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NON-DESTRUCTIVE CONTROL OF CRANE RAILS

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Abstract: Crane rails are an important element of the road. Their condition depends on the required speeds and on the safety of the cranes. An effective way to control the condition of the rails is non-destructive control. Its application allows timely detection of inconveniences and defects in the rails. The principle of action of the control means is based on the use of magnetic and ultrasonic methods. The aim of the paper is to review the methods for non-rational control of crane rails, to present the ways of their design and on the basis of a real section to make experimental studies on the track when it is used by a load crane.

Keywords: Safety, crane rails, non-destructive control, defects

Introduction

Cranes should travel or track along their runway rails with a minimum of skew and without binding. Improper tracking leads to premature wheel and rail wear, resulting in costly repairs and downtime, as well as inefficient and suboptimal crane operation.

There are many reasons why a crane does not travel correctly on the runway:

-Rail may be misaligned or worn
-Clips may be missing
-Pads may be worn
-Runway structure is uneven, bent or twisted due to column settlement, overloads or impacts
- Corrosion
- Improper installation

The length of crane tracks depends on the construction requirements of the site where they are located and the technology of operation.

Designing and Loading Of Crane Roads

Cranes that run on rails require highly accurate rail. The tolerances needed are more demanding than for normal civil engineering. Therefore, it is wise to carry out a survey of structures before rail installation. In cases where crane rails have been in use for a long time there can be movement of the structure and foundations.

The simplest method for calculating rail head width is to allow 2.5 mm head width per tonne for vertical wheel load for heavy duty cranes. Allow 1.7 mm for normal and light duty cranes. More conservative figures can be calculated by using the following formula [9]:

$$(1)\ H = (1580\ x\ W) / D \text{ (for heavy duty cranes)}$$

where:
D = wheel diameter in mm
W = wheel load in tonnes force
H = full rail head in mm

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The CRANEWAY program can be used to calculate the crane roads themselves and their loads. It is based and works in accordance with the regulatory requirements of [5]:
- EN 1993-6: 2008-09 (Eurocode 3)
- DIN 4132: 1981-02 и DIN 18800: 1990-11

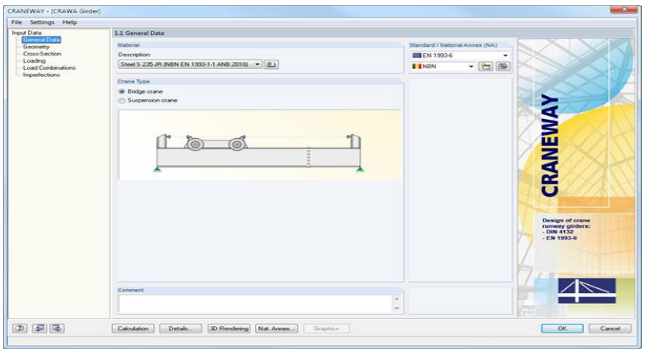

Figure 1. Vision of the CRANEWAY software

The load class of the crane road according to its load capacity can be determined by the formula:

(2) H = P/Pp (Qav + Qcr),

where:
P = 3,6 . v . t , km - crane mileage for a year;
v - speed of crane movement, m/s;
t – the operating time of the crane movement per year, h;
Pp – length of the crane path or effective front of work, km
Qav – the average load mass, t;
Qcr – the mass of the crane, t

By calculation of normal stresses because the warping torsion is taken into account, not only parts from axial force and bending, but also from the warping torsional moment occur for the normal stresses σ_x. In all, we obtain for the normal stress σ_x in a point i of the cross-section [5]:

$$\sigma_{x,i} = \frac{N}{A} + \frac{M_y}{S_y(y_i, z_i)} - \frac{M_z}{S_z(y_i, z_i)} - \frac{M_\omega}{C_w}\omega_M(y_i, z_i) \quad (3)$$

where:
N - axial force;
M_y - bending moment about y-axis;
M_z - bending moment about z-axis;
$M\omega$ - warping torsional moment;
A - cross-section surface;
$Sy(y_i,z_i)$ - section modulus about y-axis for point (y_i,z_i);
$Sz(y_i,z_i)$ Section modulus about z-axis for point (y_i,z_i);
Cw - warping constant relative to the shear center M;
ω_M - principal warping at point (yi,zi)

When the crane roads are located on the ground, the geometric parameters shown in Figure 2 must be observed.

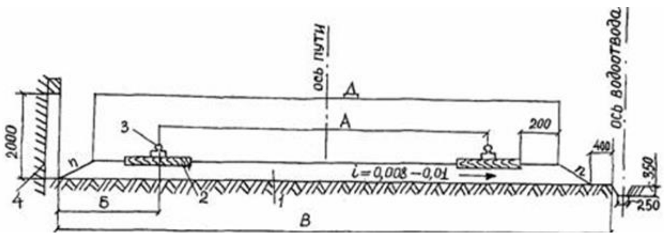

Figure 2

Calculation of crane ways is typically performed by taking complex resistances from vertical and horizontal bending and twisting

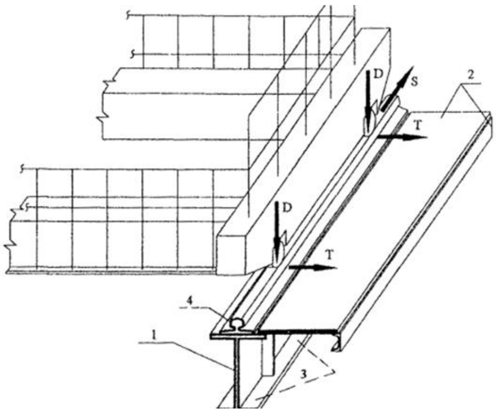

Figure 3. Load diagram of crane road
1-beam bar, 2-beam balancing, 3 - connections, 4 - crane track

In connection with the safety in the operation of crane rails, the nominal and permissible wear levels of the rail rails used for these roads must be respected in height and width of the rail head.

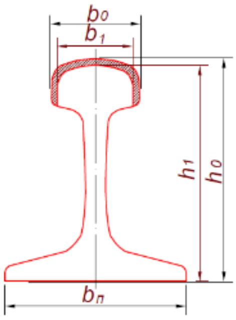

Figure 4

Table 1. Wear on crane rails

Rail type	Nominal wear in mm		Allowable wear, mm	
	*h*0	*b*0	*h*0	*b*0
P43	140	70	133	61
P50	152	72	144,5	62
P65	180	75	171,5	63
P75	192	71,8	183,75	61,3

The important for the safety of crane railways is also the grounding devices. The number of this devices for crane roads depends on their length. Every 50 meters in length requires at least one earthing device.

Non-Destructive Control of Crane Rails

The periodic inspection of the defectoscope rails determines the condition of the rails, starting from the type of defect, the nature of the defect development, the condition and the condition of the operation of the road and other features. Defectoscopes detect 99% of all detected defects in the railway track and in the welding plants. Optimal timetable planning for non-destructive testing, developing the best route to check for defective tracks allows for a partial solution to the problem of track diagnostics. In the case of defectoscopy of rails, the technical and economic indicators are determined by the number of defective rails found and replaced.

The analysis of common defects in crane rails in Bulgaria for 2013-2016 shows the following number of defective rails:

1. Head rail defects from tracking technology – 36 numbers:
- insufficient strength of the metal
- abnormal impact of rolling stock defect
- welding technology
- technology of quenching

2. Defects in the neck of the rail – 1780 numbers
- from production technology
- from defects in the profile and the fastener
- from deficiencies in ongoing maintenance

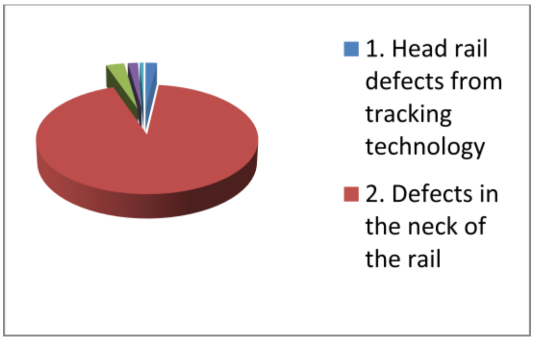

Figure 5. Common defects in crane rails in Bulgaria for 2013-2016

- from impacts and mechanical impacts
- from welding technology

3.Defects in the heel of the rail – 58 numbers
- from defects in the profile and the fastener
- from strokes and mechanical injuries
- from welding technology

4. Breaking the rail across the section – 32 numbers
- from production technology
- by an abnormal impact of the rolling stock

5. Rail distortion – 12 numbers
- from strokes and mechanical injuries.
- from welding technology

There are most common for non-destructive control (NDT) of crane rails.

- Visual
- Liquid Penetrant
- Magnetic
- Ultrasonic
- X-ray

Visual Inspection is Most basic and common inspection method. Tools include fiberscopes, borescopes, magnifying glasses and mirrors. Portable video inspection unit with zoom allows inspection of large tanks and vessels, railroad tank cars, sewer lines.

A liquid with high surface wetting characteristics is applied to the surface of the part and allowed time to seep into surface breaking defects. The excess liquid is removed from the surface of the part.

A developer (powder) is applied to pull the trapped penetrant out the defect and spread it on the surface where it can be seen. Visual inspection is the final step in the process. The penetrant used is often loaded with a fluorescent dye and the inspection is done under UV light to increase test sensitivity.

The part is magnetized. Finely milled iron particles coated with a dye pigment are then applied to the specimen. These particles are attracted to magnetic flux leakage fields and will cluster to form an indication directly over the discontinuity. This indication can be visually detected under proper lighting conditions.

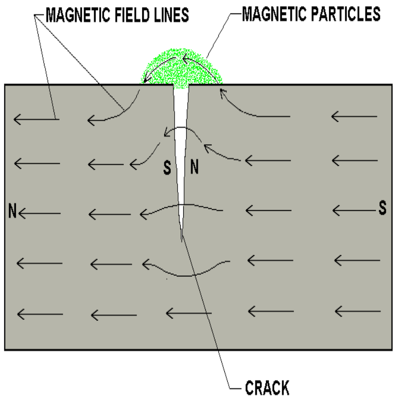

Figure 6

The radiation used in radiography testing is a higher energy (shorter wavelength) version of the electromagnetic waves that we see as visible light. The radiation can come from an X-ray generator or a radioactive source.

Ultrasonic Inspection (Pulse-Echo)
High frequency sound waves are introduced into a material and they are reflected back from surfaces or flaws. Reflected sound energy is displayed versus time, and inspector can visualize a cross section of the specimen showing the depth of features that reflect sound.

The wear of the rail profile (can have several causes: excessive loads, poor alignment of the crane runway, unbalanced loading by the crane (e.g., by exceeding tolerances according to International Organization for Standardization (ISO) 12488-1) or wrong material pairing between the wheel and the rail. The consequences can be plastic deformation or material deterioration at the rail head. As a result of the change in the cross-section, the possible static absorption load changes, which may cause a rail break or a change in the tracking [10].

Another negative effect is the additional stress on the structure. The width of the head, the rail height, the width of the burr (cold rolled lip) the side of the rail head on which the burr is located, cracks as well as breaking out in the rail head, and wheel slip marks can be defined as the target values.

More frequently an ultrasonic testing method is used for railway axles flaw detection with the scanning of testing zone provided by the NDT inspector and operator by means of manual device, which has a number of disadvantages, including:

- law testing productivity;
- operator influence on testing results (human factor);
- possibility of results distortion during the testing protocol preparation.

By the ultrasonic inspection of crane rails we use the real object in the company Podem Group Ltd. The length of the crane rails is 120 m. We use for our investigation the Ultrasonic Inspection MF800C.

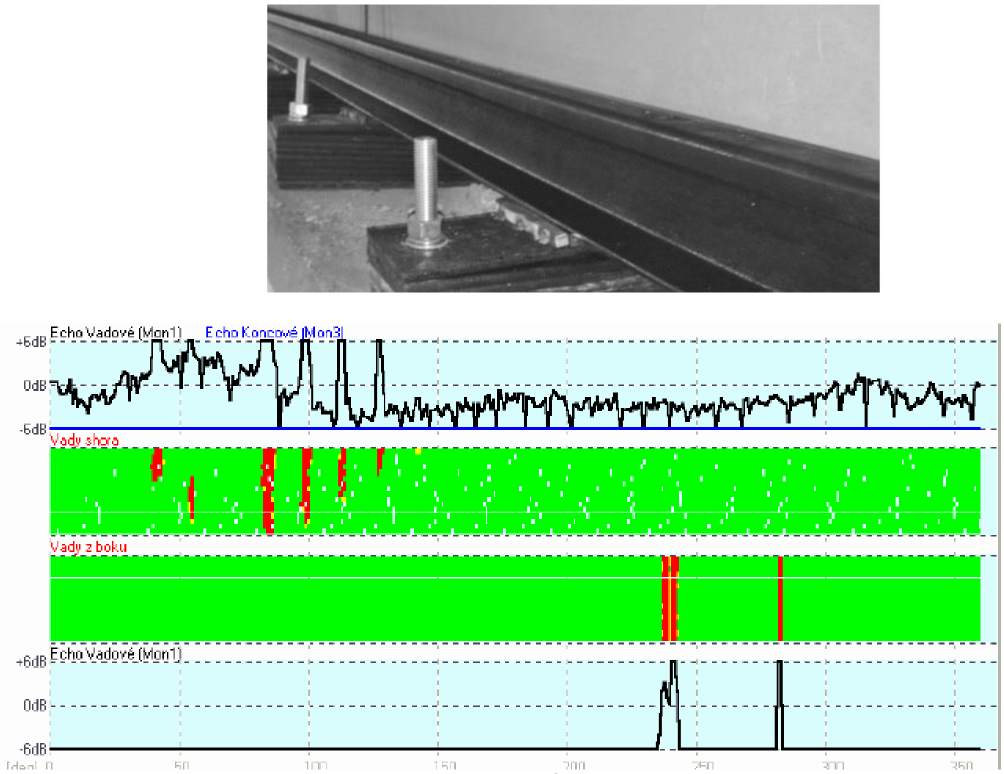

Figure 7 Results from crane rails inspections

Conclusion

With increased rail traffic carrying heavier loads at higher speeds, a quicker more efficient way of inspecting railways is needed. Eliminating contact with the rail could one day allow high speed detection of flaws.

Suitable assessments of inspected areas are necessary conditions for covering of safety service of important components in crane rails. It is possible to use simulations for interpretation of results obtained by examination.

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