Non Destructive Testing in Railway Industry by Ultrasonics

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Abstract

Indian Railways is considered as the lifeline of the nation. It fulfills vital transport necessity and large number of people travel daily on its network. The safety of the traffic is to be given paramount importance on a railway system. Lots of advancements have taken place in track infrastructure and better track maintenance practices have been evolved to improve the reliability of the system. The noteworthy among these are the conversion of free rails into long welded rails, use of pre-stressed concrete sleepers, mechanization of track maintenance, improvements in the rail manufacturing technology, improvements in the rolling stocks etc. The track structure today is sturdier and the track parameters are better maintained. This has certainly reduced the risk of accidents due to rail wheel interaction. However, discontinuity caused due to rail/ weld breakage is an area of concern for track maintenance engineers. The present paper discuss the detailed study about NDT in railway industry.

Introduction

Any defect in the rail or any material which may lead to fracture or breakage is called a flaw or a defect. The development of flaws in rails is inevitable. The two main reasons for Occurrence of flaws are the inherent defects in the rails generated during manufacturing and fatigue of rails due to passage of traffic. The inherent weak spots or inherent defects in the rails such as non-metallic inclusions, hydrogen flakes, rolling marks, guide marks etc. at the manufacturing stage pose a threat in the form of rail breakages. The inherent defects can be taken care of by improving the rail metallurgy and the process of rail rolling during the manufacturing stage. On the other hand the defects due to fatigue in the rail during service will depend on the residual stresses in the rails, magnitude of the rail stresses and the number of load cycles.

Techniques

It is essential that detection of flaws be carried out well in advance so that timely preventive action can be taken to avoid in-service breakage. This assumes importance as the consequences of in service failures may sometimes be disastrous.

Different types of Non-Destructive testing techniques presently available are

- Visual Inspection
- Dye Penetrant testing
- Magnetic particle Testing
- Radiography
- Eddy Current Testing
- Ultrasonic Testing

Apart from the visual inspection, ultrasonic testing has been considered to be the most effective means of ensuring the soundness of the rails and welds world over due to its versatility, accuracy, sensitivity, overall economy and flaw detection capabilities. Ultrasonic technique is having advantage of its

high penetration power, estimation of severity of defect, feasibility of automation, scanning at high speed and requirement of access from one surface only. The use of the other techniques such as eddy current system for detection of surface defects, flaw detection using magnetic flux leakage, rail inspection using electro-magnetic acoustic transducers, rail inspection using alternating current field measurement, inspection using ultrasonic phased array are also in practice on limited scale on some railway systems. Some of these techniques are still in developmental stage.

Indian Railways, depend primarily on ultrasonic technique for reliable flaw detection. The ultrasonic testing of rails and welds is being used on Indian Railways for more than five decades. Testing procedures are continually being modified to suit the requirements of the newer kinds of flaws being noticed. For example, the detection of gauge face corner defects was started in 2005 by providing 70^0 gauge face side probe.

Defect In Rails and Welds

These defects can be broadly classified as below:

1. Horizontal defects
2. Transverse defects
3. Gauge face corner defects
4. Longitudinal vertical defects
5. Bolt hole cracks.

In addition to these, there are certain defects which are specific to alumino thermic weld. These are:

1. Half moon defects
2. Porosity or blow holes
3. Lack of fusion
4. Slag inclusion

The defects in the rail are named as per their orientation i.e. the plane in which they lie - horizontal or vertical and their direction of propagation - longitudinal (i.e. along the length of the rail) or transverse (i.e. along the cross section of the rail).

Horizontal Defects (Hf):

These defects are horizontal and longitudinal i.e. they grow along the axis of the rail. They can develop in the head of the rail, at the head-web junction or at web-foot junction of the rail. High vertical stresses, high residual stresses and inclusions in the rails are responsible for initiation of these defects. These cracks can be easily detected using 0° probe during USFD testing. Fig. 1 shows a horizontal defect in the web of the rail through an AT weld.

Fig. 1 - Horizontal Flaw in Web through Weld

Longitudinal Vertical Flaw (Lvf):

As the name suggests, these flaws are in vertical plane and run parallel to the longitudinal axis of the rail as shown in Fig. 2 and 3. These are caused by presence of non-metallic inclusions, poor maintenance of joints and high dynamic stresses. These defects cannot be easily detected in early stages by USFD due to their unfavourable orientation. These can be detected by 0^0 probe when grown up or by 45^0 tandem rig used on the side of the rail head.

Fig. 2 - Schematic Diagram for Longitudinal Vertical Flaw

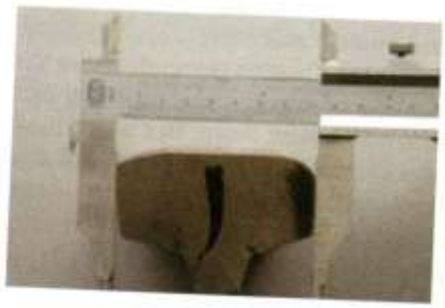

Fig. 3 - Longitudinal Vertical Flaw in Rail Head

Transverse Flaws In Rail Head (TF):

These flaws grow along the transverse plane i.e. along the cross section of the rail and their growth along the rail axis is quite small. These are mostly in the shape of a kidney when fully grown and hence, also known as kidney defects. They are generally inclined at an angle of $18\text{-}23^0$ to vertical plane and can be detected by 70^0 probe by USFD. Hydrogen accumulation and non-metallic inclusion coupled with high stresses are the main cause of this type of defect. A Transverse or kidney flaw is shown in Fig. 4.

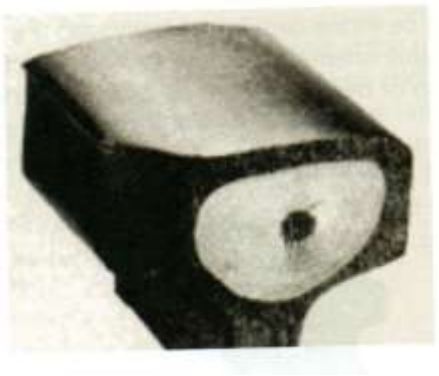

Fig. 4 - Transverse or Kidney Defect in Rail Head

Conclusion

Indian Railways, depend primarily on ultrasonic technique for reliable flaw detection. The ultrasonic testing of rails and welds is being used on Indian Railways for more than five decades. Testing procedures are continually being modified to suit the requirements of the newer kinds of flaws being noticed. For example, the detection of gauge face corner defects was started in 2005 by providing 70^0 gauge face side probe.

USFD technique is successfully being used world over for the detection of internal flaws in the rails and welds. However, there are certain apprehensions about the capability of this technique on Indian railways. The reasons for this are more of administrative in nature rather than technical. The testing on Indian Railways is being carried out manually using hand testing equipment that brings in lot of subjectivity to the process. The results of testing thus depend upon the knowledge and sincerity of the USFD operator apart from the reliability of the equipment. The knowledge of track maintenance engineers is also one of the important issues that need to be addressed on our system. Without the complete and clear understanding of the technique in the minds of supervisors and officers, the doubts about its efficacy are natural. Understanding of the subject will expel most of the doubts regarding the capability and the limitations of the technique.

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