A Study of an Improved Overhead Crane Wheel Flange Lubrication System

This paper discusses a microporous polymeric lubricant (MPL) system for reducing wheel flange wear. Described are the results of a study which demonstrates that MPL arcs are an effective lubricant for overhead crane wheels in an automotive assembly plant. The improved lubrication system will result in savings from reduced production downtime and maintenance costs.

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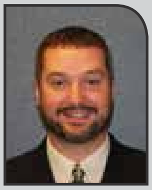

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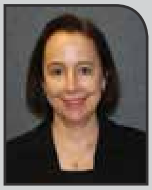

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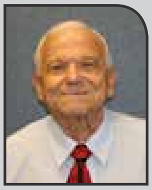

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An improved wheel flange lubricating apparatus employing arc-shaped rigid blocks of microporous polymeric lubricant (MPL) was installed on 16 crane wheels in an automotive assembly plant. Wheel flange wear on these crane wheels was measured over a 53-month period and compared to the flange wear before the lubrication system was installed. The results of this study show that the average wear rate of the wheels studied in these plant trials was reduced more than tenfold, from 0.712 to 0.034 mm/month after the installation of the new MPL system.

Microporous Polymer Lubricants

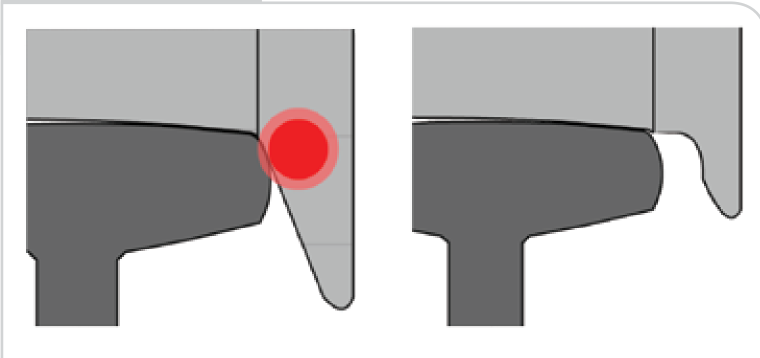
MPLs are comprised of two major components: a polymer containing a continuous microporous network and oil contained within these pores.[1,2] The type of oil incorporated into the polymer can be tailored to the requirements of the application. Examples include U.S. Food and Drug Administration (FDA)/U.S. Department of Agriculture (USDA)/National Science Foundation (NSF)-approved food-grade lubricants and oils with an extreme pressure (EP) additive for high-load applications. Other additives can also be used to alter the lubricant's properties. Examples include oil property enhancers such as corrosion and oxidation inhibitors, and coefficient-of-friction modifiers and lubricating solids such as molybdenum disulfide, graphite and Teflon. The oil content in the polymer can be controlled during processing, and the MPLs contain more than 50% oil by weight.

The microporous polymer acts like a sponge, releasing and absorbing the oil. The oil is released from the polymer through capillary action to its surface and is transferred to any high-energy surface it contacts to provide the necessary lubrication. As the quantity of oil on the surface decreases, the MPL releases more oil. If excess oil appears, it is re-absorbed by the porous polymer. For example, as the temperature of the MPL increases, more oil is typically released; however, this is re-absorbed by the MPL as the temperature decreases. Because of this, MPLs reduce or eliminate the need for re-lubrication, therefore minimizing or eliminating maintenance and housekeeping.

Wheel Flange Wear

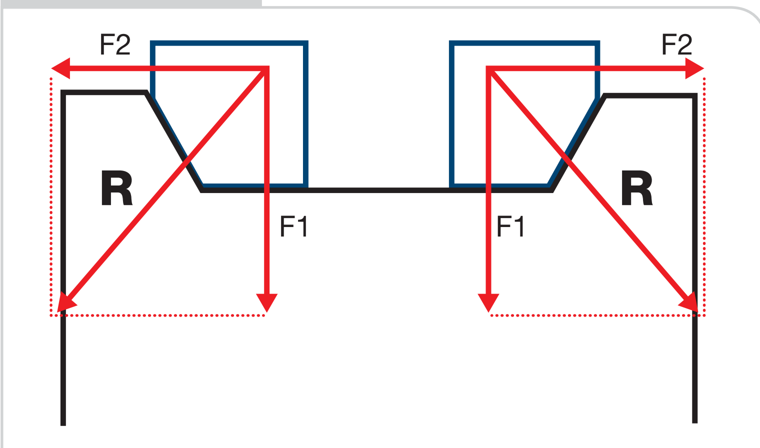
Friction between rails and wheels on overhead cranes is known to increase the wear of the wheel flange.[3] The

Figure 1



Wear that occurs to the wheel flange.

Figure 2



Two independent force vectors are used to push the lubricant against the wheel flange.

friction between the mating surfaces can cause noise, increase energy consumption and cause safety problems. The wear on the wheel flange results in the expense of replacing or refurbishing the crane wheel. In extreme cases, friction between the wheel flange and rail is so great that the crane will ride up the rail until it slips and crashes back down onto the rail. An even worse scenario would be if the crane derailed and created an unsafe condition.

It has long been known that the application of lubrication to a wheel flange reduces the friction between the crane wheel flange and the rail and also reduces the flange wear. Conventional lubrication methods such as automated oiling systems and greases have many disadvantages, including storing, mounting and refilling the lubricant container. Controlling the amount of lubricant applied to the wheel flange is important in order to avoid getting the lubricant on the tread of the wheel. This could reduce the braking action of the crane, leading to safety issues. Also, the environment below the crane can also be compromised if excess lubricant drips from the wheels or rails. Because the conventional lubrication systems are often heavy and difficult to mount, most of these systems rely on the lubricant rubbing from the wheel flange onto the rail and carrying the lubricant back to subsequent flanges. The amount of lubricant being shared with subsequent wheel flanges is not easily controlled.

Misalignment occurs between the rail and wheel flange due to the vertical and horizontal movements of the wheel and deflection of the wheel caused by loading and unloading of the crane. Rail alignment will also contribute to wheel flange wear, and if misalignment occurs, the wear rate will accelerate. The movement of the wheel flange relative to the rail causes the contact point and wear surface on the wheel flange to change. It is important for the lubricant to be applied at the point the wheel flange makes contact with the rail. In order to maintain constant contact of the lubricant with the flange, the wheel flange lubrication system must track the position of the wheel flange throughout all operating conditions.

The rail and crane industries are still in need of a flange lubrication system, which applies lubricant in the desired amount and location while also being easily mounted to the vehicle. Applying lubricant to a wheel flange, which is subject to a great range of movement, has not been solved by previous lubricant stick or block application systems.

Description of Lubrication System

The flange lubrication system employed in this study consists of two arc-shaped MPL blocks and a mounting system which forces the blocks into the wheel flange.[4] Each block has a contact surface that matches the profile of the wear surface of the wheel flange. The lubrication system uses springs as a means to provide the forces which cause MPL arcs to maintain the contact side of the lubricant block laterally against the wheel flange and radially into the crotch of the wheel. The rigid block has independent radial and lateral forces for improved control of the position of the blocks relative to the wear surface (Figure 2). Improved control minimizes lubricant contact on the tread of the wheel and concentrates it in the areas where lubrication is needed. It is important that the tread remains unlubricated so that the braking on the overhead crane is not compromised.

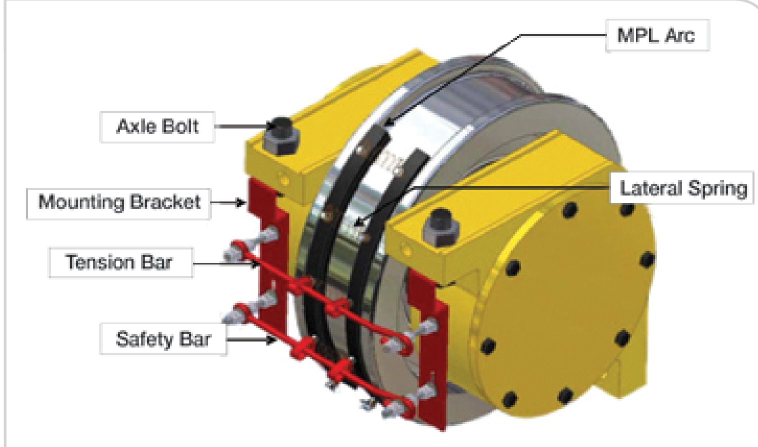
The MPL blocks are held in place by a pair of brackets that attach to the crane using the existing axle bolts on each side of the crane wheel (Figure 3). This means that no special modifications, such as welding, will be necessary in order to attach the lubrication system to the end truck. Installing the system consists of a few relatively easy steps. The bracket is connected to the end truck by using the front bolts on each side of the wheel. The holes in the tension bar and safety bar are aligned with the corresponding standoff bolt in the mounting brackets, while the MPL blocks are pushed into the crotch of the wheel. Four spring washers and four nylon locking nuts are used to attach the tension bar and safety bar to the mounting bracket and the installation is complete.

Each mounting bracket is specially designed for each individual application, allowing the system to be flexible enough to overcome obstacles such as rail sweeps, which might get in the way of other lubrication systems.

Experiment Procedure

The wear study was conducted on two overhead cranes in an automotive assembly plant in England. The lubrication system installed on two of the wheels is shown in Figure 4. The wheel configuration of both cranes is shown in Figure 5. The average of the thickness of both wheel flanges of each wheel was measured on a regular basis. On the first crane, D1, the flange thickness was also measured on the wheels before the lubrication systems were installed in order to establish a baseline of the flange wear. Wheels 3, 4, 5 and 6 were fitted with the lubrication system after nine months.

Figure 3

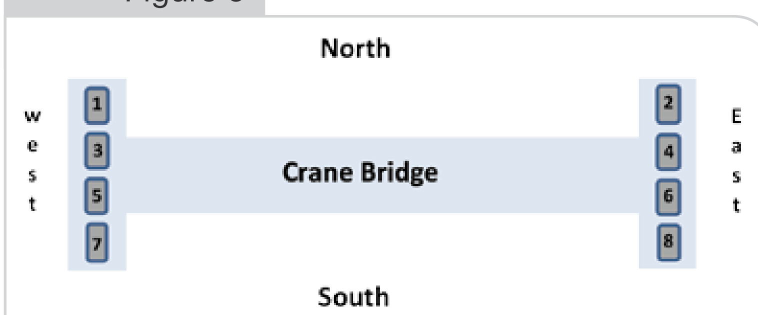


How the MPL system is fitted to the crane wheel.

Figure 4

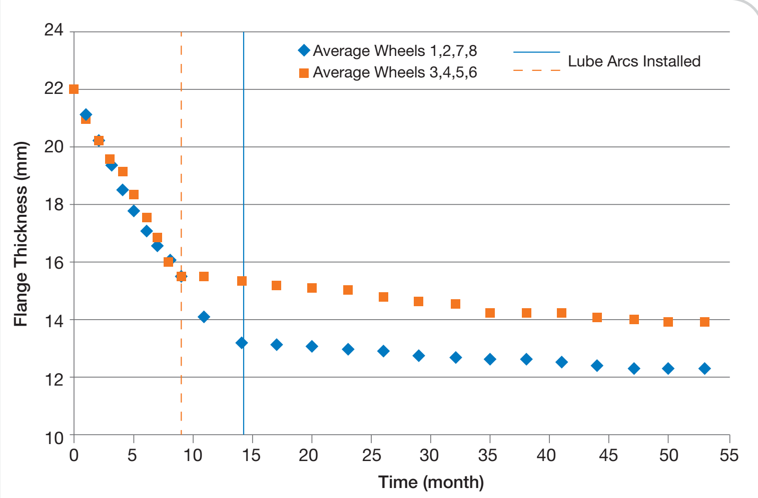
Two wheels in the crane fitted with the MPL flange lubrication system.

Figure 5



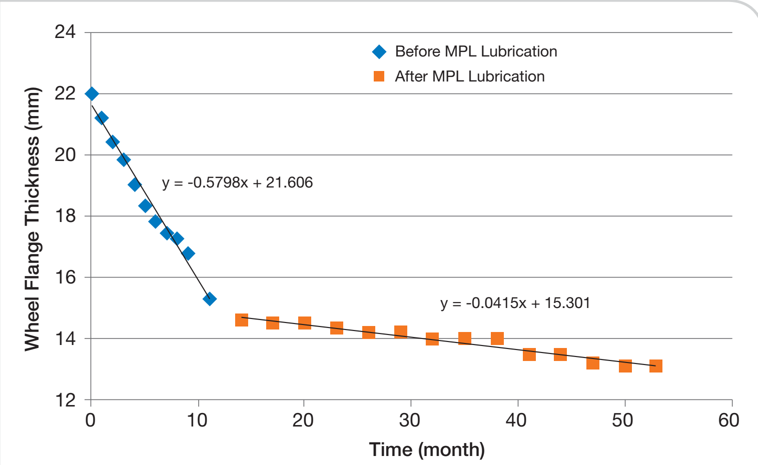
Schematic drawing of the configuration of the crane's wheels.

Figure 6



Average wheel thickness versus time for the D1 crane.

Figure 7



Estimate of wear rate before and after installation of MPL arcs for wheel 1 of the D1 crane.

The lubrication system was installed on wheels 1, 2, 7 and 8 after 13 months. These measurements were taken over a 53-month period. The wheels of a second crane, D4, were also fitted with the lubrication systems, and the average flange thickness was measured over a 28-month period. The wear was not measured on the D4 crane before the lubrication system was installed.

Results and Conclusions

The results from the wheel flange thickness measurements on crane D1 are shown in Figure 6. To simplify the graph, the average flange thicknesses (mm) of wheels 3, 4, 5 and 6, and 1, 2, 7 and 8 are plotted against time (months). The vertical lines indicate when the flange lubrication systems were installed onto the wheels. It is clear that the wear rate was reduced significantly after the flange lubrication systems were installed.

The wear rate of the flange of each wheel was estimated by plotting flange thickness versus time. A straight line was fitted to the data before and after installing the MPL arcs using Microsoft Excel's regression analysis. The data for wheel 1 of the D1 crane is shown in Figure 7 along with regression equations.

Figure 7 shows that a straight line adequately fits the data. The slope of each line is an estimate of the wear rate.

Table 1

Wear Rate of the Wheel Flanges on the D1 and D4 Cranes

	D1 crane		D4 crane
Wheel No.	Wear rate before arcs were installed (mm/month)	Wear rate after arcs were installed (mm/month)	Wear rate after arcs were installed (mm/month)
1	0.580	0.042	0.042
2	0.609	0.030	0.052
3	0.613	0.036	0.039
4	0.603	0.048	0.047
5	0.832	0.032	0.053
6	0.808	0.044	0.027
7	0.860	0.027	0.060
8	0.852	0.012	0.046
Average	0.712	0.034	0.046

This method was used to get the wear rate of all the wheels on the D1 and D4 cranes, and the results are shown in Table 1.

In this automotive plant, the flange thickness of a new wheel is 22 mm. The wheels are changed when the flange thickness reaches 11 mm. The data collected in the study indicates that, without the MPL system, the wheels of the D1 crane will have to be changed every 16 months (22–11)/0.712. The wear rate after installation of the MPL arcs indicates that the wheels would last 324 months (22–11)/0.034. Similarly the wear data from the D4 crane indicates that the wheels would last 234 months.

Conclusions

This study demonstrates that MPL arcs are an extremely effective lubricant for overhead crane wheels in this automotive assembly plant. A new wheel for these cranes can cost up to US$3,000, or US$24,000 per crane. In addition to the replacement cost of the wheels, the improved lubrication system will result in savings from reduced production downtime and maintenance costs. The results in other overhead crane applications would depend on a number of factors, namely, size of the crane, the frequency of use, the weight being lifted, the contamination from the environment, etc.

Acknowledgments

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