BEST PRACTICE IN RAIL CURVE LUBRICATION AND REMOTE PERFORMANCE MONITORING IN HEAVY HAUL LINES

Gopinath Chattopadhyay¹,², Md. Gyas Uddin¹,², A. Desai¹,², Peter Sroba³, Mohammad Rasul¹,², Alex Howie⁴

PhD (UQ), MBA(OM), ME(P&IE), BE(Mech); B.Sc. (Mech), M Eng (Industrial); B.E. (Mech, QUT), ME (QUT); BEng, CPE; PhD(UQ), M Eng, B Eng; B Eng, CPE

1. CRC for Rail Innovation, Australia
2. Centre for Railway Engineering, CQ University, Australia
3. Sroba Rail Services, Australia
4. QR National, Australia

SUMMARY
Rail curve lubrication is widely used to enhance below rail and above rail assets life, reduce rail/wheel maintenance and replacement costs. There are various types of applicators and greases used by rail industries. This includes mechanical, hydraulic, electrical actuators/ pumps, short and long bars and various types of grease. There is wide variation of performance of the wear levels for rails and wheels across the industry for similar operational, track and rolling stock characteristics. There is a need for best practice in rail curve lubrication. To establish lubrication best practice extensive field and lab tests of lubricators and greases are essential. Evaluation of latest technology equipment, their placement, optimal settings of grease application rate, reduced wastage, and quality are essential to achieve this. The research on Australian heavy haul lines in this area has been limited. This paper considers the effectiveness of the lubrication equipments, the length of lubricator bars, the bar location of lubricators in tangent track and the spirals of curved track and the different types of grease along with effectiveness of remote performance monitoring in heavy haul lines.

1 INTRODUCTION
Rail curve lubrication can produce enormous benefits to the rail industry by managing friction to the desired level, reducing wear of rail and wheel, improving rail/wheel life, saving energy and reducing noise. This paper considers the effectiveness of the lubrication equipments, the length of lubricator bars, the bar location of lubricators in tangent track and the spirals of curved track and the different types of grease along with effectiveness of remote performance monitoring in heavy haul lines.

2 OVERVIEW
Improper lubrication practice leads to accelerated wear of rails. Gauge face wear on high rails due to lubrication problem is shown in Figure 1.

The American Association of Railroads (AAR) has estimated that the wear and friction occurring at the wheel/rail interface due to ineffective lubrication costs American Railways in excess of US $ 2 billion each year [1]. Daniels reported that more than US $ 10 billion was spent on rail transit system maintenance in USA [2].
3 Lubrication Best Practice

3.1 Establish Rail Curve Lubrication Guidelines
Field tests and laboratory tests are essential to demonstrate the critical issues. Current literature shows that specific research based on the rail curve lubrication regime is rare and that rail curve lubrication specification and lubrication regime is not covered well.

3.1.1 Friction Management Guidelines
American Railway Engineering and Maintenance-Of-Way Association (AREMA) recommends [3] as follows -
- Gauge Face friction values should be < 0.20
- Gauge corner friction value should be < 0.20 which was under review
- Top of Rail (TOR) friction value should be 0.35 +/-0.05
- Left to right rail friction value differential should be < 0.1

The Canadian Pacific Railway recommends [4] as follows-
- Maintain top of rail friction coefficient differential, left to right < 0.1
- TOR friction coefficient should be 0.3 ≤ µ ≤ 0.35
- Gauge Face of high rail coefficient of friction µ ≤ 0.25

Figure 2 shows the guidelines for friction values at different zones on rail/wheel contact area.

3.2 Evaluation of Lubricator Technology
The technology of wayside gauge face lubrication equipment has changed dramatically over the last decade [5]. Electric lubricators (Figure 3) are capable of precise control of grease application rates based on wheel count and pump cycle time. The equipment consists of a grease reservoir, power supply unit (either AC or solar panel powering a re-chargeable battery), electronic controller unit, pump, distribution hoses and applicator bars. The tanks hold up to 400 Kg of grease which, depending on traffic levels, may only need to be filled twice per year.

![Electric Lubricator in heavy haul lines](image)

Table 1 shows the tribometer reading for hydraulic lubricator sites.

<table>
<thead>
<tr>
<th>Location (Fry Mt. Rainbow Section) (km)</th>
<th>Applicator bars</th>
<th>Rail Condition</th>
<th>Average Coeff of Friction(GF-H) of 60°</th>
<th>Average Coeff. of Friction(TOR-H)</th>
<th>Average Coeff. of Friction(TOR-Low)</th>
</tr>
</thead>
<tbody>
<tr>
<td>79.4</td>
<td>2 short bar</td>
<td>Wet</td>
<td>0.32</td>
<td>0.36</td>
<td>0.37</td>
</tr>
<tr>
<td>79.9</td>
<td>2 short bar</td>
<td>Wet</td>
<td>0.35</td>
<td>0.34</td>
<td>0.41</td>
</tr>
</tbody>
</table>

Table 1: Average Coeff of Friction (COF), µ data within first 2 curves from Hydraulic Lubricator

3.3 Evaluation of Applicator Bars
Current wayside electric lubricators come with 2 types of applicator bars such as short (600 mm in length) and long bars (1400 mm in length). Two short bars are placed in the spiral of the curve whereas either two or four long bars are placed in the tangent track before curves. Field trials indicate that long bars in tangent track (Figure 4) are more effective compared to short bars with benefits such as:
• Long bars do not need to be removed during grinding cycle.
• Delivery of grease to a greater area of the wheel circumference (Figure 5) and consequently measured transfer of lubricant to a greater track length when compared to short bars.
• Uses less grease compared to short bars.
• As installed on both rails in tangent track both left hand and right hand curves are lubricated by one unit.

Field studies showed that long bars have a greater carry distance compared to short bars. Figure 7 represents the comparison of lubricator performance (with different configuration in applicator bars) using grease E in the lubricator field test conducted in one of the Australian heavy haul rail networks. It shows that longest carry distance has been achieved with configuration 5 of lubricator with around 550gms of grease per 1000 axles.

The performances of long applicator bars have been evaluated with different types of grease and carry distance. Project team has measured the coefficient of friction using tribometer. Effective lubrication has been considered up to the distance where gauge corner coefficient of friction was less than or equal to 0.25. Figure 8 shows that the maximum carry distance has been achieved with application of grease E which is around 4.6km.

Field test results indicated the positive results from long bars compared to that of short bars.
3.4 Location and Position of Applicator Bars

Lubrication can be successful if the transport mechanism is effective [5]. The bar height from top of rail is estimated using worn wheel gauge (figure 9). The amount of grease to be applied to the wheels is set by the electronic control system and splash test.

3.5 Grease Ranking

The field test outcomes on grease performance concluded that different greases from different suppliers have different performance levels based on carry distance. Table 3 shows the performance of grease from different suppliers with same bar combination.

<table>
<thead>
<tr>
<th>Bars Combination</th>
<th>Grease</th>
<th>Achieved Carry Distance (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2+2) Long Bars, Supplier X</td>
<td>A</td>
<td>0.33</td>
</tr>
<tr>
<td>(2+2) Long Bars, Supplier X</td>
<td>B</td>
<td>2.568</td>
</tr>
<tr>
<td>(2+2) Long Bars, Supplier X</td>
<td>C</td>
<td>4.623</td>
</tr>
<tr>
<td>(2+2) Long Bars, Supplier X</td>
<td>D</td>
<td>1.65</td>
</tr>
</tbody>
</table>

Table 3: Comparative results of performance of different types of grease in carry distance with same applicator bar type

Laboratory ranking of grease have been undertaken to rank the lubricants in a pure sliding test using the Cameron and Plint apparatus. This is a reciprocating friction and wear tester that permits dry or lubricated tests at room temperature or with heated lubricants. Various contact geometries, including circular and linear-contact can be used with this apparatus. Partial analysis of this test has been undertaken to verify the repeatability of the test.

Extended experimentation is expected to study results from friction measurement, wear rates over a specific period and wear type. It is expected to emulate pure sliding similar to that of a motion between the flange face and gauge face.

An initial test has proven to have good repeatability of this test method as shown in Figure 10. Figure 11 shows the laboratory test apparatus and samples used in the experiments.
4 Remote performance monitoring

One of the currently available remote performance monitoring systems was tested in this research. Drivers for remote performance monitoring of rail lubricators are:

- **Grease Level** – In real-time practice it is important to know what the grease level in grease tank is and what the consumption rate of grease is over a period of time. Maintenance planners need to be able to know in advance when the lubricant is expected to run out and thus can plan refilling.

- **Clogged up grease hoses or blades** – Sensors can pick up grease bleeding, clogging, foreign bodies in the form of dirt, grease impurities, pieces of coal or ore or pump motor drawing extra current. Until these are rectified the rails start to run dry causing accelerated wheel and rail wear. It may also lead to complaints from the community because of increased noise levels.

- **Health of lubricator** – Knowing the health and condition of a lubricator. Remote performance monitoring system can forward the results of the system diagnosis, temperature, current, rain, voltage, safety and security of the lubricator and alert maintenance team of any irregularities.

- **Quantity of grease output** – due to change in traffic, pump rate can be remotely controlled in a cost and time effective way.

4.1 Safety Aspects: Accessibility of lubricators

Access to lubricators for maintenance might be difficult in high traffic corridors. Accessing track in tunnels, cuttings, and where there is poor trackside access may require lubricator attendants
to take possession of the track, stop trains, which has adverse impact on operations.
Lubricators located in remote locations often cost more because of the travelling time to reach to lubricators.

Figure 12: Tunnels often have very limited room [7]

4.2 Remote Performance Monitoring technology and few benefits

There are many ways to transmit data using wireless technology. These include GPRS - General packet radio service (cellular technology), RF (radio frequency) and Microwave.

Figure 13: Cuttings have little or no room [7]

GPRS technology provides data transmission at higher speeds and longer distances. The selection of GPRS is dependent on cellular network coverage that provides data transmission capability. This includes the 2G and 3G service. The 3G service can utilise the latest HSDPA (High-Speed Downlink Packet Access) for faster data transmission compared to the 2G service which is much slower. With 3G data transfer rates of up to 10.5Mbits/s can be achieved.

Figure 14: Remote performance monitoring

The information that can be accessed remotely from the lubricator includes the following:

- Remote activation / de-activation
- Traffic directions
- Battery Voltage
- Lubricant reservoir level
- Rain Sensor for Pump De-activation
- Pump output pressure
- Wheel detection / Axle count
- Ambient and Rail Temperatures
- Motor Current Draw

An electronic wayside lubricator was setup for this trial in a heavy haul coal line north of Gladstone. After two days of normal operation a rapid drop in pump motor current was recorded (see figure 15). This was investigated and found that it was due to cavitation in the pump inlet which was preventing grease being pumped. The pump was running itself without pumping grease and real work done. Therefore there was no extra power consumption and the current intake went down sharply. This resulted in the rails running dry. The current increased when the problem was fixed.

Figure 15: Drop in average Pump Current due to cavitation. [7]

It was found by Australian railways during inspection that around 25% the lubricators are not...
in working condition. Kramer [8] observed that the wear rate would increase substantially in similar condition as shown in Figure 16.

![Figure 16: Wear rates with 25% increase with non functional lubricators](image)

In absence of remote performance monitoring, lubrication related problems would not have been picked up until site visits. Maintenance of lubrication system effectively is not only time consuming and expensive but also relies on the experience of the lubricator attendant. This research found that remote performance monitoring is cost and time effective.

5 CONCLUSION

The research on Australian heavy haul lines in the curve lubrication has been limited. Field trials have been carried out to develop techniques for measuring lubrication effectiveness and the effectiveness of different types of lubricants and applicator bars. Various rail curve grease were tested in the laboratory for their ranking based on coeff of friction and wear performance. Remote performance monitoring technology was tested during a field trial for initial feasibility in condition monitoring of lubrication systems placed in remote places on heavy haul lines. The outcome of this research is promising. The authors are working on this project and further results will be published in the future.

ACKNOWLEDGEMENTS

The authors are grateful to the CRC for Rail Innovation (established and supported under the Australian Government's Cooperative Research Centres program) for the funding of this research Project No. R3:110 “Wayside Lubricator Placement Model for Australian Heavy Haul Lines.” The authors would like to kindly acknowledge the support rendered by Centre for Railway Engineering, Division of Operation & Maintenance Engineering and Machine Elements Division, Lulea University of Technology, Queensland Rail and QR National’s staff.

References


2. Daniels, L, E, 2008, 'Track maintenance costs on rail transit properties,' Transit Cooperative research program-Transport Research Board, Fair Oaks, CA

3. IHHA, 2001, ‘Guidelines to best practices for heavy haul railway operations: wheel and rail interface issues,’ International Heavy Haul Association (IHHA) 2808 Forest Hills Court Virginia Beach, Virginia 23454 USA


