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EVALUATION OF LONGITUDINAL WING SLOPES FOR NO. 20 FROGS

SUMMARY

In a collaboration between the Federal Railroad Administration (FRA) and the Association of American Railroads (AAR), Transportation Technology Center, Inc. (TTCI) investigated the benefits of modified No. 20 frogs on mitigating damage to the frog point, heel, and wing rails under heavy-haul operations. This long-term study, which began in 2013, is being conducted on a heavy-haul mainline in the eastern United States. The latest iteration began in 2019 and focused on evaluating longitudinal wing slopes in No. 20 frogs.

A smooth wheel transition needs the proper elevation relationship between wing rail and the frog point. When the elevation relationship is not correct, wheels traversing a frog in the facing-point direction will abruptly transfer from the wing to the point due to the sudden elevation differences between the two, resulting in a crushed frog point over time (Figure 1). Frog points worn to the point of being substantially lower than the running surface of the wings further worsen the problem; this results in more accelerated degradation on the frog point, which could potentially lead to a derailment (e.g., wheels picking a worn or broken frog point).

Figure 1. Surface damage on the wing rail

To mitigate this risk, researchers worked with Norfolk Southern (NS) Railway to evaluate new frog designs that may reduce this unwanted contact in revenue service. The team designed the testing to examine the benefits resulting from design modifications made to No. 20 rail-bound manganese (RBM) and welded-boltless manganese (WBM) frogs. More specifically, researchers made modifications to the surface of the wing rail.

Results to date have not conclusively shown that the wing designs help mitigate the studied issues. It is likely that additional tonnage may be required to demonstrate a clear benefit.

BACKGROUND

Previous studies (Davis et al., 2019) have shown that the tread and profile wear on a wheel can affect how it transitions from the wing to the point when traversing a frog. Worn wheels must climb up the flangeway to get on top of the wing, resulting in high forces and stresses on the frog wings. Also, in the facing-point direction, worn hollow wheels will ride on the wing until the point becomes wide enough that they run out of wing and drop onto the point. In this scenario, the point is not tall enough to contact the wheel tread, which results in crushed frog points. Furthermore, poor longitudinal profile combined with worn hollow-tread wheels create concentrated point loading on the frog wing.

Preventing this detrimental dynamic loading environment for both the point and wing led to the current set of design modifications being evaluated: wings with longitudinal slopes on a frog with a defined point slope. The successful model for this design was a switch point riser that is already widely used. The difference in the studied frog running surface design was that

instead of the frog point being raised above nominal rail height, the wing was lowered.

The modified slope designs used in this study were based on previous work (Sasaoka et al., 2002, 2003). Figure 2 illustrates the profile view of the longitudinal slope relative to the frog point. The downward slope was designed to prevent point impacts from hollow-tread wheels in facing point moves and to stop the same wheels from slamming into the wing surface in trailing point moves.

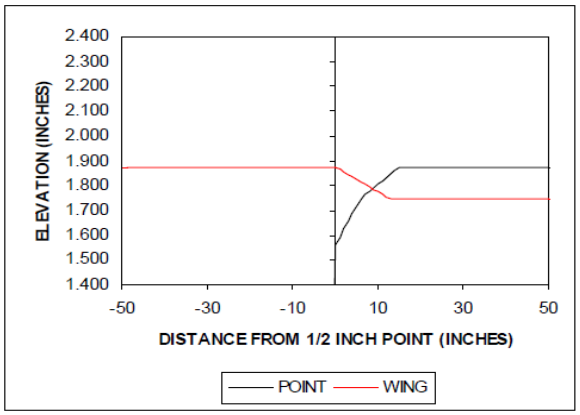

Figure 2. Profile view of the longitudinal wing slope versus the frog point slope

OBJECTIVES

The primary objective of this project was to evaluate the performance of a modified longitudinal slope design for No. 20 RBM and WBM frogs in revenue service.

METHODS

Progress Rail and VAE Nortrak North America provided the heavy-point No. 20 frogs used in this research, which were modified with variations in the slope design. Progress Rail donated a RBM frog ("Bracht"), which had uniform longitudinal slopes on both wings (i.e., 1/8 wing slope in 24 inches on both the main and diverging routes). VAE Nortrak donated a WBM frog ("Reid"), which had longitudinal slopes of varying lengths and steepness (i.e., 1/8 wing slope in 24 inches on the main route, and 1/8 wing slope in 12 inches on the diverging route). These designs allowed researchers to determine if a slight slope over a longer distance was more effective at preventing point impacts and wheel slamming than a steeper slope over a shorter distance. Figure 3 shows the frog fabricated with these two different slopes.

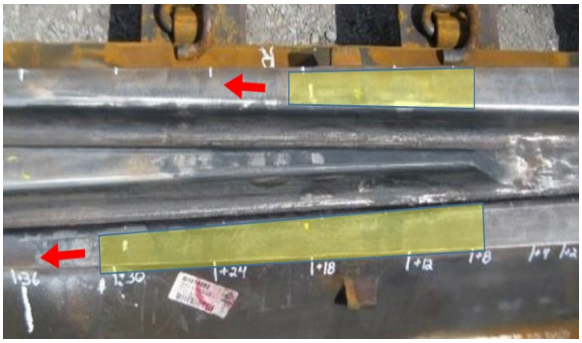

Figure 3. The modified test frog with two different longitudinal wing slopes: a steep slope over a shorter distance (top), and a slight slope over a longer distance (bottom)

In 2019, the two frogs were installed for long-term monitoring at two revenue service locations along the same mainline in rural Kentucky. For comparison, two additional standard (i.e., unmodified) heavy-point No. 20 WBM frogs ("Kings Mountain" and "Palm") were also selected for monitoring on the same mainline.

It is important to note that both the modified and unmodified frogs in this study featured flat-top wing rail profiles, rather than the more recent conformal profiles (Sasaoka et al., 2002, 2003). The research team conducted bi-annual inspections to (1) document the condition of the frog point and wing rail, and (2) measure the wear along the wing rail using a profilometer.

RESULTS

Figure 4 presents the diverging wing height loss collected after 139 million gross tons (MGT) for the modified frogs and 150 MGT for the unmodified frogs. Figure 5 shows the mainline wing height loss for the same tonnages. In Figure 4, the green line indicating the wear along the wing rail for the standard (i.e., unmodified) frog shows a large increase in height loss between approximately 12 and 18 inches from the point of the frog (POF).

Maintenance records obtained from NS indicated that the diverging wing rail had already received both a weld repair and subsequent grinding to address degradation. However, no maintenance was needed for the mainline wing rail, which showed a height loss consistent with that of the modified frogs in Figure 5.

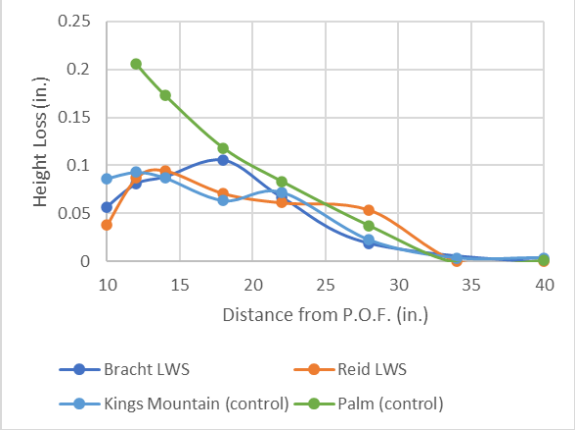

Figure 4. Plot of the diverging wing height loss for all frogs

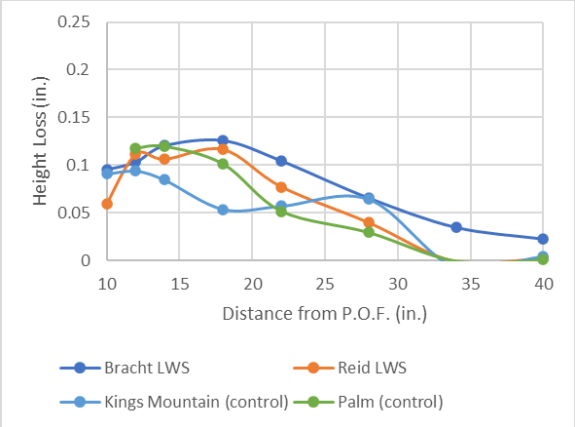

Figure 5. Plot of the mainline wing height loss for all frogs

In terms of surface condition, only minor spalling was observed on the frog point itself. Figure 6 shows the condition of the modified frog at Reid, which had the most spalling of the four frogs monitored in this study.

Figure 6. Condition of the frog point for the modified frog at Reid (139 MGT)

CONCLUSIONS

As this is a long-term field study, this report only provides an initial update on the status of the heavy-point No. 20 RBM and WBM frogs, modified with two variations in the wing slope design. Regarding degradation to the frog point, none of the frogs suffered a crushed head or previously received maintenance to address a crushed head. Of note, Bracht received a weld repair beyond the transfer zone at some point before 181 MGT. This was in response to an internal defect found in the casting approximately 37 to 40 inches from the theoretical POF, beyond the ends of the wing slopes. Despite some notable spalling present on the modified frog at Reid, the remaining frog points and wing rails were in excellent condition at the time of the most recent inspection in 2022.

Based on the wing height loss, there doesn't appear to be a significant difference between the modified and unmodified frogs. While maintenance (i.e., welding and grinding) was required on the unmodified frog at Palm, it is possible that this could be the result of a manufacturing quality issue rather than the design. As such, additional data is needed to be confident about the benefit of variable longitudinal slope design on wing degradation.

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CONTACT

Jay Baillargeon
Program Manager
Federal Railroad Administration
Office of Research and Development
55000 DOT Road
Pueblo, CO 81001
(719) 584-7155
jay.baillargeon@dot.gov

Stephen (Sean) Woody
Chief, Track Research Division
Federal Railroad Administration
Office of Research and Development
1200 New Jersey Avenue SE
Washington, DC 20590
(202) 573-3252
sean.woody@dot.gov

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