TTCI TECHNOLOGY DIGEST

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Performance of Two Frog Weld Repair Techniques

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Key Findings:

- Initial results show the experimental laser clad weld repair procedure has sufficient promise to continue development and refinement but that it is not ready for revenue service repairs in the field at this point.
- The laser clad frog was weld repaired after 23 MGT due to localized spalling 6 inches from the half-point of the frog (POF). No further weld repairs were required for the duration of the test (an additional 45 MGT for a total of 67 MGT of tonnage). Test completion was due to failure of frog components other than the weld repair.
- Direct comparisons of weld performance was not feasible due to differences in running surface profiles.
- The two castings performed similarity with wear rates that were considerably lower than weld repairs.

Weld repairs are a common technique used to extend the life of frogs after cracking or point failure. This study looks at an experimental frog welding method called laser cladding, and a conventional weld in Section 33 of Transportation Technology Center, Inc.'s (TTCI) Facility for Accelerated Service Testing (FAST). The proposed benefits of laser cladding are that less heat is used — typically less than 400°F — which reduce heat damage and leaves no porosity or slag preventing the need for ball peening or arcing.

Currently, this method only can be performed in a shop; thus any frog repaired via this means would require removing, replacing, transporting, and reinstalling. The industry is working towards implementing repairs such as these in a revenue service setting.

WELD REPAIR AND INSTALLATION

Both the laser cladding frog (test frog) and conventional weld repair frog (control frog) had weld repairs on the point and one of the wings. For the laser cladding frog, the weld repair on the point extended about 23 inches from the 5/8-inch point of the frog (i.e., the physical start of the frog point) and about -6 to 20 inches from 5/8-inch point on the wing. For the control frog, the weld repair on the point extended about 11 inches from 5/8-inch point and about -2 to 7 inches from 5/8-inch point on the wing.

Prior to installation, the frogs were checked for cracks using dye penetrant testing. No cracks were observed from the laser cladding frog while additional welding was required for the control frog.

Both frogs are No. 10 and received no tonnage since weld repairs were made. To minimize effects from any vehicle dynamics caused by one frog on the other, the frogs were spaced at a half-car length apart (~31 feet) and were installed on opposite rails because the weld repairs were made on opposite wings. The frogs in Section 33 are shown in Figure 1.

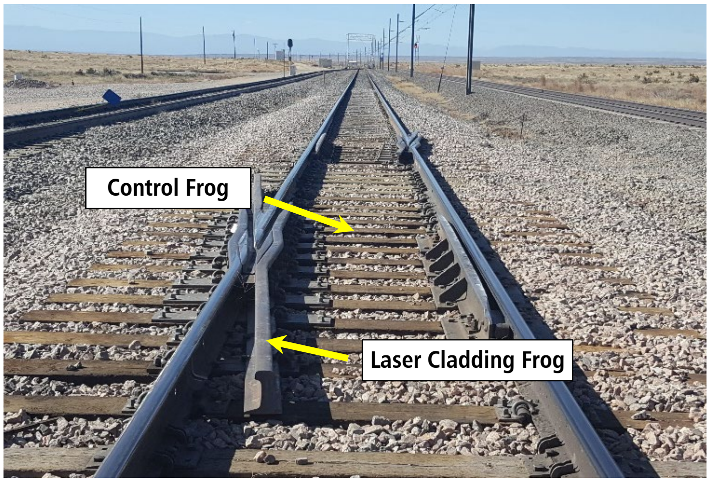

Figure 1: Configuration of test frogs in track

MAINTENANCE

The laser cladding frog encountered 23 MGT before spalling appeared about 6 inches from the point and required a weld repair using conventional methods. The spalling at 23 MGT is shown in Figure 2. The repaired laser clad frog lasted another 45 MGT before removal for reasons unrelated to the weld repair after a total of 67 MGT. The control frog experienced 52 MGT and no defects were observed with the weld repair.

Figure 2: Chipping of laser cladding frog after 23 MGT

A maintenance log that includes grinding, surfacing, and repairs is shown in Figure 3. The 18.6 and 24.5 MGT grinds were suggested by the weld manufacturer and the railroad who supplied the two frogs.

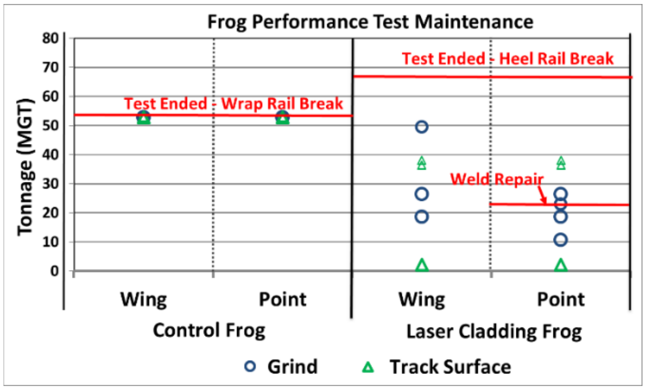

Figure 3: Maintenance log of frogs

WEAR RESULTS

To measure the wear, the profiles of the point and wing were measured at specific locations and intervals. The analyzed locations for the control and test frogs are shown in Figures 4 and 5, respectively. The red lines are the profile measurement locations, the yellow shapes are the weld repair regions, and the white line is the half-point of frog (POF). The measurement locations allow the comparisons of the weld repairs at 4 and 10 inches from POF and weld repair against castings with the -8 and 28-inch measurements. The additional measurement at 18 inches on the test frog is to verify material behavior of the weld repair.

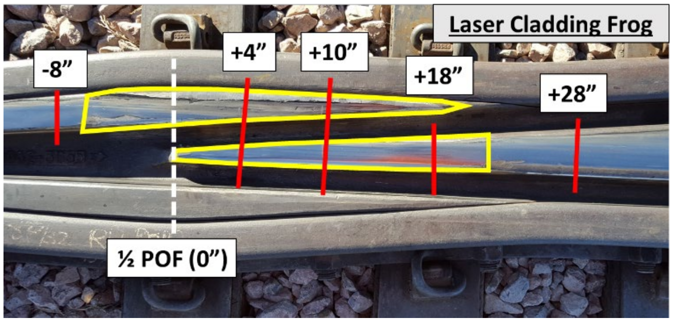

Figure 4: Locations of weld repairs and profile measurements from 5/8-inch point of the laser cladding frog

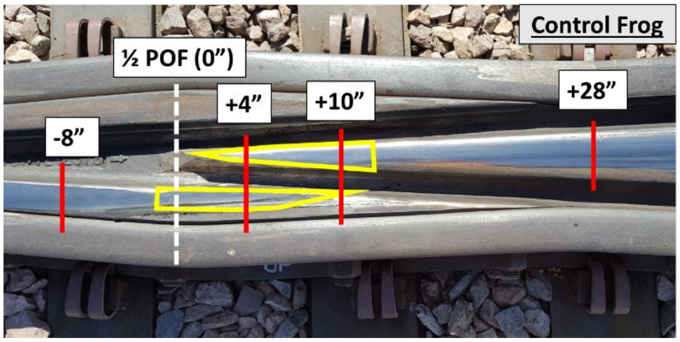

Figure 5: Locations of weld repairs and profile measurements from 5/8-inch point of the control frog

The control frog had a conventional point running surface design. The point depression was about 3/16 inch at the 5/8-inch point; rising to nominal top of rail height at 10 inches. The laser cladding frog had almost no point depression or point slope. This difference meant that most wheels were in contact with the laser cladding repair frog point sooner in facing point moves. Thus, wear comparisons of the wings and point in this 10-inch region (0 to +10 inches from POF) are of interest to frog designers; but are of little practical value for comparing weld materials.

Nevertheless, some valid comparisons were possible for the two weld repair methods.

- The laser clad weld repair had a lower initial surface hardness. (220 BHN vs. 283 BHN). The two repairs show similar work hardening trends. The lower initial hardness may account for some of the larger height loss in the laser clad frog.
- Where most comparable, at the top of the point slope (+10 inches), the laser clad weld repair had about 6 mm of wear in 50 MGT. The control repair frog had about 3 mm in the same interval. This is shown in Figure 6. The laser clad repair frog also required more frequent metal flow grinding.
- The lack of a point slope on the laser clad frog caused a re-apportioning of wear between wing and point. This is likely to shorten frog life as the point wears out first. In addition, a large deviation in wear ratio (between point and wing) from 1.0 may impair the ability of wheels to transition from wing to point without causing impacts. Figure 7 shows height loss ratio (point/wing) for the two frogs at +4 inches.
- Castings performed similarly. As shown in Figure 8, the original casting materials performed similarly in wear during the test. A location on the frog point, towards the heel of the frog was selected for comparison (+28 inches). This location has a wide bearing area for the wheel. Thus, the wear rates are very low here, as compared to the wheel transfer zone.
- The test duration was affected by failures of other frog components. The 60-degree heel rail joints, for example, had rapid degradation under HAL traffic. Failures of these components during the test affected frog availability and dynamic load environment. In addition, a failure of a wrap rail on the laser clad repair frog occurred after about 50 MGT. The current method weld repair frog was removed from track to provide a wrap rail that allowed continuation of the laser clad repair frog test.
- The volume of material repaired was greater on the laser clad frog. This may have affected the wear results, especially if the depth of repairs was larger.

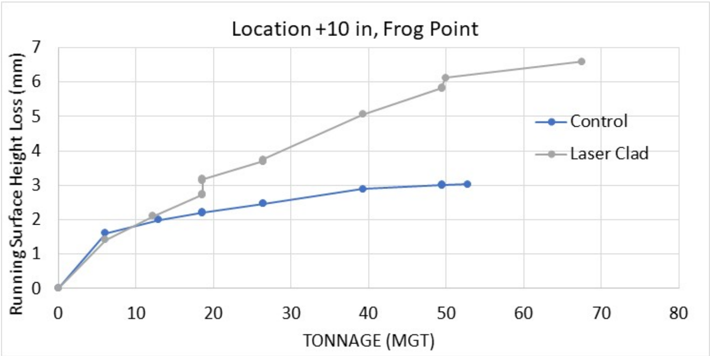

Figure 6. Vertical height loss of frog points vs. tonnage for test frogs

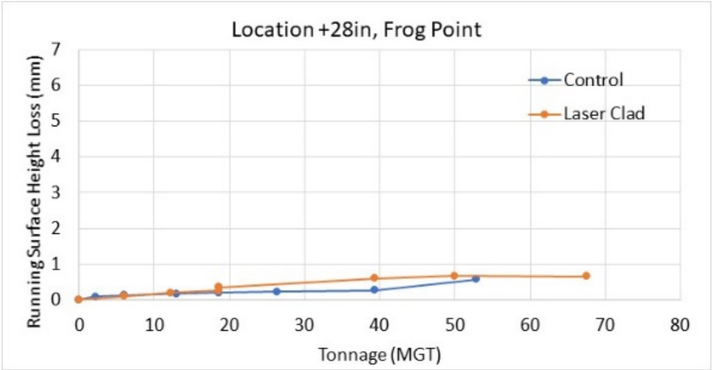

Figure 7. Height loss ratio (point to wing) for the test frogs over the duration of the test

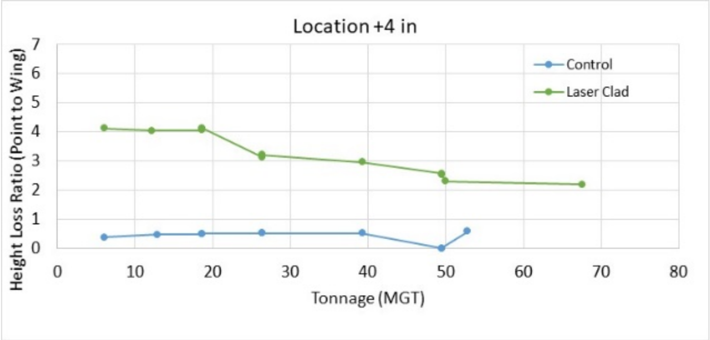

Figure 8. Running surface height loss vs. tonnage for the original casting material

CONCLUSION

Although a true wear comparison between the two repair methods proved impractical, and compounding component failures ultimately led to the removal of both frogs, the two frogs did still provide valuable data that documents the importance of having a proper point slope in the area of wheel transfer. The difference in wear at the +10 measurement location illustrates that just by having a point slope, you can potentially reduce initial deformation substantially. If paired with a weld repair method and material that has optimum wear performance, this could provide extensive savings in both time and maintenance for frogs that routinely encounter heavy axle load traffic.

FUTURE RESEARCH

The potential cost advantages of an automated weld repair procedure for frogs and the initial performance of the test weld in heavy axle load service suggest that additional research and development effort is warranted. The focus of future work will be concerned with optimizing the point slope design of the frog to minimize deformation, and also to document the long term performance and wear characteristics of additional repair methods.

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