Final Report Summary - U-RAIL (Non-contact Ultrasonic System for Rail Track Inspection)

The 'Non-Contact Ultrasonic System for Rail Track Inspection' (U-RAIL) project proposed a non-contact ultrasonic system for periodic inspections of rail tracks that has many advantages over conventional technologies currently available to the railroad industry. Periodic in-track rail inspections are performed to detect critical defects before they grow enough to cause structural failure. Non-destructive inspection technologies currently used worldwide rely mainly on contact ultrasonic methods that, even though extensively used and proved to be reliable, are not perfect.

In particular, the main objectives of the project were:
1. To develop a non-contact ultrasonic technique for in-track rail flaw detection.
2. No use of water.
3. To perform high speed inspection.
4. To bring the system into the market.

In the effort to improve railway transport safety, the general project objectives were:
- to increase the inspected area of the rail cross-section;
- to detect cracks that are not detectable with methods currently available to the railroad industry;
- to reduce the number of false calls;
- to increase the inspection speed.

Results achieved in the first reporting period of activities are:
- Definition of technical specifications that the system must satisfy
- Results of analysis on rail steel ablation with high power laser
- Design of source/receiver configurations for the inspection of the complete rail section
- Assessment of sensitivity of the laser-based technology and comparison with the conventional contact method
- Design of the rail position measurement system and related software
- Design of the automatic positioning system
- Design of the ultrasonic inspection unit
- Signal processing software

The U-Rail system has provided excellent results in detecting cracks that are not detectable with methods currently available to the railroad industry. Overall inspected area is about 80% of the entire rail section.

Head inspection for internal and surface defects has been performed focusing the laser beam into the gage side of the head. Longitudinal and surface waves, simultaneously generated, propagate through the bulk and the surface of the head allowing its complete inspection. Acoustic waves are acquired by the air-coupled transducers in pitch-catch configuration. To guarantee a high reliability the configuration uses six air-coupled transducers for a single laser pulse. Flaws that have been detected in the rail head with this
configuration are:
- horizontal and vertical split head
- transverse defects
- head checking
- shelling.

For the web inspection the laser beam is focused at the bottom of the web, on the gage side. Bulk waves propagate through the web up to the rail head, where they are detected by the air coupled transducer.

Internal flaws that have been detected in the web with this configuration are:
- split web
- horizontal split crack (included head and web separation).

For the base inspection the laser beams were focused, from above the rail, on the gage and the field sides. Two surface waves, created by each laser source, propagate along the base in opposite directions and are detected by the air-coupled transducers located in pitch-catch configuration, symmetrically respect to the generation point. Transverse defects at the outer edge of the base have been detected with this configuration.

Main objectives of the second reporting period were:
- Laboratory tests of assembled components
- Development of software to control laser triggering, acquisition and processing of signals
- Development of software for the characterization of defects
- User interface design
- Design and production of the final system
- Assembling of components (optics, electronics, hardware, etc)
- Functionality tests of the prototype
- Modification of the rail vehicle provided by RFI
- Installation of the system in the rail vehicle
- Validation of system functionality
- In-field tests on selected flaws to validate the inspection system
- Test for repeatability of measurements
- Promotion and spreading of project outputs.

All the contractors have been involved in the activities of this period and the main achievements of the project in the second reporting period are:
1. design and production of the inspection system
2. installation on the rail vehicle
3. in-track test on selected flaws.

Related information

<table>
<thead>
<tr>
<th>Result In Brief</th>
<th>Improved rail inspection boosts safety</th>
</tr>
</thead>
<tbody>
<tr>
<td>Documents and Publications</td>
<td>Final Report - U-RAIL (Non-contact Ultrasonic System for Rail Track Inspection)</td>
</tr>
</tbody>
</table>

Reported by

TECNOGAMMA S.A.S.
13, vicolo Ongarie
31050 MORGANO (TREVISO)
Italy

Last updated on 2011-04-14
Retrieved on 2019-07-01

Permalink: https://cordis.europa.eu/result/rcn/52078_en.html
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