WHAT YOU NEED TO KNOW ABOUT

ROLLING CONTACT FATIGUE

ELECTROLIZING
PROVIDENCE, RI

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STRESS AND CURVED SURFACES

Rolling contact fatigue (RCF) is a destructive force affecting metal parts that have curved surfaces. Specifically, it is a failure or material removal driven by crack propagation caused by the near-surface alternating stress field. If a bearing, for example, is properly mounted, aligned, lubricated, maintained, and not overloaded, and nevertheless fails, the failure typically is attributed to RCF.

WHERE TO LOOK FOR ROLLING CONTACT FATIGUE

Also referred to as surface contact fatigue, pitting fatigue, or simply contact fatigue, RCF is a common failure mechanism on many machine components that roll against one another under high normal forces. Examples include:

CAMSHAFTS AND ROLLER FOLLOWERS

LOADED FLANKS OF GEAR TEETH

RAILROAD TRACKS AND RAIL CAR WHEELS

ROLLING ELEMENT BEARINGS

At its most benign, RCF can manifest as finely dispersed pitting that has little or no effect on the performance or life of the component. At the other end of the spectrum, it can result in spalling of the surface that contaminates the lubricant, cause an increase in vibration and noise, and ultimately result in catastrophic failure.

Complicating matters is that although data exists for some well-documented materials and applications, RCF can be very difficult to predict in a wide variety of scenarios.

ROLLING CONTACT FATIGUE, METAL FAILURE, AND THIN DENSE CHROME (TDC)

Like most failure modes, no single number describes the life expectancy under RCF conditions. Instead, fatigue life is defined as a probability of failure under a specific set of conditions.

For example, for a particular test piece made from M50 steel and tested with a contact stress of 733ksi, 10% of the population will be expected to fail at 5.6M load cycles or less, while 50% of the population is likely to fail at 18M cycles or less. These values are referred to as the B_{10} and B_{50} lives, respectively. Engineers use them to predict the useful life of a component or assembly.

Electrolizing® has been widely used in the bearing industry to improve resistance to RCF. One study, conducted by the Aero Propulsion Laboratory at Wright Patterson AFB using a specialized RCF tester, found up to a 13% improvement in the B_{50} life of Electrolizing® thin dense chrome (TDC)-coated test pieces made from M50 steel when compared to the uncoated base metal. Polishing the as-plated surface resulted in an even more dramatic 31% improvement over the non-plated samples![3]

The basis for this improvement is likely the result of two of the unique features of Electrolizing®. First is a reduction in the coefficient of friction (COF). Surfaces in rolling contact also experience some amount of sliding. The amount of sliding is a function of operating parameters, machining and assembly tolerances, and lubrication conditions.

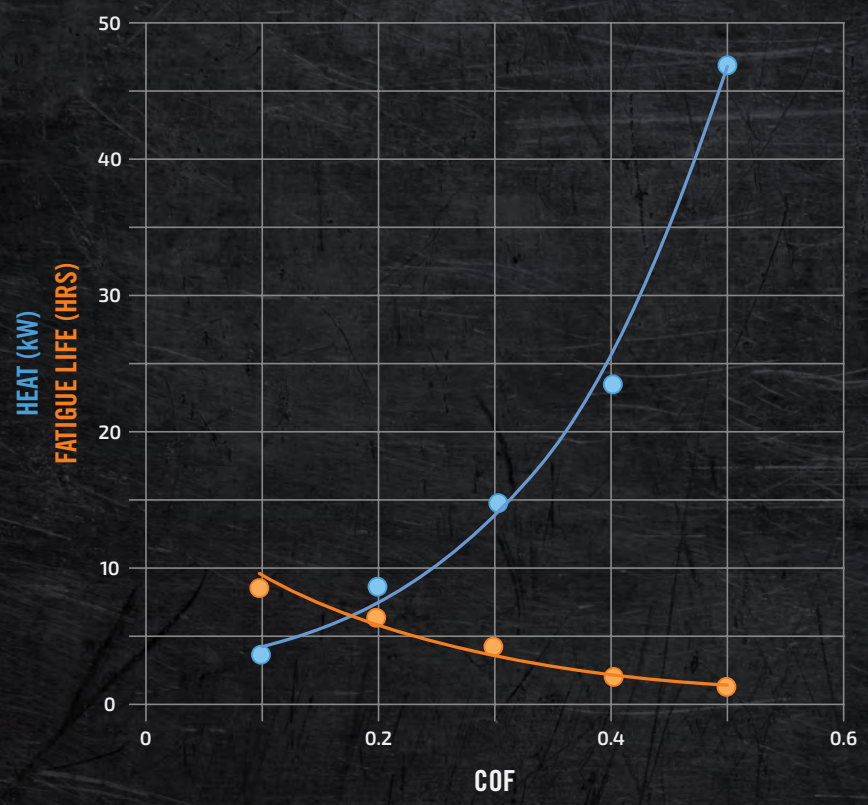


Figure 1. *Relationship between COF and heat generation (blue) and RCF life (orange).*[2]

Sliding affects RCF life significantly, but reducing the coefficient of friction minimizes that effect. Typical COF for steel on steel is 0.18, while the COF between steel and Electrolizing® is 0.15, a 17% reduction.[1] In addition to reducing the stress due to sliding, a lower COF results in cooler operating temperatures, substantially improving the life of the component and the lubricant. These phenomena are illustrated in Figure 1, which shows the nearly inverse relationship between COF, temperature, and RCF life.

The second unique characteristic of Electrolizing® that helps prevent RCF is its tolerance to poor lubricant condition. This is a function of two things: corrosion resistance and wear resistance. Since RCF often initiates at tiny surface defects, corrosion pitting can be especially detrimental. Electrolizing® has good corrosion-prevention properties that help minimize attack from oils containing excess water or that are heavily oxidized (and thus acidic).

Besides corrosion, the Electrolizing® coating increases the bearings' tolerance to lubricant that is contaminated with hard particles. Like corrosion pits, hard particles can leave microscopic impressions on the steel surface that act as RCF initiation sites. Testing has demonstrated an increase in the B50 life of 37% on M50 bearings that have been coated compared to their uncoated counterparts when run with particle contaminated oil.[3]

[1] *Rolling Bearings With Armoloy TDC Coating TI-I-5011.2/E*

[2] *Development of New Materials for Turbopump Bearings, Maurer, et al*

[3] *Improved Fatigue Life Bearing Development, Bamberger, et al*

BENEFITS OF REDUCING RCF

Coating parts with Electrolizing®—and as a result, reducing or preventing RCF—provides several proven operational benefits. They include:

- **Extended life and lower operating costs.** Items that resist pitting and cracking do not have to be replaced as often.
- **Reduced friction.** When rollers, bearings, or other parts have and maintain an incredibly smooth surface, they experience less friction and wear.
- **Increased productivity and profitability.** Systems that require less downtime for repairs enable teams to get more done, and productivity and profitability go hand-in-hand.

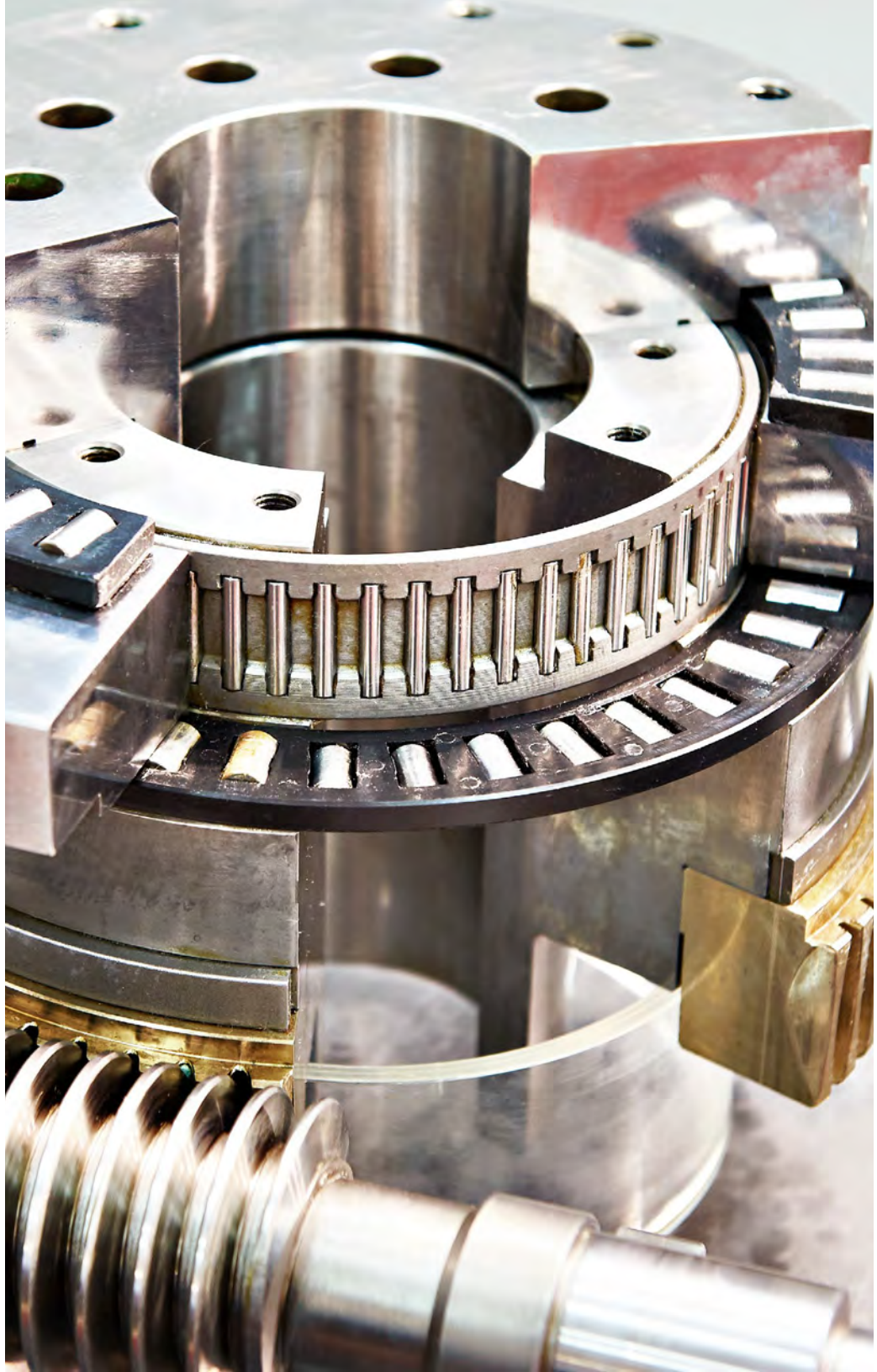
These thin coatings can be applied to parts with virtually no impact on their design specifications, which is helpful for companies looking for enhanced protection that doesn't require a costly redesign.

In addition to the operational benefits, applying a coating to rollers, bearings, gears, and other metal assets can provide business advantages. Customers notice increased productivity and reduced downtime-driven delays. And when they tell their peers about their experience, the inquiries from prospective customers tend to pick up significantly.

INCORPORATING CHROMIUM COATINGS FROM THE START

While chromium coatings can be applied at any point in a metal asset's life cycle, many designers and product manufacturers incorporate a particular coating into a new item's design. They work with Electrolizing® coating experts to determine the optimal coating solution, often coating proof-of-concept pieces to ensure they achieve the desired performance and appearance.

Taking that approach streamlines the process of getting parts to customers. In addition, simply taking the initiative to research chromium coatings demonstrates a commitment to maximizing product longevity that can provide a tremendous boost to a designer or manufacturer's reputation.



ELECTROLIZING
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THE ORIGINAL THIN DENSE CHROME

For over 77 years Electrolizing, Inc. of Providence, RI has provided the highest quality coating technologies to industrial markets. Our coating technology has been developed and refined over the years giving the Electrolizing® coatings a distinct advantage in the marketplace. As a result few comparisons can be made with conventional plating products.

Providing a full range of Thin Dense Chrome surface coatings, Electrolizing serves the greater manufacturing community in both North America and internationally.

As part of the Armoloy Corporation, Electrolizing serves as one of two Innovation Centers within the ecosystem of Armoloy's 18-location fulfillment network. Along with the Innovation Center located at Armoloy of Illinois in DeKalb, IL, Electrolizing engineers solutions to the most difficult coating challenges and empowers our fulfillment network to deliver them anywhere in the world. Armoloy is often the first place customers in the oil and gas, nuclear power, aviation, food-manufacturing and other sectors turn to for solutions to “impossible” coatings challenges.

Electrolizing ISO 9001:2015 certified.

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