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Prototype Demonstration Freight Car-Based Top of Rail Friction Modifier Application System

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Summary

Top of rail (TOR) friction control has been shown to provide significant benefits though reduced curving forces, improved train energy, wheel, and rail life. The most common application systems developed to apply friction control products to the top of rail are either wayside or locomotive-based.

A new application technology for applying top of rail (TOR) train mounted friction control was demonstrated on the Quebec Cartier Mining Railroad (QCM) in December 2004. This concept, which utilizes an application system mounted in the carbody of a revenue producing ore car, produced effectiveness in a similar fashion as a locomotive-based system. Average curving forces indicated a reduction of up to 35 percent when compared to previous, non-TOR periods.

QCM supplied funding for design and fabrication of the prototype, while monitoring efforts were supplemented by funding from FRA and AAR programs.

The entire application system is mounted in an ore car that is operated at the head of the train. The spray application system is mounted on a truck frame. The system, in its current configuration, obtains air and electrical power from the last locomotive. As presently configured, this concept is particularly suited for captive freight fleets. When compared with more traditional locomotive mounted systems, this approach provides the potential for higher capital utilization and no impact on locomotive maintenance scheduling. During the 6 months of testing, no system failures were experienced.

After several weeks of test operation, lateral curving forces were shown to be reduced on not only trains equipped with the TOR system, but also the following non-equipped trains. This suggests that with proper deployment, long-term conditioning of rail and wheels will allow both TOR and non-TOR equipped trains to receive benefits of TOR friction control.

Additional evaluations of train braking have been conducted and will be reported separately. Based on these initial results, QCM has elected to implement four TOR equipped cars in the near future.

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Transportation Technology Center, Inc.

BACKGROUND

Top of rail (TOR) friction control has been shown to provide significant benefits in reducing forces and energy consumption in increasing wheel and rail life. The most common application systems developed to apply friction control products to the top of rail are either wayside or locomotive-based.

Locomotive-based systems have an advantage over wayside-based by being able to apply friction control materials at virtually all locations on a railroad. However, deployment has seen limited success due to interface issues with locomotive control systems and space availability for reservoirs, piping, and nozzles.

In 2004, Quebec Cartier Mining Railroad (QRM) provided funding to develop locomotive-based friction control prototype equipment and supplied field support. The FRA and AAR provided funding to monitor car performance, and the Vehicle Track Interaction Committee provided technical direction to determine performance of an alternative method of mobile application. This method utilizes locomotive-based application concepts, but is installed on a revenue-producing car. Technical, operation, and maintenance personnel from Kelsan Technologies and QCM developed basic operational and design characteristics for the prototype car-based TOR system.

This approach offers the capability to provide a much larger product reservoir, eliminates the need to interface with locomotive electrical systems, and utilizes simplified applicator control processes to obtain effective TOR friction control.

Demonstration Railroad and Route

The prototype car-based TOR system has been demonstrated by the QCM, which transports iron ore a distance of up to 260 miles on a heavy haul captive railroad operating through a rugged topography with 50 percent of its main line in curves of up to 7 degrees and a maximum grade of 1.35 percent. Annual tonnage is approximately 24 MGT with iron ore as the primary product, but trains of timber add to the traffic mix.

Demonstration Objectives

The primary objective of this program is to reduce curving forces though the use of friction control materials applied to the top of rail. This effort builds on previous programs by demonstrating an alternative application method that addresses many of the issues related to locomotive-based TOR systems.

Demonstrations by QCM in the mid-1990`s suggested that top of low rail lubrication on high degree curves significantly reduced curving forces, derailment potential, and reduced risks of low rail roll over. This policy was never implemented because of locomotive adhesion problems, as most of the high degree curves are located in areas where good traction is required.

Unlike lubricants, the use of a friction modifier (FM) producing a mid-range level of friction (0.3μ-0.4μ) creates a condition whereby locomotive traction is not impacted. This is essential, as it is difficult to limit residual product carryover on the rail.

TOR ORE CAR EQUIPMENT DESIGN

Evaluation of operating a separate, non-revenue car versus incorporating the TOR system into a revenue car suggested that the separate car option was less cost effective. However, by mounting delivery equipment on a revenue car the design needed to function and survive the operating conditions and environment of such cars.

QCM selected a standard 30-foot, 100-ton ore car to be outfitted with a friction modifier TOR delivery system. A general layout of the installed system is illustrated in Figure 1. Due to space requirements, the centrally mounted package reduces capacity of this one car by about 15 percent.

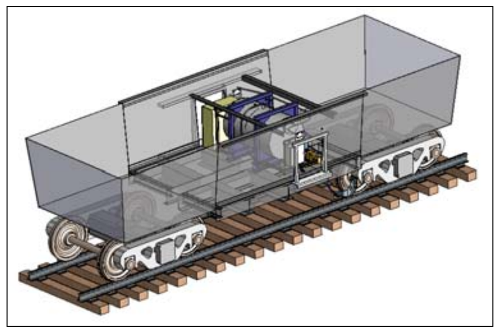

Figure 1. QCM TOR Ore Car General Layout

This car series was selected as it optimized attachment opportunities to restrain the TOR system. This was an important factor considering that the 300-gallon product tank (approximately 3,600 pounds fully loaded) would be rotated during the ore dumping process.

TOR Dispensing Equipment

The prototype TOR components are:

- 300-gallon stainless steel product tank
- Left/Right dispensing pumps and nozzles
- Head Pump
- Stainless steel material for all wetted parts
- GPS – PLC (programmable logic controller) system
- Touch screen interface
- Heat tracing cabling and elements for low temperatures
- External system indicator lights and product filling ports
- External hook-ups for 74 VDC and air

This design allows the TOR application system to be skid mounted, permitting a preassembled, pre-wired, and pre-tested package installation as a unit. Installation requires panels to be cut into the car sides.

TOR nozzle mounting brackets were designed to be attached to existing truck side frames (Figure 2). Vertical and lateral adjustment is provided to ensure proper nozzle alignment. Typically, the TOR spray nozzles are positioned 2 to 3 inches above the rail center.

Figure 2. Ore Car TOR Nozzle Mounting

The GPS-PLC System

An externally mounted Global Positioning System (GPS) provides all the required navigational information for the PLC control system including car speed, curve sensing, heading, and location. Based on this input, the PLC can be programmed to apply a constant application rate (on a per distance basis) for both tangent and curved track. Use of GPS for this application eliminated the need for having individual curve and speed sensors.

Field-testing performed during the commissioning of the prototype car indicated that the processed GPS signal was able to successfully distinguish between tangent and left or right hand curved track.

Unless prohibited by the application mode, spray operation is enabled whenever train speed is above 5 mph and disabled only when the air brake pressure switch is activated. Sensors detect which car end cable is connected to the locomotive, automatically determining the car running orientation. Car orientation is required when applying product on low rail only in curves.

Tunnels

GPS reception is not possible within the numerous tunnels encountered on QCM’s territory. The control system is programmed to recognize each tunnel using its known coordinates. If the TOR spray is active entering a tunnel, it is maintained through the tunnel using the present train speed. If GPS communications are not re-established after a pre-set time, application is stopped.

External Hook-Ups

Compressed air required for atomizing FM product at the TOR nozzles is supplied from the locomotive main reservoir system using standard railcar air hose fittings on each end of the ore car. Likewise, a 74 Vdc electrical supply for operating the TOR system is provided from a special dedicated receptacle located just below the locomotive’s standard MU electrical receptacle to connectors located on each end of the ore car.

Although it is feasible to power the base system using a single spare “pin” on a MU line, a dedicated power receptacle was used due to the high amperage heating system requirements. Current assessments are focusing on how the system could be powered completely from the MU line (multiple spare pins) or in combination with an ancillary power source such as axle generators.

MONITORING TOR EFFECTIVENESS

Significant challenges exist in monitoring TOR effectiveness, as when properly applied to the rail; friction control materials are virtually invisible to the eye. Performance parameters to determine the effectiveness of TOR friction control include rail friction, dynamic railhead deflection, curving forces, and train energy.

For this project, the primary goal was to reduce curving forces; therefore, data produced by a load monitoring station was selected as the primary method for monitoring system effectiveness. Similar methodology for monitoring curving performance is in use at many other TOR evaluation sites, thus allowing the same software package to be used in aiding performance comparisons.

Load Station Data

To determine the effectiveness of different TOR rates/patterns, average forces produced by lead or trail axles for each train may be shown in a time history format, delineated by test period. Additional analysis was conducted to display forces generated by each axle of a train, axle-by-axle, allowing front to rear effectiveness to be evaluated on a train specific basis.

The initial trial period was conducted to determine effectiveness of different application rates and patterns. Two months into the test, a rail at the load station site was struck by lightning, damaging some circuits requiring partial replacement of gages and causing a shift in calibration. For this reason, the time history reflects forces observed during the second and third (TOR2, TOR3) evaluation periods (Figure 3). During these periods, application was inhibited in tangents, and in curves, only the low rail was treated. TOR 2 applied 63 milliliters/mile (1.63 gal/100 miles), while TOR 3 applied 94 milliliters/mile (2.4 gal/100 miles). This load station was installed on a 4-degree curve near milepost 10, about 10 miles north of Port Cartier.

TOR ORE CAR OPERATION AND RESULTS

Figure 3 represents typical steady state operations time history data for southbound (loaded) trains. This allows monitoring of day-to-day progress and overall shift in curving performance with and without TOR.

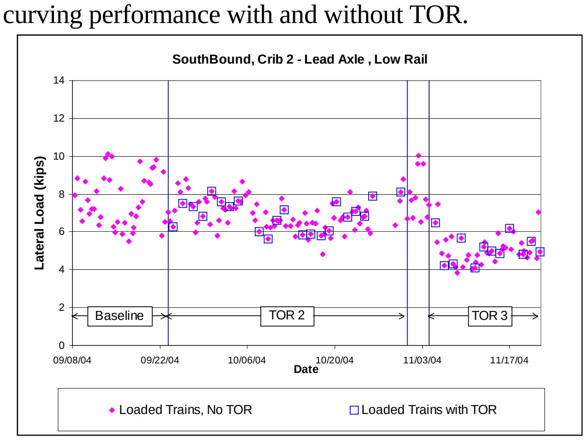

Figure 3. Data Points Represent Average Curving Forces

By averaging all trains of similar nature (loaded 160 car ore trains) with and without TOR, the long-term effect of specific TOR application rates can be quantified. Figure 4 shows average forces for baseline, TOR 2, and TOR3 periods. These conditions resulted in curving force reductions of approximately 35 Percent.

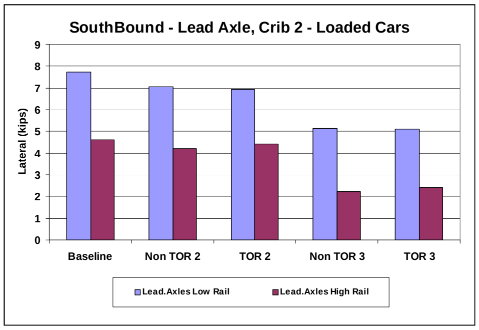

Figure 4. Lead Axle, Loaded Trains Average Forces

The average forces produced by passing trains show a reduction with time, indicating a gradual buildup and conditioning of wheels and rails. By examining forces produced within a specific train (front to rear), the effectiveness and degradation of the product applied for that train can be determined. Figures 5a and b show front to end of train curving forces for two different, but identical train consists. Figure 5a shows performance when no TOR car was operated, while Figure 5b shows curving performance with the TOR car in operation.

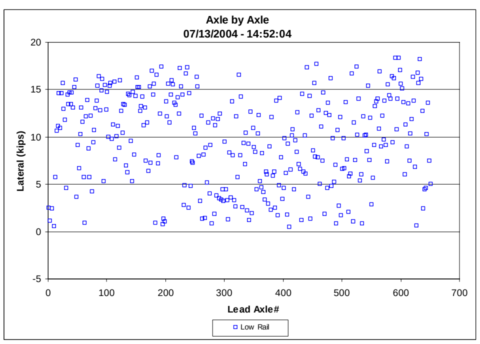

Figure 5a. Front to End of Baseline Train Curving Forces

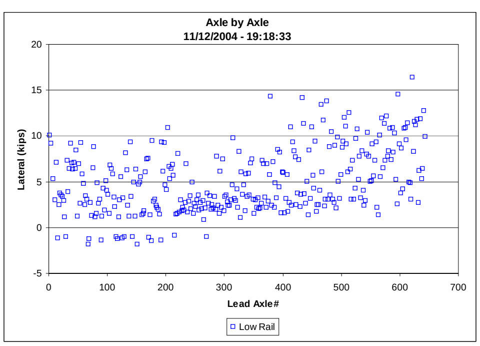

Figure 5b. Train Curving Forces TOR Conditioned Train

Data for a typical non-equipped train shows peak forces of about 18 kips, with little variation between front to rear of the train. Data for a typical TOR equipped train shows several features when a friction control material is applied at the head end of a train.

- The peak forces are reduced, with only a few at the higher levels noted on a non-equipped train.
- Forces at the front of the train (starting with axle 1) are lower than the end of the train, signifying that the product is gradually loosing effectiveness towards the end of train.
- The end of train is not producing the same high lateral loads as the end of a non-equipped train, signifying some end of train carryover.

The product remaining on the rail after the end of the train acts to reduce curving forces on one or more following trains. This explains the reduction in curving forces noted for non-TOR equipped trains as shown in Figures 3 and 4.

Operating a greater number of trains equipped with a TOR car will eventually result in more end of train carryover. In the long run, this will reduce curving forces for more of the non-equipped trains. The steady state level of curving forces achievable (as well as end of train effectiveness) will depend on a combination of the number of equipped trains and the friction control product application rate.

FUTURE

A braking test was conducted with a variety of TOR application rates, which will be reported separately. Deployment of additional TOR units in a captive system is being planned by QCM in late 2005. Product application rates and patterns required to maintain a conditioned system will be evaluated to determine optimum deployment under such conditions.

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