

# Detection of Weld Defects in Rails using Phased Array Ultrasonic Analysis Software

Keywords: phased array ultrasonic processing software, rail welds, defect detection, phased array, spectral filtering, golden image

## Detection of Weld Defects in Rails by Ultrasonic Software

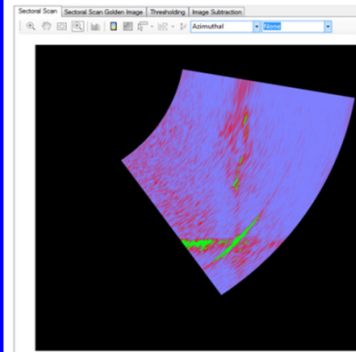
Statistical and algorithmic ultrasonic software techniques are used in the analysis of ultrasonic images in order to automatically detect potential weld defects using techniques such as spectral filtering and feature identification. The analysis concentrates on weld defects that are internal and volumetric in rail welds because it is highly relevant to the transport industry. Failure in rail welds is an on-going concern for rail safety. A means to detect flaws using phased array ultrasonic techniques promises to minimise catastrophic failure and provide paths to preventative maintenance.

The use of phased array analysis software to automatically detect defects in phased array ultrasonic inspections provides a valuable preventative tool that will serve to help maintenance engineers to locate rail welds that contain defects, and to provide a quantitative analysis of the severity of the defects, including sizing and classification of the defect so as to support a decision to accept a newly welded rail or to repair a defect as part of a maintenance schedule.

## Aim of Ultrasonic Software in the Detection of Weld Defects in Rails

The purpose of Kingston Computer Consultancy's (KCC) involvement is to support development of software that is intuitive for inspection engineers to use, can profile different defect types and can automatically detect, and ideally characterise, potential defects in inspected rail welds. In particular, this case study relates to the extension of requirements to include quantitative analysis of the ultrasonic based image data of aluminothermic rail welds through spectral filtering and golden image thresholding.

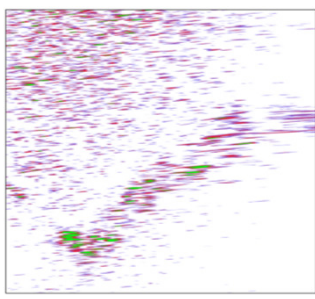
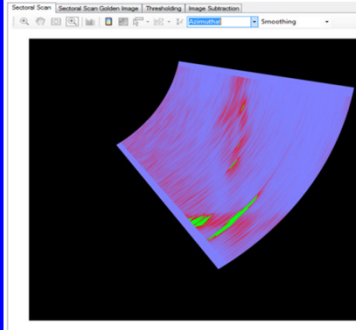
## Ultrasonic Software Defect Analysis of Image



Shrinkage defect S11 is shown on the left as an azimuthal intensity plot. The shrinkage is simulated using a ceramic insert.

Shrinkage defect S11 is shown below left, this image illustrates the use of the averaging filter. Below is represented the golden image subtraction of a porosity defect. Both filters separate background noise from defects allowing for successful defect recognition.

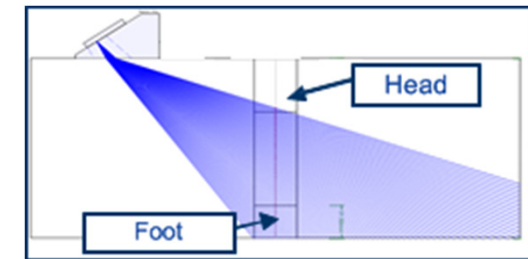
Below right, the schematic representation of a phased array probe as it is positioned to perform a scan at the location of a rail weld, the beam profile is indicated. The modelling was performed using the ESBeamTool software.



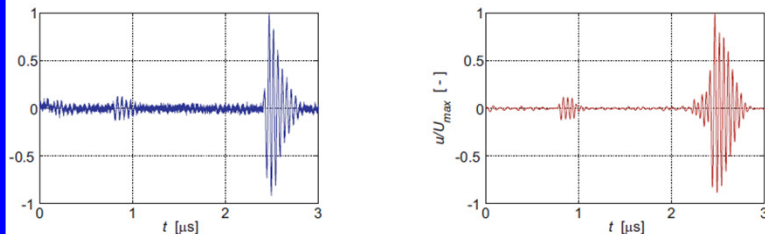
## Phased Array Ultrasonic Software Development

The first stage of image analysis focused on separating areas of potential defect from the image background where there is no anomaly. As the rail weld is precisely located within the scan, the region of interest (ROI) can be precisely defined, and further analysis can be tailored to process just this region. The phased array ultrasonic instrument generates data using a phased array probe, and this data can be used to produce linear or azimuthal plots. The requirement for further analysis of data surpassed that provided by the phased array ultrasonic instrument, and dictated that a custom designed software solution be created for the Railect project. Kingston Computer Consultancy Ltd, as advisors to TWI, has assisted in creating a software solution that allows for the import of phased array ultrasonic instrument data files, and the generation of azimuthal plots.

After the initial requirement of import and display, the next step was to provide additional analysis. With the aim to identify and locate two types of defects, Kingston Computer Consultancy Ltd researched methods used to identify porosity and shrinkage defects, and developed an averaging filter and a golden image subtraction filter to assist with this task. The KCC software has successfully identified both defect types and automatically sentenced defects correctly.



## Ultrasonic Software Image Processing Challenges: Spectral Analysis, Filtering in Detection of Rail Weld Defects



Real A-Scan results shown in the original form and a post-filtered result, using a fast Fourier transform to gather noise statistics and remove this component from the signal

Real signals from field measurements often present background noise that significantly lowers the signal-to-noise ratio of the received signal response used in software analysis of ultrasonic signals. In such cases it is advantageous to employ signal filtering and conditioning so that the maximum possible signal is recovered from the data to detect defects in rail welds. Spectral representation of a signal allows for noise statistics to be gathered and filtered from the signal frequency profile, thus reducing the noise component. Wavelets, Fast Fourier Transform, and Wiener filters are proven to be successful in filtering backscatter noise and electronic noise from A-Scans, and can be included in the analysis using KCC software.

## Conclusions

The KCC phased array ultrasonic processing software has developed statistical and algorithmic methods to process phased array data images so that indications of defects within rail welds may be detected and effectively sentenced. The images have been processed to reject background noise and to enhance the regions where flaws may be present. Engineer controlled defect inspection assists in identifying the type and severity of present defects, using filtering and golden image background subtraction methods to detect weld defects in rails using phased array ultrasonic processing software.

## Acknowledgements

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