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editorial

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Can there be anyone alive today who does not believe that, in the words of the Chinese curse, we are living in "interesting times"? We seem condemned to suffer under a prolonged perfect storm, battered globally by simultaneous and interconnected existential threats: climate change, species collapse, bacterial resistance to antibiotics, nuclear weapons proliferation, and so on. And if those were not enough, we have now entered what some call the Fourth Industrial Revolution (artificial intelligence, robotics, automation, the internet of things) which, if not controlled by fiscal measures as yet untried, will supposedly lead to a hollowing-out of society: a few very rich innovators and entrepreneurs at the top, an army of low-paid service workers at the bottom – and, in between, just some doctors, educationists and the like. We will be able to produce many wonderful things, but few will be able to buy them.

Quite alarming figures are being bandied about. The think tank Future Advocacy estimates that one in every five UK jobs may be automated by the 2030s, a figure based on a PwC prediction that ten million workers are at risk of replacement by automation. A Deloitte analysis concluded that the most vulnerable sectors were wholesale and retail (over 2 million jobs at risk) and transport and storage (over 1.5 million). But some say this is just futurology, looking in the crystal ball; others believe in reading it in the book, and basing their judgements on experience. History, they say, has taught us that every technological revolution – steam-powered, electricity-powered, computerised – has given birth to more jobs than were eliminated, many of them unimagined, and this revolution will be no different.

What is certain is that more new machines and systems than ever before will be created and, like all artefacts, they will need to be repaired or replaced – in other words, maintained. Moreover, it is likely that many will comprise systems that will be complex and highly interactive, and could therefore fail more often and be less reliable, needing to be maintained even more frequently. Practitioners, researchers, designers, developers, and technicians in the disciplines addressed in these pages – plant and maintenance engineering, physical asset management, reliability engineering (call them all "terotechnology" if you must) – will surely be needed in this new age, and make a growing and positive contribution to it. To respond to such profound changes, our universities and centres of further education and training should increase their efforts in these areas.

in this issue

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ABSTRACT
Investigation to solve machinery problems is a key activity in managing assets to improve their reliability. A determined engineer can achieve much in leading such troubleshooting by consulting all involved, but some plant problems can still prove difficult if not impossible to solve. Two case studies are presented, with the aim of encouraging engineers, particularly those early in their career, to use a group approach rather than try problem-solving by working alone. The first was a long-standing major plant problem that had eluded solution for many months. Eventually, all the technical people from the operating, maintenance and engineering departments were brought together at the one time in one room. The synergy that was developed in a relatively short meeting brought out more observations and facts – leading to successful solution of the problem – than any of the people had recalled when questioned individually. The second study shows a variation in style of group problem-solving that was found to be more appropriate, at the time, for non-technical issues.

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ABSTRACT
Oven chains can be lubricated by a liquid or by a solid suspended in a fluid. Increased operational efficiencies can be achieved by selecting chain lubricants and methods of applying them that match the operating environments and failure modes of the chains. Several mini-case studies show that an application-specific chain lubricant designed to combat the deleterious effects of water, dust, heat, etc. can save a considerable amount of money.

Improving Oven Chain Lubrication

The importance of effective, correct lubrication of high-temperature environments in the food industry

Abstract

Oven chains can be lubricated by a liquid or by a solid suspended in a fluid. Increased operational efficiencies can be achieved by selecting chain lubricants and methods of applying them that match the operating environments and failure modes of the chains. Several mini-case studies show that an application-specific chain lubricant designed to combat the deleterious effects of water, dust, heat, etc. can save a considerable amount of money.

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Oven chains operating at high temperatures can be lubricated in two different ways: with a liquid lubricant, or with a solid lubricant suspended in a carrier fluid. Whether solid or liquid, the lubricating film physically separates contacting metal surfaces, thereby reducing friction and wear.

Fluid film lubrication

Fluid film lubrication is the regular oil film lubrication used in most ambient temperature applications. This type of lubrication can also be used at higher temperatures, provided that you take into account the decreased viscosity of the fluid (thinner oil film), the increased oxidation rate of the oil (can leave varnish and sludge), and the volatility of the oil (as it evaporates, there is less oil with which to lubricate).

A variety of synthetic base oils – polyalphaolefins (PAO), esters, silicones – allow lubrication at higher temperatures than can be achieved with petroleum oils. They have the same limitations (thinning out, oxidising and evaporating) as petroleum oils, but at higher temperatures.

At higher operating temperatures, frequent lubrication is required to replace fluid lost to evaporation. Evaporation, oxidation and decrease in viscosity make proper lubrication difficult to achieve with a liquid lubricant alone. In such cases, using a solid lubricant provides better wear protection and consumes less lubricant.

Solid film lubrication

Solid film lubrication is used at high temperatures or in applications where it is impossible or undesirable to use a liquid. The solid is usually suspended in a liquid carrier designed to disperse (evaporate) after the lubricant has been applied and, in the case of chains, after it has penetrated into the pin area of the chain. The example that most people are familiar with is graphite powder dissolved in kerosene, but technology has advanced well beyond this.

Solid lubricants provide a smooth, low drag surface, which reduces friction, wear, operating temperatures and electricity consumption.

The choice of the specific type of solid lubricant technology has an enormous impact on performance and should not be taken lightly. Materials commonly used as solid lubricants include molybdenum disulphide (MoS_2, also known as moly), graphite (C), fluorocarbon polymers such as polytetrafluoroethylene (PTFE, commercially known as Teflon), metallic oxides, and a highly refined powder of aluminium, magnesium and silicate (Al-Mg-Si, commercially known as Almasol). Table 1 (over page) shows a comparison of these technologies.

On a microscopic level, all metal surfaces are uneven and have high and low spots. The high points, called asperities, on opposing working surfaces meet under heavily loaded conditions and the instantaneous contact temperatures of these asperities often exceed 500°C. Pressures in the contact zone can exceed 175,000psi.[1] Only the Al-Mg-Si technology meets these needs and remains inert and intact under these extremes of temperature and load. Neither graphite nor PTFE has sufficient load-carrying capacities, and moly becomes abrasive, which causes wear. Consequently, NASA has used the Al-Mg-Si solid film technology on every manned US space flight including the lunar landings and the space shuttle.[6,7]

The size and the morphology of the particles of the Al-Mg-Si powder are carefully controlled. The particles are platelets, which form a single-layer coating on the surface of the metal through particulate attraction. The particles carry the load when the hydrodynamic oil film is gone (squeezed out or evaporated off), preventing metal-to-metal contact.

Reduction in friction

The reduction in friction translates into less wear, cooler operating temperatures and smaller electricity bills. The energy savings alone typically pay for the lubricant several times over. The most noticeable differences are the elimination of squealing and screaming of the chains. Another benefit is that the Al-Mg-Si powder does not build up on itself or make a mess like some other solid lubricants do.

Carriers

Different carriers allow the solid lubricant to be applied at different temperatures. For room-temperature application, light carriers such as kerosene are used. But if the chains

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Comparison of Solid Lubricant Technology				
	Al-Mg-Si (Almasol)	**Molybdenum Disulfide (Moly)**	**Graphite**	**Fluorocarbon (PTFE)**
Maximum Service Temperature	1,038°C (1,900°F)	343°C (650°F)	426°C (800°F)	260°C (500°F)
Load-carrying Capacity, psi	400,000	400,000	80,000	5,000
Lubrication Mechanism	Slippage between particles	Shearing of molecular bonds	Slippage between particles	Polymer alters orientation
Acid Resistance	Inert	Some – cannot tolerate hydrochloric acid, nitric acid, fluorine, chlorine, pure oxygen	Some	Inert
Comments	Has a natural affinity to metal as a result of surface attraction. Will not build up on itself or affect machine tolerances.	Oxidizes in air above 343°C (650°F) to form molybdenum trioxide which is abrasive. Tendency to build up on itself and affect close tolerances. Cannot tolerate hydrochloric acid and nitric acid, which are often present in lubricant environments especially where heat, water and air are present.	Galvanic corrosion problems. Tendency to build up on itself.	No load-carrying capacity. Tendency to build up on itself.

Table 1: Various Technologies [2,3,4,5]

◀ 33 are hot, the low flash point of these fluids is a fire hazard, so a variety of synthetic carriers are employed.

The best ones are smokeless and odourless. Unlike lubricants that rely on the fluid to provide the lubrication film, the evaporation rate of these products should be high rather than low because the oil is only a carrier to take the solids to where they are needed – inside the pin and bushing area.

The light carrier ensures proper penetration into the links of the chain at cool temperatures. During extended production runs, a smokeless, odourless, high flash point chain lubricant is applied to the hot chain as required. Because the chain is hot, this heavier carrier rapidly thins out and penetrates into the pin area of the chain.

When using lubricants containing suspended solids, it is important to agitate them before application. Many plants apply them to oven chains by hand using a garden hand sprayer (the type you pump, shake and spray) and apply them only once every week or two. There are also automatic lubrication systems, which circulate or agitate the fluid (to keep the solids in suspension) and then spray the fluid to the appropriate points on the chain.

When switching over from a liquid film lubricant, or when lubricating a new chain, the chain needs to be impregnated with the solid lubricant, initially requiring frequent application. Once the solids are in the chain, additional lubricant is required only to replenish the lost solids, and the amount of lubricant can be reduced significantly.

Frequency

The frequency and amount of lubricant required depends on the temperature and other aspects of the operation, but in general you should start lubricating every other day and extend lubrication intervals from there. Because most bakeries apply lubricant at weekends when the chains are cold, they typically apply a solid lubricant in a light carrier once a week, then extend this to once every two or three weeks. If you use a drip system you will have to apply the lubricant more frequently because it applies less lubricant at a time.

Another way of optimising the lubrication frequency and amount is to measure the current required to drive the chain. As the lubricant gets depleted, the friction, and hence the electrical power requirement, increases. This provides a useful feedback loop indicating that more lubricant is required. This is also a great way to evaluate chain lubricants, because the better they work, the lower the current drawn.

CASE STUDIES

Pretzel maker (Ohio)

The Rold Gold Foods division of Frito-Lay in Canton, Ohio, produces a variety of pretzels. One of its ovens has a chain drive kiln screen used in the baking process. The commercial-grade lubricant in use was black and messy. If it was not applied on a regular weekly basis, the chains would bind up, which in turn tripped the main power for the oven and shut down production. This problem occurred six to eight times a year. The temperature of the oven where the chains pass through is 246°C (475°F), with pretzel dust and salt present.

Since switching from the commercial lubricant to Al-Mg-Si, Rold Gold has never had a power failure due to build-up of solids or lack of lubrication. The company uses less lubricant than with the previously used chain lubricant, and they appreciate the improved cleanliness of the chains.

Bakery (Argentina)

Bimbo de Argentina, a large bakery in Argentina, operates Stewart ovens with skate wheel chains operating at above 200°C (392°F). The chains are lubricated with a centralised system. By changing the type of chain lubricant, build-up on the chains was eliminated, significant amperage

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The high temperature environment in which industrial oven chains operate makes the choice of lubricant especially important

drops were recorded and the amount of lubricant applied was reduced. The starting current dropped from 4A to 2A, and the operating current from between 0.70 and 0.90A to between 0.50 and 0.80A.

Bakery (Michigan)

Bluebird Baking Company is located in Detroit. It produces a variety of baked goods including hot dog and hamburger buns using Wilco tunnel ovens. The company was experiencing heavy carbon deposits on its chains and even on some of its baked goods. In 1989, the bakery decided to try an oven chain lubricant containing Al-Mg-Si technology. The change in lubricant resulted in a 26% reduction in power consumption (4.60 to 3.40A). This reduction amounts to more than $288 annually (£219) in energy saving on just one oven. The new lubricant also cleaned up the deposits from the chains.

Bakeries (New Zealand and the Netherlands)

Plants in both New Zealand and the Netherlands belonging to the Quality Baker group were experiencing expensive downtime due to chain lubrication problems. The messy solids containing the oil that they were previously using were carbonising, causing problems such as chain shudder, squeaking, and the chains jumping off sprockets. After converting to Al-Mg-Si oven chain lubricant, improvements experienced included the removal of carbon, no rusting or shudder, and in the Netherlands there was a 30% reduction in current draw (from 18.3 to 12.7A) resulting in excellent energy savings.

Conclusion

Significant operational efficiency improvements can be achieved by selecting chain lubricants and application methods that match the specific operating environment and failure mode of the chain. As illustrated by the case studies, an application-specific chain lubricant designed to combat the enemy (water, dust, heat, and so on) saves a considerable amount of money through reduced downtime, cleaning, lubrication, repairs, replacement chain and even electricity. Consider the factors that shorten your chain life and what you are going to do to prevent them.

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