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Evaluation of an Automated Gage Face Lubrication Technology at FAST

Ananyo Banerjee, Joseph A. LoPresti

Summary

In 2017, Transportation Technology Center, Inc. (TTCI) conducted an assessment of the Robolube Linear Lubricator™ (RLL), an automated gage face (GF) lubrication technology that uses a sensor-based grease spraying method developed by Robolube, Inc. The unit was installed on the high rail in a spiral leading to a 6-degree curve of Section 25 on the High Tonnage Loop (HTL) at the Facility for Accelerated Service Testing (FAST) in Pueblo, CO. The year-long test, performed under the Association of American Railroads' (AAR) Strategic Research Initiative (SRI) program, resulted in the following conclusions:

- Performance metrics depended on the size of nozzle orifice, the spraying distance of orifice from the rail gage corner surface, the length of grease applied, and the viscosity of grease.
- In ideal operating conditions, grease consumption varied between one-third and one-quarter of the amount used per train pass when compared to the conventional GF lubrication system used at FAST. Comparable carry distance was observed along the curve with minimal grease contamination of surrounding ties and ballast. No grease catch mats were used during testing.
- Spraying inconsistency was largely dependent on grease viscosity and temperature. Grease carry was found to be intermittently adequate from the RLL location on most of the 6-degree curve, with its effectiveness dependent upon grease temperature and the precise spraying location on rail gage corner. On many hot days and cold nights, the spraying was observed to be inconsistent and led to inadequate grease carry along the 6-degree curve.
- Thicker grease tended to get applied below the gage corner, leading to poor pick-up by the wheels and causing inadequate lubrication further down the track.
- The unit's mechanical systems functioned without issue, but a few issues related to programming cycle were encountered during the operations. The rack assembly's installation is compatible with ties with cut spike fasteners, but is currently incompatible with elastic fasteners.

The RLL is designed to apply grease to the gage face of the high rail of the track; preferably in the apex of the curve for bi-directional train traffic. In-curve installation is possible because this application system is not affected by wheel flange contact. The technology is designed to consume less grease than conventional GF lubricators, eliminating the need for grease catch mats and preventing waste of grease that can lead to contamination of ballast, ties, and other track components in the vicinity.

Please contact **Ananyo Banerjee (719) 584-0713** with questions or concerns regarding this *Technology Digest.* E-mail: Ananyo_Banerjee@aar.com.

INTRODUCTION

Top-of-rail friction modification, along with GF lubrication, can provide adequate friction reduction between wheels and rails to prevent premature wear. Most GF lubrication technologies have application bars installed next to the rails that release grease when wheels pass over the rails. The grease sticks to the wheels and is carried along the rails by their movement. As shown in Figure 1, there can be considerable contamination of the surrounding ballast and ties caused by wastage of the grease. Thus, catch mats are placed in between rails to reduce contamination by grease.

Figure 1. One of two applicator bars of a conventional GF lubrication unit releasing grease with surrounding contamination

In 2017, TTCI conducted a year-long evaluation of an automated GF lubrication technology at FAST. Robolube Inc. developed this technology to apply grease on the rails by a sensor-controlled spraying mechanism and without directly applying on the wheels. The methodology was to achieve less consumption of grease than conventional GF lubrication systems and prevent further wastage that causes contamination of ballast and ties.

Operating principle

As shown in Figure 2, the RLL was installed alongside the track with hydraulics and electrical cables connected to an application rack assembly mounted on top of the ties on the inside of the high rail and secured to the base of the rail with three metal brackets. The unit is powered by an electronic, fuel-injected 25-horsepower LP liquefied petroleum (LP) gas engine that provides the hydraulic power required to run the unit and to heat the grease. The engine and the hydraulic unit is housed in the enclosure outside the track. The enclosure also includes the grease tank, control panel, storage for grease, and spare parts.

The engine is coupled directly to two hydraulic pumps that provide the hydraulics required to perform all operations. The activation occurs when the wheel sensor, (mounted adjacent to the application rack assembly), detects a time lag of few seconds after the last wheel of the train has moved over the sensor. The greasing cycle commences with the activation of the motion sensor. The time lag of the motion sensor is an adjustable parameter. The unit then applies a bead of grease at, or near, the gage corner of the rail. After the grease is applied, a hydraulic cylinder mounted inside of the application rack returns the dispensing nozzle to its standby position. This unit is designed to spray the grease after a train has passed. The intent is that the grease is carried by the wheels of the subsequent train followed by another application of the grease and so on. The unit heats the hydraulics and the grease tank to maintain optimum operating temperatures. When the temperature of the hydraulics or grease reach a predetermined temperature, the RLL starts a heating cycle to increase the oil and grease temperatures to predetermined settings. At the end of the heat cycle, the application rack will run the nozzle one more time without dispensing grease to cycle the colder hydraulic oil out of the dispensing cylinder. The 55-gallon grease tank comes with a level indicator and the control unit has an emergency red light that activates if the control unit encounters a fault code. The fault codes can be sent to appropriate personnel via e-mail and/or text.

Figure 2. Complete assembly of RLL installed at FAST

Although the RLL can run on 110V or 240V electrical power, most GF lubrication systems are installed on track in revenue service where power outlets are not available. For simulating applications in such areas, this test was conducted using a solar panel supplied by Robolube for charging the battery and a propane tank was installed 200 feet from the track with underground connections to supply propane to the engine.

General observations

The RLL unit was installed on the spiral approaching a 6-degree curve of Section 25 on the HTL at FAST and was started at the onset of train operations. The FAST crew routinely monitors the grease buildup on the gage side of the rail in the Section 25 6-degree curve at three specific locations after approximately every 15 laps during train operations. The RLL was installed approximately 15 feet ahead of TTCI's GF lubrication unit, which has two applicator bars attached to the high rail. The RLL unit was run only on nights when the FAST train ran in the counter-clockwise direction. The performance metrics were evaluated based on the following list of criteria:

Consumption of grease: The FAST GF lubrication system can be programmed to apply grease after a specified number of wheel passes, varying from 1 to 255, and is set at 20 wheel passes for most nights. For an average of 400 wheel passes equivalent to one train pass, the GF lubricator applied grease 20 times. Thus, samples were collected from both applicator bars after the lubricator applied grease on the rail 20 times. The RLL applied grease once per train pass as it sprays after the last wheel of the train has moved over the sensor. Samples were collected from RLL at the same time. Both lubricators had the same grease when the samples were collected. The comparison in grease consumption is shown in Figure 3.

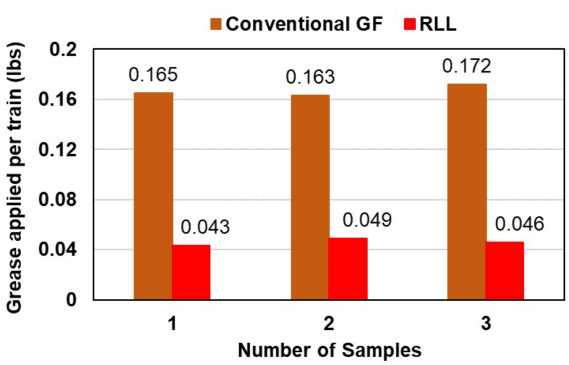

Figure 3. Comparison of grease consumption between RLL and conventional GF lubrication system at FAST

Temperature effects: Since the RLL is a non-contact lubrication system, the performance is mostly dependent on the precise location of grease applied from the spraying nozzle located inside the rack assembly at approximately 4 inches away from the gage surface of the rail. This is a limitation of the system as any vertical movement of the unit or the rail can cause the location of grease application to shift from its intended location. Although the spraying pressure is adjustable in the two pumps controlling the hydraulics, the projectile motion of the spray is dependent on the viscosity of the grease present at the nozzle. The viscosity is dependent on the temperature of the grease present in the nozzle, which further depends on the surrounding temperature. On days/nights with temperatures below 60-65°F, the grease would often become thick and the nozzle was found to spray below the gage corner. Spraying below the gage corner caused the wheel flanges to pick up less grease causing the high rail to become dry within a few laps because of poor carry distance. On days with temperatures above 90-95°F, the grease was found to become too thin although train operations did not start until after air and rail temperatures had dropped. Spraying grease having optimum or lower viscosity (thin) was found to be less problematic than spraying grease in colder temperatures as thick grease tends to clog the nozzle orifice.

Another possible contributing factor to the inconsistency in spraying was the four to five days of inactivity when the RLL unit was turned off as the train ran in the clockwise direction, or was not in operation. This caused the grease in the nozzle orifice to stay idle. When the unit was turned back on, it required several passes before fresh grease could be sprayed and proper lubrication could be achieved. When proper grease application was delayed in such conditions, the 4 to 5 minutes frequency of the FAST train would make it difficult for the RLL to spray grease in the first 10 to 12 laps and provide adequate lubrication to the rail. The RLL unit is designed for revenue service train operations and consistent train traffic that would cause the unit to spray grease without having long periods of inactivity. Figure 4 shows the viscosity effects causing differences in spraying location. It is to be noted that the temperature ranges mentioned above are for reference purposes only and effects of temperature on spraying differences was not quantified as a part of this study.

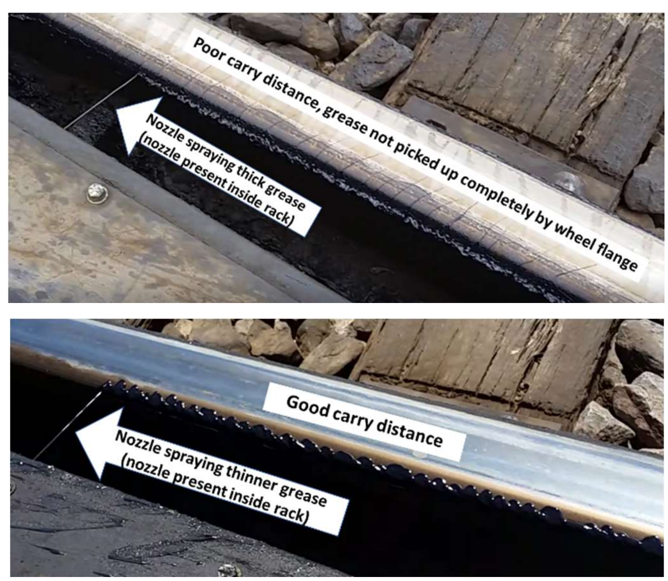

Figure 4. Difference in spraying application caused by temperature effects on grease viscosity

Grease carry distance and lubrication: On nights when the RLL ran for all laps from start to finish of train operations, grease was found to carry well through the 6-degree curve as observed by FAST personnel at distances of 675, 1,350 and 2,000 feet, from the beginning of Section 25, though it was not observed whether the grease carried to the end of the curve. Coefficient of friction (μ) measurements on gage corner using a tribometer were measured at specified distances of 50, 100, 200, 400, 800 and 1,600 feet from the RLL on three nights in March, April and June. These measurements were taken when the RLL unit operated throughout the entire night of FAST train operations. The μ values were found to vary in the range of $\mu = 0.11\text{-}0.30$ with μ increasing from 0.11 to 0.30 with increasing distance from the RLL. AREMA Chapter 4 recommends $\mu=0.20$ at gage corner, $\mu<0.20$ on gage face and $\mu=0.20\text{-}0.35$ between gage corner and top of rail.[1] But on many nights, the grease on rail was found to decrease during consecutive laps as surrounding temperature decreased and the RLL unit's wheel sensor had to be activated manually to spray more grease before the next train pass.

Mechanical systems and maintenance: No issues were encountered with the mechanical systems during the testing phase. The RLL's engine requires oil and filter changes at regular intervals when it is operational daily.

Other observations on RLL performance

- Length of spray application: The nozzle traverses a length of approximately 5 feet while the circumference of the FAST wheel is about 10 feet. The entire grease sprayed in one pass is picked up by half of the wheel's circumference and might cause variable lubrication on the high rail depending on curvature and grease temperature.
- Heating grease in pipes and rack assembly: Although the RLL maintains optimum grease temperature in the grease tank, grease carried by the pipes from the tank to the nozzle orifice of the rack assembly needs to be maintained at an optimum temperature range to prevent clogging and inconsistency in spraying caused by variation in grease viscosity.
- Reducing variability of the distance between nozzle orifice and rail: The distance between nozzle orifice and the gage corner of the rail is critical to spraying consistency. Variability in the distance between nozzle orifice and rail can cause variability in grease application. The current design of the RLL allows the nozzle to stay inside the rack assembly while spraying grease. Sometimes leftover grease from previous cycles was found to stick on the outside walls of the rack assembly; thus blocking the path between the orifice and the rail.
- Broader application of grease: During this testing phase, different orifice diameters were tested which resulted in minor improvements in spraying application. Spraying a broader band might eliminate orifice clogging issues that were observed during cold weather applications as well as make the location of grease application less susceptible to shifting due to any vertical movement of the unit or the rail.
- Design changes to accommodate fastener variation: The RLL unit's rack assembly is easily attached to the base of the rail by three brackets, but this design is only applicable for rails having wood ties and cut spikes as fasteners. The current design of the rack assembly needs additional ground clearance for installing on track having elastic fasteners.
- Train frequency effect: The frequency of the FAST train activating the RLL unit's sensor is approximately 3 to 4 minutes when the train is running at its usual speed. This frequency caused a timing conflict between completion and initiation of the next grease spraying cycle and triggered the alarm. A programming modification rectified the problem.

CONCLUSION

During the current phase of testing, the unit could meet its desired objectives of reducing the amount of grease consumption and wastage compared to conventional lubricators, but multiple performance issues were observed related to grease application that need to be addressed for improving the unit's consistency and efficiency.

References

1. The American Railway Engineering and Maintenance-of-Way Association, Section 4.11, *AREMA Manual for Railway Engineering*, 2017, AREMA, Lanham, MD.