AUTOMATED NON-DESTRUCTIVE TESTING AND MEASUREMENT SYSTEMS FOR RAILS

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ABSTRACT

Railways are expected to operate with ever increasing levels of availability, reliability, safety and security. Rail track NDT inspection is one of the ways how the current state of weld integrity can be assessed. Different technologies were used for testing of rails. The inspection techniques covered were as follows: Phased Array, Ultrasonic, Eddy Current, Digital Radiography for welds and visual tracking. Due to the higher demand of speed of trains, the tracks are subjected to extensive predictable or unpredictable stresses in the material, which usually results in rail track failures. Worldwide, the statistics predict that high percentage of those failures resulted in accidents of large magnitude. Thus, continuous monitoring and predictive ma intenance is the only way to safeguard the railways against such disasters. New SPG 80 and of old handcart NW 60 for examination of mistakes in rails with new and old ultrasonic machine and tandem ultrasonic heads is compared
Automated Non-Destructive Testing and Measurement Systems for Rails is adopted for assuring higher reliability and safety railway traffic.
For rail inspection we used also others techniques. Such procedures use usually for confirmation of found mistakes round examination of measuring train.

Key words: automation, assuring of quality, condition based maintenance, rail track¸

INTRODUCTION

The railway traffic requires safety and reliability of service of all railway vehicles and rail tracks. Suitable technical systems and appropriately adapted working methods, which meet the requirements on safety and good order of traffic, should be maintained. All driving units are, therefore, equipped with corresponding protective devices, these exclude possible subjective errors by operators by the inclusion of dead - man's handles and auto-stop devices - as well as through radio communications permitting reports on the actual state of the railway line, which are indispensable in modern traffic. In addition to safe work it is indispensable to ensure safe operation of the braking system and continuous supervision of its operation, which also includes detection of defects in vital elements of locomotives, wagons and rails. For detection of defects, non-destructive testing methods - which should be quick, reliable and cost-effective - are most often used [1].

Inspection of characteristic parts is carried out periodically in accordance with internal standards or regulations; inspections may be both regular and extraordinary. Their damage or breakdown would, in fact, entail considerable material losses and endanger human lives. Maintenance of rail tracks is scheduled in accordance with periodic inspections and regular repairs. Inspections and repairs are prescribed according to the criteria of operational life, limited by the time or according to the criteria of operational life including the path travelled.

Inspection of rails

For safe ride sound rails should be provided. On several years basis they are tested with a specially adapted shunting engine automatically marking suspicious rail sections. The latter are then inspected manually with a SE probe or an angle probe (tandem procedure). The same procedure is followed in the inspection of thermite-welded joints in repair and maintenance of railway tracks [2]. Rail inspection with tandem ultrasonic probes are shown on the Figure 1.

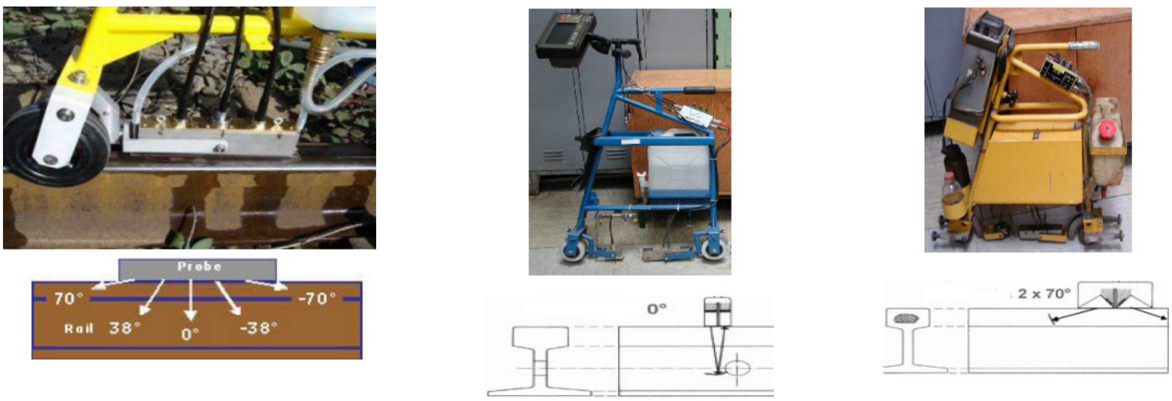

Figure 1: Rail inspection with single and double ultrasonic probes.

Walking Stick non-contact magnetic encoder

RLS was founded in December 1989 in Ljubljana, Slovenia. RLS stands for "**R**otary and **L**inear Motion **S**ensors". In the early beginnings they were focused on providing solutions for a wide field of motion control and metrology applications. From 2000 the company began to specialise in the design and manufacture of magnetic encoders and components for supply to industrial clients and distributors worldwide. They design, produce and supply advanced rotary and linear motion sensors to meet growing global market demands. Their experience and knowledge combined with innovative ideas enable us to offer custom product solutions to match customer's needs. With a vast team of experienced sales engineers became Renishaw partner company and distributors provide leading sales support for our products worldwide [3].

The RE22 is part of Renishaw's extensive range of magnetic encoders developed in close co-operation with its associate company RLS d.o.o. based in Slovenia. It is a compact, high-speed rotary magnetic encoder designed for easy integration and for use in harsh environments. A magnet is mounted to the shaft within the compact 22 mm diameter encoder body and the rotation of this magnet is sensed by a custom encoder chip within the body. The encoder chip processes the signals received to provide resolutions to 13 bit (8192 positions per revolution) with operational speeds to 20,000 rpm and output signals provided in industry standard absolute, incremental or analogue formats.

Sperry Rail's 'Walking Stick' uses Renishaw's non-contact magnetic encoders, developed by its associate company RLS d.o.o., to help locate microscopic cracks in rail track – part of a long-term program of preventative maintenance designed to prevent crashes caused by rail defects. Chosen for their overall performance characteristics, including resolution, power consumption, weight, size and I/O configurations, the encoders also help record auditable data [4].

Network Rail is responsible for the UK's thousands of miles of track, and with rail passenger numbers on the increase, has embarked on a long-term program of preventative maintenance. Helping Network Rail to find and monitor microscopic cracks is UK-based testing technology company Sperry Rail International, which uses Renishaw RE22 magnetic rotary encoders within its new 'Walking Stick' crack detector to help locate the exact position of faults before they cause track failure. On the Figure 2 we can see non-contact magnetic rotary encoders.

Figure 2: Sperry Rail's 'Walking Stick' non-contact magnetic rotary encoders contribute to rail track safety

Helping Network Rail to find and monitor microscopic cracks is UK-based testing technology company Sperry Rail International, which uses Renishaw RE22 magnetic rotary encoders within its new 'Walking Stick' crack detector to help locate the exact position of faults before they cause track failure. Rail cracks are generally born of two sources, small defects inherent in the rail at the time of manufacture and damage caused by the wheels of passing railway vehicles. Boltholes and other fittings can also be the focus points for stress fractures, there's no clear model of how cracks propagate. They depend on many factors, including frequency and weight of traffic and extremes of weather. Cracks usually form at an angle of 20 degrees against the direction of normal travel, but a bi- directional line can grow cracks in both directions.

Devices for testing

The most commonly used means of testing rail is an ultrasonic tool, which can detect defects in the railhead, in the web and in the foot. The standard method of flaw detection on a pedestrian operated device is A-Scan, where the ultrasound reflection is displayed on a screen. With a B-Scan flaw detector (BSFD) the signals received are displayed in a different format on the screen but can also be collected and stored in a file for later analysis and verification. A BSFD can store multiple data sets.

The Sperry Walking Stick is a pedestrian inspection tool, which the operator pushes along the line and can be operated in A-Scan or B-Scan modes. Walking Stick has a roller search unit and has 9 transducers that project sound into the rail at a pre-determined angle to produce reflections from defects. Rail inspection 'Walking Sticks' in various forms have been around for at least 25 years. The Sperry device differs from others in that it uses a polyurethane tyre containing liquid, incorporating fixed, non-contact probes. The devics is perpendicular to the rail foot, and there are probes that provide a refracted angle in the rail of 37 degrees, which look for defects in the web and the foot. The RE22 magnetic encoder was the ideal weight, size, resolution, power consumption and suited the I/O configuration requirements.

Recording data

The Sperry Walking Stick uses a number of systems to log the location of the suspect signal. The magnetic encoder starts at a fixed point, at zero, so that when the analyst goes through the data he can see the specific encoder count, which is then translated into railway mileage or distance from the starting point of the inspection. This particular model BSFD is used for collecting data. GPS signals are also downloaded every second of the inspection and imprinted onto the data file. At the end of the test, suspect data is sent back to a portal, which Sperry sets up and maintains for the customer. The data is analysed and the suspect readings are reloaded on to the portal. The customer can then refer to the portal and, thanks to a combination of GPS data and linear positional data provided by rotary magnetic encoder, see exactly where faults exist. Track maintenance is expensive, especially given that the rail track network stretches to more than 22,000 miles in UK. The Sperry Walking Stick is, compared to other, mechanised methods, relatively low-cost but can still be used to inspect up to 8km of track a day and is very well suited to regular inspections of stretches that are particularly vulnerable or heavily utilised. Defects can be marked, monitored and dealt with before they become a serious threat. With dirt immunity to IP68 the RE22 can be used in a wide range of applications including marine, medical, print, converting, industrial automation, metalworking and instrumentation.

Rail measuring area with ultrasonic and Eddy current

With the Eddy current is momentarily tested the inspection of the fault on the rail driving edge, which achieve the depth till 10 mm, not-homogeneous and other faults, which are close under the surface and on the surface. On the Figure 3 are shown the measuring area in the rail, which are covered by the ultrasonic and Eddy current measuring heads. (A- rail measuring area with normal ultrasonic head (0°), B- rail measuring area with angle ultrasonic heads, C- rail measuring area with Eddy current measuring heads).

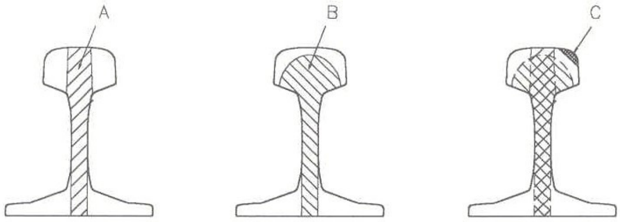

Figure 3: Rail measuring area with ultrasonic and Eddy current

The advantage of this method is detection of the faults in the very early stage of fault development, because the sending off of this fault is with proceeding of grinding with the grinding train still economical. [5].

Rail track testing by ultrasonic measuring car

With the law for the security of the railway traffic it is defined, that the railway track and their parts must maintained assure safe railway traffic. It must be also regularly supervised and periodically inspected. In context of regular track maintenance also the ultrasonic inspection of the rails was included. Regarding to the Regulation for conditions of projecting, building and maintenance of railways superstructure it is necessary at least once per year on the entire railway network to execute the »not demolished« ultrasonic inspections of rails.

The evaluation of the faults (defect) is performing accordance to the »339 – Directive for united criteria for the control of the track condition« and »UIC 712 Kodex [6].

In the last several years the ultrasonic rail inspections on the Slovenian Railways are made contract by the MAV- Central Rail and Track Inspection Ltd. with the ultrasonic measuring car »Ab25-SDS-Ab35«, which are shown on the Figure 4. The procedure of the measuring is automated and it is performing after the preliminary elaborated measuring plan. For the realization of the ultrasonic measurement on the entire network of Slovenian Railways, which contain cca. 1550 km of the tracks, it is needed to be planed about 13 working days.

Figure 4:Hungarian ultrasonic measuring car »AB25-SDS-AB35«

Ultrasonic measuring car »Ab25-SDS-Ab35« is the vehicle with the own drive, with the length of 70,5 m and with the common mass of 180 tons. The speed by the ultrasonic control is between 30-50 km/h, it depends upon the track speed, the conditions of the rails and weather condition. The average daily extent of the measurement is about 125 km. The measuring car is equipped with the water tank (10 m^3). On the car are installed two measuring system, for each rail one. Each measuring system composed two ultrasonic angle heads 70° in 45° (2 MHz), two vertical 0° ultrasonic heads (4 MHz) what is shown on the Figure 5.

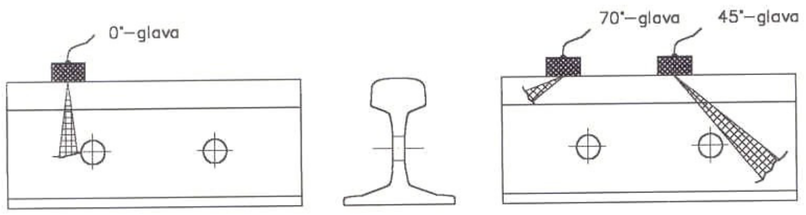

Figure 5: Rail inspection with normal ultrasonic head (0°) and angle ultrasonic heads (45°, 70°)

Short ultrasonic impulse with low frequency 2-4 MHz are from the ultrasonic heads sent to the rail and after the rebound on the impediment (fault) they are received back. As contact stuff between the ultrasonic heads and rail is used normal water. On the places where the wear of rails are bigger, is needed more water supply to the ultrasonic heads, because of the bigger outflow of the water. The system is supplemented also with two cleaning heads

Because of the easier data processing, some date, such as the name and the official number of the railway line, »km« kilometer position of the basic track elements, speeds on the track, the direction of the »km« position rising, left/right rail, the gradient of the track, etc.[7]. are included in the computer data base in advance. The measurements are usually made in spring or in autumn, because the weather conditionst must be taken into consideration.
The precision of the measuring dates on the place are within 5-10 m, therefore follows also the secondary hand ultrasonic measurement. The measuring system on the measuring car is made so, that it is possible to detect the places, where the rails are welded or connected with the joint plates. (The principal of borehole detecting).
The secondary micro location and evaluation of founded faults are made with hand ultrasonic devices (USK-002). For the hand inspection of the entire network of Slovenian Railways with two separated working groups around 15 working days is needed. On the hand ultrasonic rail inspections the technical workers of the Slovenian Railways company are always presented. All micro located faults are marked with the color and evaluated regarding to the level of criticalness. The average daily extent of the hand ultrasonic rail measurement are about 50 km/day, dependent of the faults number on the line section and the access to the track.
Typical faults are so-called »shelling« type of the fault, regarding the UIC 712 kodex are signed with number 211,111 are shown on the Figure 6. It is the type of vertical fault (defect) in the rail head. The largeness of the fault is fast getting bigger because of the material tiredness and leads to the break. These faults are often very close to each other because it can happen, that the rail breaks in more pieces. Relatively there are not many of these faults, around 1%.

Figure 6: The example of the fault type »211« (shelling) regarding the Kodex UIC 712

Conclusions

European Railway authorities keep special services for taking care of safety and flawlessness of railway vehicles and equipment by non-destructive testing of vital parts of vehicles and infrastructure. It is their duty to prescribe and approve to controllers the use of devices, accessories and procedures for non-destructive testing, prescribe technical qualification of controllers and a hierarchic traceability of procedures from the management to performers and vice versa. They also control the implementation of the examinations prescribed. For practical purposes they have special atlases of geometries and procedures for each type of shaft separately, required settings of apparatuses with a certain type of probe. For practical comparison they have at their disposal reference shafts with flaws simulated at critical locations.

In our country the service for non-destructive testing should be re-organized. The re-organization should include: preparation of documentation, harmonization of regulations, personnel instruction, elaboration of instructions for ultrasonic testing, modernisation of equipment, elaboration of atlases of ultrasonic examinations, introduction of hierarchic traceability [8].

In the paper the applicability of different non-destructive testing methods, particularly ultrasonic ones, being the most appropriate for the railways, was shown. In the neighbouring countries more up-to-date methods, such as flaw scanning, are already being employed. They are, however, comparatively costly and not realisable in Slovenia. It turned out that the application of simple resources produced by our services of maintenance make it possible to relatively accurately detect flaws in railway machine elements.

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