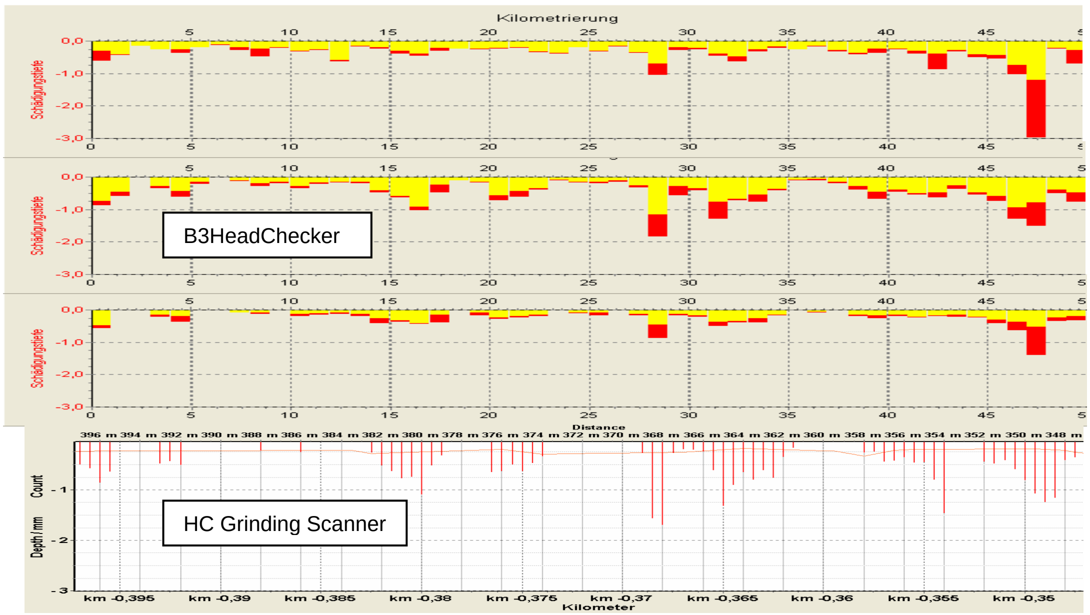

Figure 8: comparison between the results of B3HeadChecker and HC Grinding Scanner

Conclusions and further activities

The eddy current measuring system developed for a grinding machine has reached complete operational state. Significant features of this system are:

- Analysis and representation of the measurement results of 8 eddy current channels on a real-time basis.
- Representation of results and system operation can be adapted to the grinding machine.
- Printout of the grinding result can be customised to fit customer requirements.

Following development steps are being planned:

- Improvement of the measuring accuracy of the system by comparison of the eddy current measuring data with material removal data. If necessary, adaptation of the calibration curves to the measuring system.
- Investigations relating to the measuring accuracy in head-hardened rails. If possible, provision of suitable calibration curves.
- Development of new data filters for the detection of other surface defects for example wheel burn or short pitch corrugation.
- Investigation on whether a depth calibration for other surface defects is possible.

References

[1] R. Pohl, R. Krull, R. Meierhofer; S. Rühe; "Wirbelstromprüfung im Schienenschleifzug"; DACH-Jahrestagung Salzburg (2004)

[2] Railtrack PLC; "Rolling Contact Fatigue in Rails"; RT/PWG/001 (2001)

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[4] R. Krull, H. Hintze, M. Thomas, T. Heckel;"Nondestructive testing of Rails today and in the Future"; ZEVrail Glasers Annalen 127, pp. 286-296, (2003)