Failure and Stresses Develop in Insulated Rail Joints: General Perspective

Washimraja Sheikh, P. N. Awachat, S. M. Sheikh

Abstract* — Rail joints are use for the purpose of joining the two rails. Due to large number of drawbacks and for safety purpose the number of joint in mainline track has been minimized by the widespread use of continuously welded rail (CWR) .For automated block signaling it is required to have sections of track electrically insulated from each other, disallowing the rail to be continuously welded as is done where possible ,this joint is called as insulated rail joint(IRJ).The IRJ is however substantially weaker than the rail and so is subjected to large stresses, causing failure. This paper is part of study into various stresses develop in various components of IRJ and future scope in it so that performance of assembly can be improve.

Keywords—Insulated rail joint, stresses, wheel rail contact, en

I. INTRODUCTION

Two main types of rail joints are employed in modern railway track: continuous welded rails (CWRs) and insulated rail joints (IRJs). The purpose IRJs is to allow a railway signaling system to locate trains by maintaining a shorting circuits system. The closed circuit track circuit was patented by Dr. William Robinson in 1872 and allowed for automatic block signaling to be implemented [1, 2].

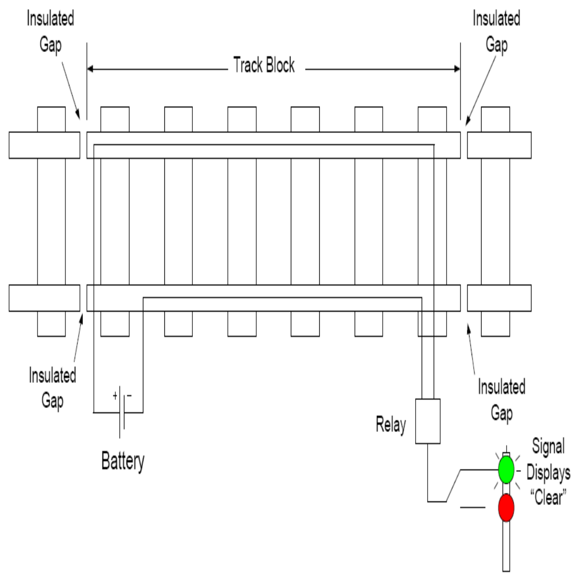

Fig. 1 Clear Track Circuit

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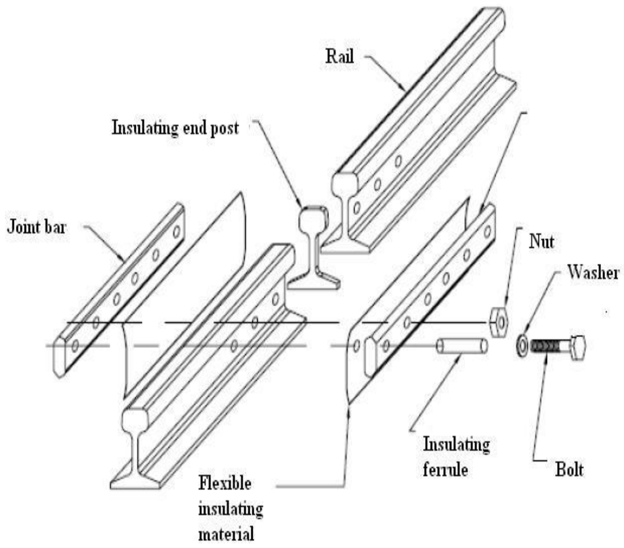

Fig. 3 Component of IRJs.

II. OVERVIEW

Today IRJ has short service as 200 million gross tons (MGT) i.e. only about 20 % that of non-insulated joints including continuous welded rail (CWR).This service life is lower than virtually all other. . It has very short service of replacement as 12-18 months [6]. Due to degradation and failure of insulated joints there may be chances of failure of signal which will cause delay in train and also there is chances of accident. There are two types of failure occur in IRJ: Electrical and Mechanical failure. Before failing electrically it leads to mechanical failure, which occur due to different stresses develop in various component of IRJs.

Joint stresses and failure —

- Bending stress
- Thermal stress
- Residual stress
- Shear stress
- Von mises stress
- Stresses due to static and Dynamic load
- Fatigue failure
- Broken bolt
- Epoxy layer debonding from rail, joint bar or both
- Joint bar failure
- Delamination of end post
- Crushed end post and metal flow.

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III. OBJECTIVE

Investigation of stresses developed in insulated rail joint. Study of various mode of failure in rail, joint bar and endpost.

IV. PREVIOUS WORK ON IRJ STRESSES

Kerr and Cox [1] carried out an analysis of insulated rail joints subjected to vertical wheel loads. They presented a semi-analytical relationship to illustrate bending moment distribution in the vicinity of joints and central deflections. It was indicated that the bending moment distribution leads to delamination failure due to the large deflections at the joints. The most frequent cause of IJ insulation failure, as documented by the railroads, is adhesive debonding.1 The weakened adhesive bond allows moisture intrusion causing metal corrosion and adhesive debonding. The higher stiffness of epoxy adhesives, as compared to the rail steel, seems to be responsible for cracks at the end post. In cases where most of the epoxy bond is still intact, shearing action in the bolts and friction at the debonded surfaces has little effect. On the other hand, when the epoxy debonding becomes extensive enough, the relative displacement between bars and rails grows larger. This allows the bars and rails to bear directly on the bolts, concentrating forces at the edges of the bolt holes. It also creates shear stress on the debonded surfaces that exceeds the maximum static friction stress and causes slippage.[4] In addition to bending, thermal, and residual stresses, rail joints are also subjected to dynamic loads due to these discontinuities[5]. A lower difference in elastic modulus can reduce the interface stress magnitude in the rail ends, however, it could adversely result in higher stress in the insulation material, which may lead to its earlier failure [6].

Electrical failure often results when the loose joint experiences contact between metal surfaces on the rails and joint bars or bolts – a result of fretting, deterioration or wear in the insulator, relative component movement, and related processes. [7]. The modes of failure of IRJ’s is different for different countries. Metal flow or plastic deformation in the vicinity of IRJ’s is a major problem in Australia, whereas delamination, bond failure, broken joint bar, or looseness of the bolts are the various modes of failure in India ,America and other countries. The weakened epoxy IRJ bond allowed moisture entry and larger deflection. A sign of rust is evident near the end post (fig. 4)

Fig. 4 Failed Glued Bond in IRJ

The wheel/rail contact impact and the associated longitudinal stress due to wheel loads and perhaps also to thermal effects contributed to bolt looseness. As a result, breaking of joint bar bolts (due to bending), battered end post (fig. 5) and broken joint bar (fig. 6) failures might occur.

Fig. 5 End Post Crushed in IRJ Due to Pull-Apart

Railhead surface defects due to metal plasticity (metal flow) in the vicinity of the IRJ is another type of failure mode. Initiation of this failure mode depends on the presence of running surface defects on the railhead (fig.6) . It can progress to railhead metal failure such as squashing (fig.7) and chipping out. (fig.8).

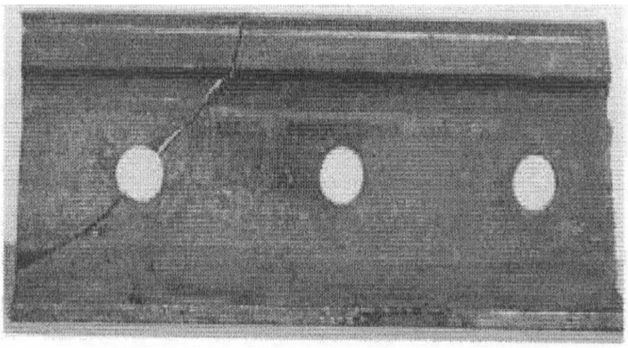

Fig. 6 Shear Failure of Joint Bar Due to Shear Mode of Failure

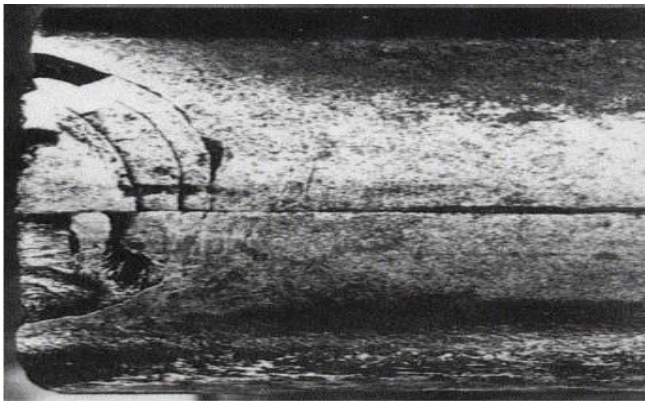

Fig. 7 Squashing of Railhead

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Fig. 8 A Typical IRJ Failure (Chipping Out)

V. FUTURE RESEARCH

Maximum work has been done on the component of IRJs like Joint bar, Rail,nut- bolt but the failure of joint start from the end post (insulating material) and then move towards the other component. so there is need of more concentration towards the endpost.

Stresses develop in endpost are-

- Crushed endpost
- Delamination of endpost
- Thermal stresses develop in endpost
- Static and dynamic load acting on it.
- Fatigue failure

In future scope we will concentrate on stresses especially thermal stresses develop in endpost. Generally epoxy fiber glass is used as insulating material for end post .another alternative to this is poly tetra flouroethylene (PTFE) and Nylon-66.

VI. CONCLUSION

Insulated joint failure causes significant disruptions to railroad operations. Better information and study about various failure occur in IRJs can help to improved IRJs .Also by using specification , design and by collecting necessary data related to IRJs , we can find out the various stresses develop in endpost analytically and can also analysis by using different software which help to identify suitable material for end post .

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