Discussion on "Field Test Performance of Noncontact Ultrasonic Rail Inspection System"

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Discussion of "Field Test Performance of Noncontact Ultrasonic Rail Inspection System" by Stefano Mariani, Thompson Nguyen, Xuan Zhu and Francesco Lanza di Scalea.

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In general, the development of novel technology for rail inspection is very welcome indeed. The paper under discussion was well written by the authors. The field investigation results at the Rail Defect Test Facility of the Transportation Technology Center in Pueblo, Colorado are critical for rail inspection management in practice. In the paper under discussion, the authors have focussed on the effectiveness of noncontact air-coupled ultrasonic inspection system (or so-called 'UCSD System') on rail defect detection using the imbalance of two ultrasonic arrays. The 'new-generation' UCSD system collects data on the gauge side of rail(s). The authors have found that the velocity of the inspection vehicle or the test speed plays a key role on the performance of defect detection in the field. Their experiments show that

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reasonable performance of the UCSD system can be achieved at the test speeds between 1.6 and 8 km/h. In addition, it is highly appreciative that the authors concluded that there are limitations of the system and the authors plan to develop more work in order to distinguish between defects and welds; and to expand the coverage area of the system over rail head.

The field trials by the authors were carried out on curves with radii of 233m (or 7.5°) and 350m (or 5°). Note that the curve radius (R) has been converted from $R = 50 / \sin(D/2)$. The assumption is based on 30.5m (100ft) chord and D is the degree of curvature in radians. It is very frequently found that in practice various types of rail defects can develop on railway tracks with sharp curves (i.e. <350m radius) depending on the characteristics of rail (i.e. standard carbon rail, head hardened rail, residue stress, manufacturing imperfection), operational parameters (i.e. train speed, axle load, rolling stock imperfection, cant deficiency), and maintenance quality (e.g. grinding frequency, tamping method, etc.). A common rail defect is of course the rolling contact fatigue (RCF) on gauge corner (or called ‘head check’ or ‘gauge corner’). This RCF defect can further grow and cause rail squats, rail studs, transverse defects and other modes of failure. Figure 1 shows an example of moderate rail squats. The real examples of various rail defects found on curved tracks can be seen in Ishida (1989; 2015), Li et al. (2008), Grassie (2012), Grassie et al. (2012), Wilson et al. (2012), Kaewunruen and Ishida (2014, 2016), Kaewunruen et al. (2014), Kaewunruen (2015), and Andersson (2015). Note that the type of defect, its size and severity help track engineers to prioritise inspection and maintenance tasks. On this ground, not only is the defect identification essential to rail industry, the classification of defect type and maintenance prioritisation is also mutually crucial to mitigate safety risks in railway operations. It is even more important that early-age rail defects are detected quickly enough to enact predictive and preventative track maintenance, instead of costly corrective one. The defection of transverse defects might be slightly too late for any preventative actions.

The field data shown in Figure 1 demonstrates that rail surface defects can potentially spread over the rail head. Note that the field observations showed that rail surface defects can also develop at both low (inner) and high (outer) rails in curved tracks. The dimension and scale of rail defects are again dependent on various factors. If rail corrugations and wheel burns are present, additional vibration might also provide additional problems to the system in practice. As such, suitable device installation and noise cancelling technique will be required to enhance reliability of data analyses such as receiver operating characteristics (ROC), damage index (DI), probability of detection (PD), and probability of false alarms (PFA).

Hopefully, the field experience and some practical findings in this discussion would be useful and should encourage the authors to extend their future research and development with respect to the classification and quantification of rail surface defects in practice.

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a) WEL-related stud (multiple squats)

b) RCF-related squat (single squat)

Figure 1. Rail squats in railway tracks based on their initiation types (photos taken in 2012 by Sakdirat Kaewunruen)