Maintenance: new approaches and enhanced efficiency

The Real Costs of Lubrication Delays

When selecting lubricants and fluids, maintenance managers and purchasing agents attempt to provide their plant maintenance organization the best possible value. In the final analysis, however, product selection is frequently based only on cost -- and price alone is a poor standard for making lubrication purchasing decisions. The cost of grease and oil represents less than 3 percent of the average maintenance budget (Figure 1). However, selecting the wrong products can lead to lubrication and equipment failures that drive production rates down and dramatically increase overall maintenance costs. What must be examined is the impact your lubrication purchases have on the other 97 percent of the maintenance budget. Better grades of lubricants will reduce the failure of equipment components (Figure 2).

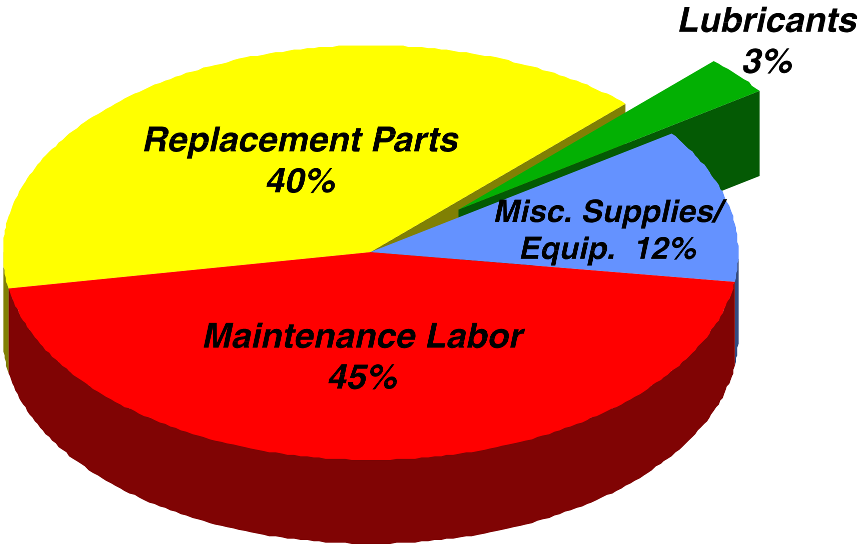


Figure 1

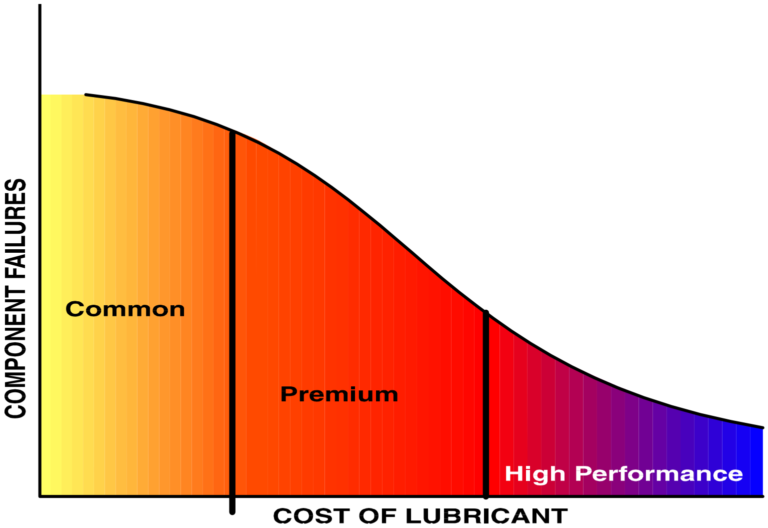


Figure 2

Generally, lubricants are divided into three grades: commodity, premium, and performance products. When purchasing lubricants, it is easy to focus on up-front costs. However, studies show that in most applications, there is no long-term cost advantage to using commodity grade products because higher-grade lubricants offer better quality with less usage (Figure 3). Furthermore, better quality generally translates into longer running life for the lubricated equipment. Longer running life means fewer repair parts, less maintenance manpower, and fewer delays. Consequently, the initial cost of a lubrication product is only one of several components to consider when developing a total maintenance program. It is worth noting that the purchase of commodity grade products is rarely, if ever, successful in bringing the cost of lubricants below 3 percent of maintenance budget because of the cost/quantity ratio. The better the grade of product the less lubricant needed, and vise versa. Higher-grade lubricants are most cost effective in applications where an equipment delay would be very costly. Better grades of lubricants are also recommended for expensive and/or long lead-time components.

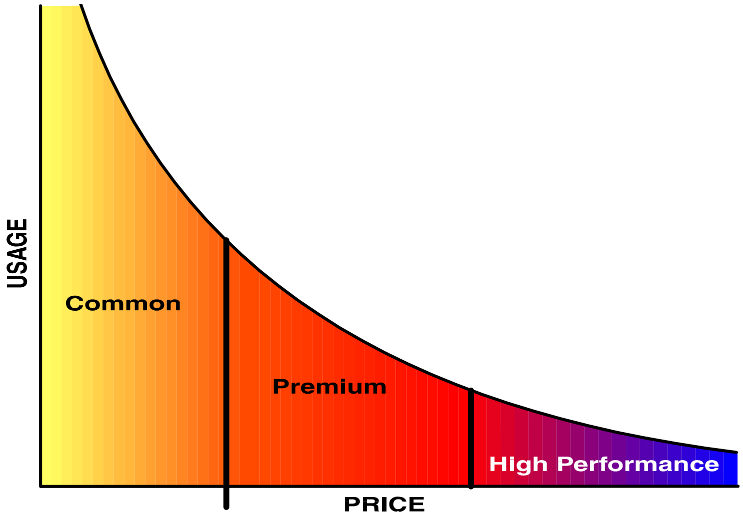


Figure 3

An example of this would be an electric arc furnace (EAF) super-structure pivot bearing. This item could cost as much as $70,000, have a nine-month delivery lead time, and take several days to install. Using a high-quality lubricant makes sense in this type application.

Method of application is an important factor in making decisions regarding grades of lubricants. There are times and situations that call for common grade lubricants. For example, older models of automatic lubricating systems, particularly those with preset timers, are particularly susceptible to lubrication waste. In situations where lubricating methods produce high waste and cannot be changed, common grade lubricants may be the best choice. On the other hand, a super-structure pivot bearing can use the furnace motions' programmable logic controller (PLC) as the triggering device for the grease cycle. In this situation, grease will be applied only when the bearing is in motion. There is no over greasing, and therefore, no piles of grease around the bearing pedestal. When waste is under control, the cost savings through the use of high-performance lubricants emerge quickly.

As with most maintenance budgeted items, there are direct and indirect costs associated with lubrication delays. Direct costs are the replacement cost of the damaged part, the maintenance labor costs, shipping, and the inventory costs that accompany the part. Indirect costs those associated with idling production equipment while the repairs being made. Production delay costs are generally greater than direct maintenance costs. (Figure 4)

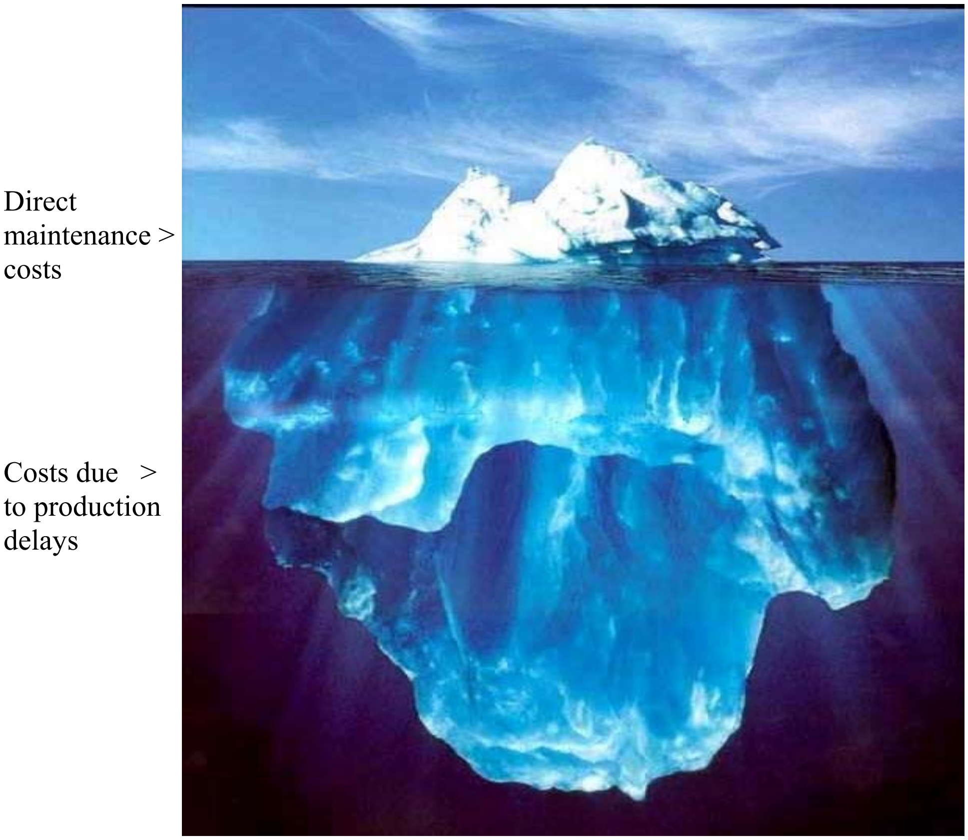


Figure 4

Just as the greatest part of an iceberg lies below the water line, so too the real cost of lubrication delays lies in lost production rather than direct maintenance expense.

For example, on an electric arc furnace, the cost of lost opportunity is very high. Lost opportunity can be calculated by multiplying the average tons produced by the average selling price. For example, if a furnace normally produces 2,400 tons of steel in a twenty-four hour period; and the average selling price of the finished product is $330 per ton, the cost of lost opportunity is $550 per minute. At those rates, even small delays are extremely expensive. Using better grades of grease will reduce unnecessary lubrication delays and increase production time.

Examples of cost savings in changing from conventional lubricants to a higher grade are shown below:

Case Study #1 – Morgan No-Twist wire mill

A mini-mill producer has a problem with breaking "iris fingers" in the reform tub area. Mill maintenance was using conventional grease and was breaking an iris finger a rate of one/month, resulting in 72 man-hours of unscheduled maintenance and 24 hours of lost production.

After changing to a performance lubricant, the grease lubrication cycle went from once a week to once a month with no broken iris fingers, no production loss and no repair costs in more than a year.

Annual Performance Analysis

	Conventional Product	Performance Product
Cost of product	$2.08/pound	$3.25/pound
Volume used	60 pounds	14 pounds
Annual product cost	$125	$46
Maintenance labor cost	$2,664	- $0 -
Parts cost	$7,104	- $0 -
Production delay cost	$164,160	- $0 -
Total annual costs	$174,053	$46

Annual Savings - $174,007.00

Case Study #2 – Krupp electric arc furnace

This company was experiencing high maintenance costs on the furnace roof ram. By converting from conventional product to a performance product, they reduced their maintenance and production costs dramatically.

Before changing products, the ram life was 12 months with high associated costs. Production delays because of unscheduled lubrication delays was 72 hours annually. After converting to a high performance product, the ram life was extended to 20 months, and lost productivity was reduced to 48 hours (annualized).

Annual Performance Analysis

	Conventional Product	Performance Product
Cost of product	$1.94/pound	$2.77/pound
Volume used	3,360 pounds	907 pounds
Annual lubrication costs	$6,518	$2,512
Maintenance labor costs (annualized)	$13,320	$8,880

Parts costs (annualized)	$100,000	$66,667
Production delay costs (annualized)	$432,000	$288,000
Total annualized costs	$551,838	$366,059

Total Annual Savings - $185,779

Case Study #3 – Sheet annealing and pickling line

Before changing to a performance grease, maintenance was having to replace three roll support bearings per week ($230.67 each) causing 57 hours of production. The unit had been lubricated with a conventional grease containing a solids package. However, the grease was not suitable for the task in this extreme environment.

Using conventional grease required greasing the unit twice per week. That cycle was reduced to once per week with the performance product.

Annual Performance Analysis

	Conventional Product	Performance Product
Cost of product	$1.01/pound	$3.55/pound
Volume used	1,660 pounds	840 pounds
Annual lubrication costs	$1,677	$2,982
Maintenance labor costs	$2,993	- $0 -
Parts cost	$34,600	- $0 -
Production delay costs	$444,600	- $0 -
Total annual costs	$483,870	$2,982

Total Annual Savings - $480,888

The simple act of choosing a better grade of lubricant significantly impact the bottom line. There are other areas of savings not itemized above. These include reduced disposal costs and better process water quality because of the reduction in grease usage, lower inventory and product consolidation, lower electric costs because of reduced friction loading, and longer equipment life.

Most steel companies have reduced their work force size. Today, some maintenance departments don't have the people needed to perform routine preventive maintenance work. Involving your lubrication supplier in your maintenance program can help compensate for staff reductions. Full-service suppliers offer sampling and product application engineering as part of a lubrication package. Whether you have to pay for these services separately or if they are provided with the cost of the lubricant, the supplier should be very involved with your program and understand how your steel making process works. He should also be responsible for the performance of his products in your process. Every recommended product may not work every time in every application, however, a quality supplier will work closely with you and your field people to make adjustments to his lubrication recommendations. Your supplier must insure proper operation of your steel making equipment even as conditions change in your operations. If your present supplier is not routinely making inspections and suggesting new and better products for your lubrication systems, then find another supplier.

In summary, price should not be the absolute determining factor when purchasing hydraulic and lubricating products. Purchase value. A small increase in the cost of lubrication can, in many cases, be cost justified through savings in maintenance and operation delays. Also, suppliers should provide the services and products necessary for good operation and the well being of your equipment. Compare the products and services of each supplier. Get commitments from them and then monitor for compliance.

1 DANIELI-FRÖHLING roll gap adjustment facilities in a narrow 20-high mill

Narrow 20-high mills are designed for small strips which are in the majority of cases for slitted materials. The cross sectional profile of these materials are for an example of a convex character, a concave character, a bone character or a wedge character. These characters demand different adjustment facilities of the rolls in the mill to adapt the roll gap exactly to the profile of the incoming material. With this high quality material this means flat material can be produced.

Traditionally mono-bloc mills (SENDZIMIR) are equipped with crown adjustment and shifting facilities for influencing the roll gap and the profile. Modern cluster mills (DANIELI-FRÖHLING) have included AGC adjustment facilities in their design to separate gap adjusting, tilting and bending of the rolls. So the adjustment facilities in the modern 20-high mills can be specified as follows:

- **Crown adjustment of the back-up rolls**
- **2nd. intermediate roll bending**
- **1st. intermediate roll bending**
- **1st. intermediate roll shifting**
- **Tilting of the upper roll chock**

With these facilities the roll gap geometry can be influenced extremely.

To demonstrate the influence of these adjustment system to the roll gap Finite Element calculations were executed from DANIELI-FRÖHLING whereupon shifting of the 1st. intermediate rolls was not part of the contemplation. Basis was a three dimensional model of a quarter cutout of the roll set in which the load and the support conditions were entered. The results along the material width were recalculated in characteristic polynomials.

The working range of each adjustment facility can be presented now in a graph. The abscissa res. X-axis will show the influences onto the rolled material as polynomial of 2nd. order and the ordinate res. Y-axis the influences onto the rolled material as polynomial of 4th. order.

As it can be drawn from the graph, the crown adjustment of the back-up rolls covers the biggest range. Due to the fact that this manipulating element is working very slow it is only used as a rough adjustment to come close into the working area. The fine adjustment will be made with the bending facilities of the intermediate rolls.

Concluding it can be derived from the results that

the bending of the intermediate rolls shall be used as primary actuator in a closed loop control considering that the negative intermediate roll bending is far more powerful than the positive bending

the crown adjustment should be used for presetting and as secondary actuator used to avoid saturation of the intermediate roll bending in a closed loop control.

Daniel-FRÖHLING have implemented several 20-high mills for small strip applications. Last references amongst others include Brockhaus in Germany and Sandvik in Sweden.

pict. 1

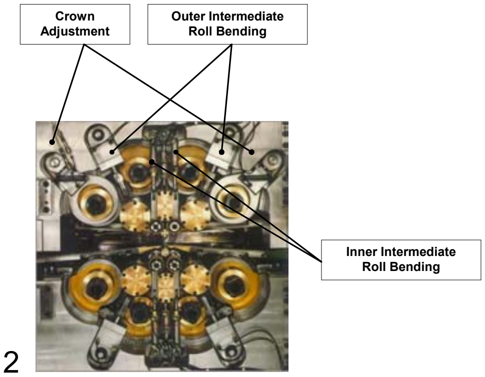
These mills were executed in a Cluster Mill design, which is according DANIELI-

FRÖHLINGS experience the most suitable solution for small strips. With the cluster technology more control capability is given to thickness and flatness control. Just this argument confirmed customers resolution.

All actuators for flatness or roll gap geometry control in common can be specified as follows:

Crown adjustment of the upper back-up rolls A and D, which is classical, and B and C, whereat an adjustment is rather seldom.

Shifting of the first intermediate rolls which together with tailored tapers is suitable to control local effects to the strip edge.

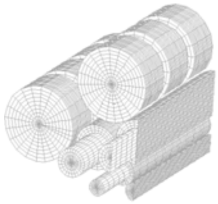


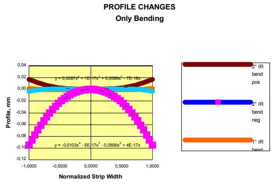
pict. 2

Bending of all the intermediate rolls as an further actuator was foreseen in a 20-high mill in 1995. At that time positive bending was entertained only. Through experience ideas of bending in both direction arose and patent rights were announced accordingly.

DANIELI-FRÖHLING initialised a FEM calculation to establish an analysis of the behaviour of all actuators in a 20-high arrangement in relation to the strip profile change.

The starting basis was to develop an adequate and reduced model with all required facilities, which resulted in a reproduction of a quarter section of the roll set.





drawing 3

On basis of the incoming forces and the constituted node conditions the influence of each actuator to the strip profile was computed, focusing on crown adjustment and bending.

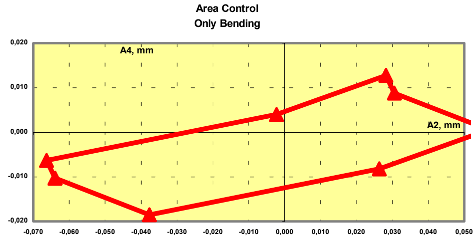
The calculated influences where transferred in a polynomial graph of forth order.

With the portions of second (A2) and fourth (A4) order the profile change respectively the control characteristic of each actuator can be described and shown. The usual manner of presentation is a graph with A2 as abscissa and A4 as ordinate, e.g. the first and third quadrant represent the concave and convex strip profile.

The characteristic for intermediate roll bending and crown adjustment can be drawn from the graphs below:

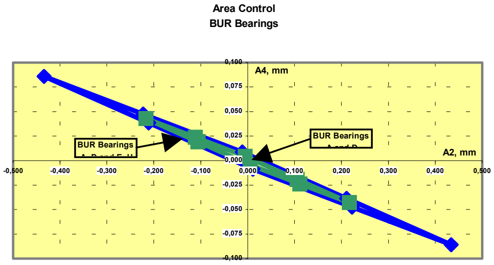
Intermediate roll bending

drawing 1



drawing 2

Crown adjustment

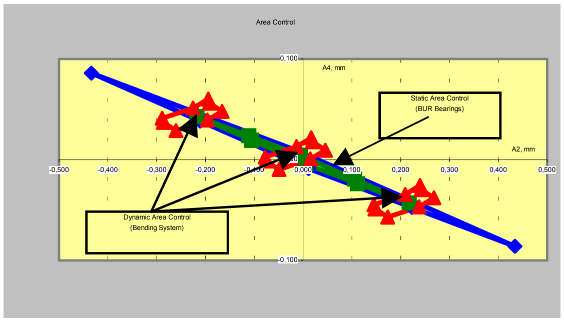


Comment: The results are linearised due to simplification reason

The calculations approved our experience. Only positive and negative bending of the intermediate rolls will have a big influence to the strip profile. Interesting is furthermore the aspect that a combination of inner and outer intermediate roll bending will add up a great influence area (analogy to Six-highs). A single actuator will be not efficient, because its just acting on a line.

In combination with crown adjustment maximum influence can be achieved. An increase of the influence area of crown adjustment of axis A and D can be achieved by adding axis E and H, which is the double then. Compare therefore above shown graph once again.

drawing 4



Remark: presentation is distorted

On basis of the results a strategy for flatness control could be worked out, whereat the different acting behaviours of the actuators were taken into consideration.

First, the crown adjustment, which is very lame in relation to the others, will be used as rough adjustment and in a tracking control respectively a monitor control loop. Which means as secondary actuator to avoid saturation of the intermediate roll bending.

Second, the shifting of the inner intermediate roll, which has to be slow also due to the fact that scratches on the roll surface during operation has to be prevented, will be used in the same manner as the crown adjustment. Which means as rough adjustment and secondary actuator.

Third, the intermediate roll bending in positive and negative direction will be used in a fast and higher-ranking control loop (Primary actuator).

All control loops can be optimised by using an appropriate model in the back ground.

Author:

Dipl. Ing. Hans-J. Biedermann, Project engineering & Sales for cold rolling mills, J.FRÖHLING GmbH&Co.KG