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THERMITE HEAD-DEFECT REPAIR WELDS AT THE EASTERN MEGA SITE

SUMMARY

From October 2013 to March 2017, thermite head-defect repair test welds from two different suppliers were installed at the eastern mega site near Princeton, WV, on mainline track of Norfolk Southern Railway (NS). Transportation Technology Center, Inc. (TTCI) conducted this research under the Heavy Axle Load (HAL) Revenue Service Program jointly funded by the Federal Railroad Administration (FRA) and the Association of American Railroads (AAR).

Eight thermite head-defect repair welds in total were installed on two 6.8-degree curves. Two welds from each supplier were installed on the high rail and two welds from each supplier were installed on the low rail of each curve. These welds had accumulated 128 million gross tons (MGT) as of November 2016, and were performing similar to the welds installed at the Facility for Accelerated Service Testing (FAST) at the Transportation Technology Center (TTC) near Pueblo, CO (Gutscher, D., 2009).

The head-defect repair welds at the eastern mega site demonstrated the following performance:

- All eight thermite head-defect repair welds had surface rolling contact fatigue (RCF) and minimal metal flow at the heat-affected zones (HAZ).
- Supplier B's low rail welds showed small amounts of shelling or pitting near the HAZ. Supplier A's low rail welds showed a greater amount of shelling or pitting throughout the weld material, as well as the HAZ.
- Periodic preventive grinding was conducted on these test welds, which has kept the RCF and the metal flow from the soft HAZ regulated.
- There were no weld failures.

Thermite head-defect repair welds were developed as an alternative repair process to the standard practice of removing the section of rail containing the defect and replacing it with a plug with two conventional thermite welds at each end. By only removing the section of the railhead where the defect is located, fewer welds are needed, the web and base of the rail remain intact, and the rail neutral temperature is preserved.

The process for both suppliers can repair the head of a rail by the use of a single thermite head-defect repair weld if the defect is less than 2 inches long in the longitudinal direction.

BACKGROUND

Thermite head-defect repair welds were developed as a way to eliminate the need for a rail plug and additional field welds by only cutting out the section of the railhead that contains the defect. The time it takes to go through the thermite head-defect repair weld procedure for both suppliers is less than the time it would take for one welding crew to align and pour two thermite field welds that would be necessary when installing a plug. The major benefit of a thermite head-defect repair weld is that it does not change the longitudinal rail stress since the rail is not cut.

OBJECTIVES

NS, in collaboration with TTCI and two weld suppliers, installed eight thermite-head defect repair welds at the eastern mega site to evaluate an alternative repair process to the standard rail defect removal procedure. This report provides a summary about the thermite head-defect repair welds evaluated at the eastern mega site.

METHODS

In 2013, eight thermite head-defect repair welds were installed at the eastern mega site in two 6.8-degree curves that are 1/4 mile apart. Figure 1 shows the test layout. Two welds from each supplier were installed 20 feet apart on the high rail and on the low rail in each curve to minimize preferential effects due to the location in the curves on any one weld supplier's product. All welds were made in minimally worn defect-free premium 141-lb. rail.

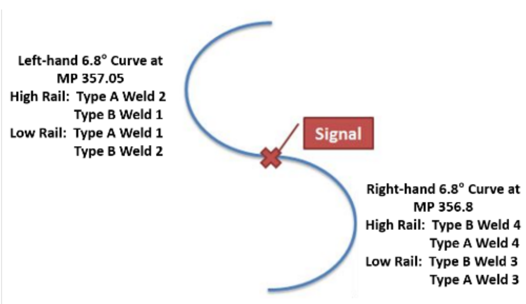

Figure 1. Head-Defect Repair Weld Test Layout at the Eastern Mega Site.

Two suppliers have developed their own versions of the thermite head-defect repair weld. For both methods, the weld portion is poured into a slot using materials and processes that are similar to those used for conventional thermite welds, according to each supplier's guidelines.

Supplier A's practice involves milling a slot into the railhead with a depth of 1 inch using a modified Matweld frog grinder. This process can remove defects that are within 1 inch in depth from the running surface and 2 inches in length longitudinally. Oxygen-propane is used in this process to preheat the rail for 6 minutes before pouring the weld.

Supplier B's practice is to mill out the full depth of the railhead using a dedicated Portico grinder with a spark shield. This process can remove defects that are within the depth of the railhead including 0.25 inches below the head fillet and less than 2 inches in length longitudinally. Oxygen-propane is used in this process to preheat the rail for 3 minutes before pouring the weld. This process is similar to the standard thermite installation process typically used at the eastern mega site. Figure 2 shows each process.

Figure 2. Supplier A's Process Requires a 1-Inch Slot (left) and Supplier B's Process Requires the Slot to be the Depth of the Full Railhead (right) (Gutscher, D., 2009).

RESULTS

As of November 2016, all eight of the head-defect repair welds were still in track and had accumulated 128 MGT. Through this section of track, the train speed is between 15 and 25 mph. With a balanced speed of 23 mph for these two curves, the mostly underbalanced operating speeds cause welds on the low rail to be exposed to the higher loads and, in turn, higher rates of running surface deformation. Therefore, the performance of the low rail welds from each supplier was the major focus of this study.

Overall, the welds on the high rail of each curve were visually in good condition throughout the test with the exception of some RCF and minimal metal flow in the HAZ.

Figure 3 shows two welds, one from each supplier, installed on the low rail of each curve at the eastern mega site. Supplier B's thermite head-defect repair weld installed on the low rail shows minor RCF throughout the whole weld and HAZ, and minor pitting only in the HAZ. Supplier A's thermite head-defect repair weld installed on the low rail shows an increased amount of RCF throughout the weld material and HAZ; however, the pitting is seen not only in the HAZ, but also in the weld material location.

Figure 3. Head-Defect Repair Weld Installed on the Low Rail: Supplier A (top) Supplier B (bottom).

Visual inspections and subsequent measurements were conducted on a semi-annual basis from October 2013 to November 2016 to monitor and document the performance of the test welds. NS provided periodic manual ultrasonic scanning to monitor the welds for the development of internal defects; however, no internal defects were ever found

Figure 4 shows the surface hardness values that were also measured at five locations for each weld. These included parent rail on either side of the weld, at approximately 12 inches from the HAZ; within both HAZ; and at the centerline of the weld itself.

The hardness values measured at the centerline were slightly lower than those of the parent rail, which is head-hardened premium rail. As expected, the hardness results measured in the HAZ were lower than those measured for both the parent rail and the welds.

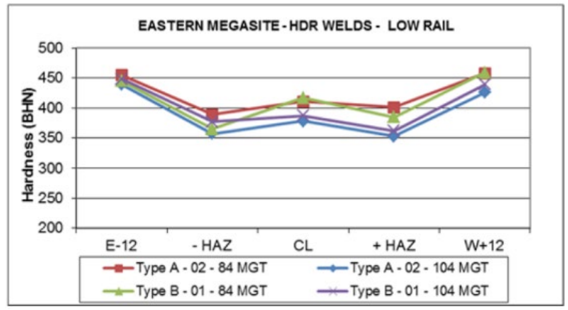

Figure 4. Post-Grind Hardness Measurements are Shown with the Data Taken at 84 MGT and 104 MGT. Type A Refers to Low-Rail Welds from Supplier A and Type B Refers to Supplier B.

CONCLUSION AND FUTURE ACTION

As of November 2016, the head-defect repair test welds at the eastern mega site were performing similar to those at FAST, especially with regard to RCF, HAZ metal flow, and pitting that were observed on the low-rail welds in the HAL operating environment. TTCI continued to monitor the performance of all eight welds at the eastern mega site until March 2017, when the welds were removed due to a scheduled rail change for the two curves housing this test.

REFERENCES

Gutscher, D. (2009, December). Results of Thermite Railhead Repair Weld Testing at FAST. *Technology Digest, TD-09-036*.

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KEYWORDS

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