Examination of Methods To Achieve Rail Lubrication

DOUGLAS B. THARP

A description is presented of the methods to apply a lubricant to rail to reduce train resistance, wheel flange wear, and rail wear. The advantages and disadvantages of application methods are discussed, as well as the characteristics of an ideal lubricant.

Applying some form of lubricant to improve the frictional characteristics of steel on steel has been popular since the invention of steel itself. Often this lubricant was applied as much for protection from corrosion as for reduction of friction between sliding surfaces. As a matter of interest, the use of journal bearings in the railroad industry inadvertently provided lubrication to the rail in the form of leakage from the journal box. The buildup of oil from this leakage became so much of a problem that laboratories of various railroads conducted elaborate experiments to determine the most practical method to remove the excess oil and grease from the rails and minimize resultant wheel slippage. The subsequent widespread use of roller bearings eliminated the dripping lubricant. Technology proved the old adage, "ignore a problem and eventually it will go away." Ironically, a great deal of time and effort is now being expended to put grease back on the rail to save energy and wheel and rail wear.

As wheel loadings increased because of heavier and improved car designs, it was not long until it became evident that the rail heads in curves wore much more rapidly. An obvious solution was to turn the high rail of the curve or to exchange the high rail for the low rail. Another obvious solution was to increase the hardness (and wear resistance) by using premium steels in curves. An eventual solution was to apply lubricant to the track to minimize the friction in curves where the forces were the greatest. The application of oil or grease for this purpose was the only benefit that the railroads considered.

Almost by accident, in 1983 the Transportation Test Center (TTC) discovered that trains operating over lubricated sections of track consistently used less fuel than when operating over unlubricated sections of track. An estimate of 30 percent savings literally staggered industry officials at a time when the cost of fuel was escalating rapidly and a great deal of effort was being used to save 1 to 2 percent on the efficiency of a locomotive engine or compressor. Even though terms like "skepticism" and "real world" permeated the discussions of those directly involved, the facts could not be ignored. As a result, a locomotive-mounted lubricating system was born and has since risen in popularity on U.S. railroads. Consolidated Rail Corporation (Conrail) was one of the first railroads to recognize the tremendous energy-saving potential of this technology and subsequently conduct an extensive series of tests.

Applied Research Laboratory, Consolidated Rail Corporation, Gables Building, Altoona, Pa. 16603.

LUBRICATION METHODS

Initially, the main purpose of rail lubrication was to reduce severe cases of wheel flange wear and to protect highly curved track from extreme rail gage wear on the high rail. The first major undertaking to solve this severe wear problem was to install "curve oilers" along the wayside. The frequency of this equipment installation was based largely on the number of degrees of central angle in a particular set of curves. One railroad uses "curve units" (each unit is equivalent to 1 ft of a 1-degree curve) as the criteria for locating their lubricators. The strategically placed wayside oilers produced the desired effect of reducing rail wear, but additional problems developed. The large number of individual locations of wayside lubricators required replenishment of lubricant on a periodic, but often different schedule because of variations in application rates. Often, overlubrication caused by temperature variation and equipment adjustment led to wheel slippage on ascending or descending grades. In other cases, underlubrication resulted from placing the lubricator at the wrong location in the spiral or using the wrong lubricant. In addition, maintenance of the equipment was complicated by poor weather, need for seasonal adjustment, and many minor features that made wayside equipment less than perfect. The problems were often so great that one employee per railroad division was designated exclusively to fill and maintain the lubricators. Other considerations in the evaluation of the use of wayside equipment include

- The maximum number of application points to provide coverage throughout the curve and associated spiral;
- Advantages and disadvantages of lubricating the low rail;
- Limitations to the ability to distribute state-of-the-art wayside lubricants because of the maximum quantity that can be applied at the oiler without risking contamination onto the rail head while spreading it longitudinally; and
- Influence of lubricant qualities that permit achieving a dispersed film thickness that will provide adequate lubrication.

Extensive research continues into the use of wayside lubrication. The new-generation lubricator is electronically controlled to regulate the flow of grease, handle variations of speed, sense train direction, and maximize the distribution of lubricant with an improved wiping bar. The potential also exists to limit the lubrication output through a centralized control system.

In the early 1980s, major railroads began looking for a means to replace or supplement the wayside systems with some type of "on train" or "on track" system. The more publicized of these was a boxcar-mounted system that sensed curves and sprayed grease on the gage side of the high rail. At a time when a great deal of effort was being spent to eliminate the caboose, it did not appear practical to add another car to a train, with the resultant switching, operating, and maintenance costs. An absence of savings in the wear rates of locomotive wheel flanges was an additional disadvantage. As a matter of interest, the reduction in locomotive wheel wear rates was the precise and only reason that lubrication was added to locomotives on European railroads.

Another method that was tried and tested was the use of a hi-rail vehicle to lubricate either rail while track inspections were being performed. Hi-rail (non-train-mounted mobile) systems must apply an amount of grease that will be adequate until the next available application cycle. This often causes overlubrication just following application and very little lubrication just before the next cycle. In concept, this system works well in medium-density lines, but it is not as effective with heavy traffic because the hi-rail vehicles interfere with train operations. Its effectiveness on low-density lines is also reduced, because of the lack of trains to benefit from the lubricant before it deteriorates. Two commercially available hi-rail vehicles were deemed appropriate for applications and cost-effective.

The potential energy savings available caused most Class I railroads to focus on on-board lubrication. Several types of locomotive-mounted hardware are available that transfer some type of lubricant (oil or grease) from a nozzle or roller directly to the wheel flanges of locomotives. From a hardware standpoint, the following factors must be considered:

- Operation environment,
- Installation cost,
- Frequency of application,
- Reservoir type and size,
- Grease replenishment,
- Maintenance,
- Crew acceptance,
- Curve sensing capability, and
- Purchase price.

When Conrail made a commitment to equip its road locomotives, the selection of hardware was limited. Flange lubricators developed and used in Europe were investigated, because they had been used for many years to prevent wheel climbs and reduce locomotive wheel flange wear. In spring 1984, two Willy Vogel wheel flange lubrication systems were procured. The available "timer" type control was replaced with a Conrail-designed distance-measuring control circuit to activate the lubricators. These two systems were installed on General Motors Electromotive Division SD50 and SD40-2 locomotives. The spray nozzles were mounted to lubricate the leading axle of each locomotive, regardless of operating direction. Over-the-road tests were then conducted to determine whether fuel savings could be detected in typical railroad service. The initial tests were conducted in central Pennsylvania with a unit coal train. The encouraging results led to a second series of tests between New Jersey and Illinois in high speed piggyback freight service. Unavoidable variations in train configuration and speed profiles made the results of these tests statistically contestable.

Nevertheless, in all of the tests conducted by the Conrail Technical Services Laboratory, the use of on-board lubrication produced an energy savings. These positive results were obtained regardless of problems encountered with lubrication rates, grease type, system reliability, crew variance, train weight differences, train type, or geographical considerations. On the basis of these indications, a corporate decision was made to equip 120 road locomotives with on-board systems and enjoy the inherent fuel savings until a more precise series of tests could be conducted to improve the accuracy of the savings estimation.

A third series of tests was specifically designed and conducted to determine how much fuel would be saved if the entire locomotive fleet were equipped with on-board lubrication. This test series was conducted between Albany, New York, and Boston, Massachusetts, with a dedicated test train consisting of 18 open-top hoppers loaded with stone ballast and instrumented to record test parameters on Conrail's research car. Test results, when transferred to a mathematical model of the entire Conrail system, indicated that the potential savings would approximate a 7 percent reduction in the amount of energy required to power Conrail trains.

Existing on-board systems are highly flexible, but they may have lubricant volumetric limitations that will require dispersal of lubrication points throughout a very long train. Limitations seem to be maximum grease line length or pumping pressure available, or both. A need to find better lubricants is evident. The potential to vary spray or discharge frequency may help solve the need to apply more lubricant in curves than on tangent track to achieve the desired benefit. Research in this field is also progressing at a very rapid rate. There are now six manufacturers of hardware conducting research to provide the optimum product for railroad use. In addition, a number of Class I railroads are in the process of conducting involved tests to evaluate hardware and the optimum lubricant. Equally important is the necessity to accurately determine the potential cost benefits.

LUBRICANTS

Petroleum and mineral oils have been used for centuries as a means of reducing the friction between sliding and rolling steel (iron) surfaces. Late in the last century, grease, which is an oil thickened by the addition of soaps (the salts of fatty acids) was introduced. The intent of such thickening was to lessen the tendency of the oil to flow. In other words, the grease had to stay where it was needed. The primary user of such materials was the steel industry, which needed to lubricate the bearings in hot rolls or other machinery.

The last several decades have brought improvements in the ability to resist flow (loss) due to temperature, wash-off from water (used extensively in steel mills), and tackiness or cling. All such improvements, normally attributed to the soaps (calcium, sodium, lithium, and to some extent boron), have raised the useful temperature and reduced the tendency to wash off.

In recent years, other additives, such as graphite, lead, molybdenum disulfide, and Teflon, have been used to improve the ability of grease to resist higher pressures. In other words, these additives are necessary to resist squeeze-out and provide some greater ability to prevent scuffing or scoring.

All such improvements increase cost but will, it is hoped, provide the surface protection that has always been the major way to reduce friction. There is no question that the type of grease selected for any hardware is the "secret ingredient" that will maximize the resulting savings. The following are considered the characteristics of a good wheel flange lubricant:

1. Transferability by wiping from wheel to rail to maximize dispersal throughout the train;
2. Sufficient tackiness to resist fling-off;
3. Low-viscosity change with a change in temperature to stay on a hot wheel and remain pumpable;
4. Resistance to washing off by rain;
5. Resistance to bleed (i.e., separation of soap or additives) due to pressure, temperature, and long periods of storage;
6. Resistance to aeration during pumping action from the reservoir to the nozzle;
7. Environmental safety;
8. Finely milled constituents to be compatible with the close tolerance of machined parts found in most dispensing nozzles;
9. Cost-effectiveness to achieve maximum benefits; and
10. Distinguishable features to determine, from a test standpoint, the dispersal through the entire train.

Development of the characteristics is left to the grease manufacturers. Present laboratory testing methods are limited in duplicating the railroad environment, but newer and better testing methods are being developed along with new qualification tests. The final choice will be based on individual field demonstration results because of geographic differences in weather or environmental conditions on the various user railroads.

CONCLUSION

Conrail currently has approximately 1,500 wayside lubricators covering 13,700 route miles. Approximately 80 percent of the 68.7 billion ton-miles of freight carried by Conrail in 1986 was accomplished with 600 locomotives applying 0.05 cm^3 of grease every 25 wheel revolutions. Wayside lubricators are used in areas of high curvature and placed on tangent track before the spiral. Route-specific location decisions are made by Division Engineers on the basis of their experience and wear patterns for a particular curve. These criteria will undoubtedly change with design changes in the new generation of lubricators. The precise location, nozzle size, frequency of application, and amount of each spray for locomotive-mounted lubricators continue in the experimental stage. It can readily be seen that the use of lubrication to reduce the maintenance and resulting cost of minimizing delays to revenue trains is more of an art than it is a science. When hardware decisions are made, the single most important element—the grease itself—is still very much in the developmental stage.

At this time, Conrail is in the process of preparing test plans to evaluate the effects of various greases used in both wayside and on-board lubricators. It is Conrail's belief that the grease currently being used with on-board lubrication does not persist throughout the length of a normal train. Therefore, the potential savings available are not being fully used. The use of the correct lubricant is the bottom line in advancing this technology to a point at which the entire industry can maximize the savings of energy, wheel wear, and rail wear and reduce the number of derailments. This technological improvement, along with continued research on all types of lubrication, will improve the competitive posture of the railroad industry.