Tribological Performance Testing of Industrial Greases

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ABSTRACT

The diversity of lubricating grease species, each with their own complexity and philosophy, raises the demand for the diversification of existing screening methods even in model testing. This article presents an overview of existing standard methods as well as application-oriented testing procedures, which can be used for evaluating friction, wear, and extreme pressure properties of lubricating greases in a model tribometer. For lubricant developers, the SRV® technology platform offers not only testing according to the established test methods and relevant standards, but also the possibility of testing new products in application-oriented load situations. The testing according to standards can be used as a screening test for the grease chemistry and the flow properties of the grease sample. However, it reflects the potential real-life operating conditions of a product in only a very limited way. This poster will present test scenarios for such application-oriented friction and wear tests through a few selected examples: (1) effect of wear particles on the lubricity of a lubricating grease; (2) high temperature fretting behavior of industrial greases; and (3) simplified examination of rolling/sliding friction of high performance greases that can be used as a FE8/FE9 rolling bearing prescreening test.

EXPERIMENTAL SETUP

With increasing requirements for lubricant performance, lubricant manufacturers face the challenge to meet these demands and more strict legal mandates. As a result, lubricant manufacturers must be able to reliably screen the most promising products early in the development stages for their greases.

The SRV oscillation system can determine the coefficient of friction of a material pairing, with or without lubricant. The test system uses parameters of frequency, stroke, test load, test temperature, and test duration, all of which can be modified before the test. During the test, the upper specimen is pressed onto the lower specimen with a set normal force. Additionally, the upper specimen oscillates on the surface of the lower specimen, with a sinusoidal motion. The SRV system monitors the coefficient of friction results from the movement of the upper specimen on the lower specimen by measuring the lateral friction force. The total wear is measured and recorded, both during and after the test. In addition to these variables, modern tribometers such as the SRV system can measure more parameters, which allow a more in-depth interpretation of the tribological process during the tests:

- Temperature:: measurement on the surface of the receiving block of the lower specimen
- Frequency: oscillation frequency of the oscillation drive
- Stroke Zero Position: steady component of the position signal per period
- Position: high-speed data with a sample rate of 40 µs
- Sliding Speed: differential of the position signal
- Electrical Contact Resistance: mean value of the resistance between the specimens
- Acoustic Emission at the Lower Specimen: amplitude of the generated acoustic emission

STANDARD TEST METHODS

ASTM D5707, ISO 19291 – Standard Test Method for Measure Friction and Wear Properties of Lubricating Grease Using a High-Frequency, Linear-Oscillation (SRV) Test Machine

ASTM D5706, ISO 19291 – Standard Test Method for Determining Extreme Pressure Properties of Lubricating Greases Using a High-Frequency, Linear-Oscillation (SRV) Test Machine

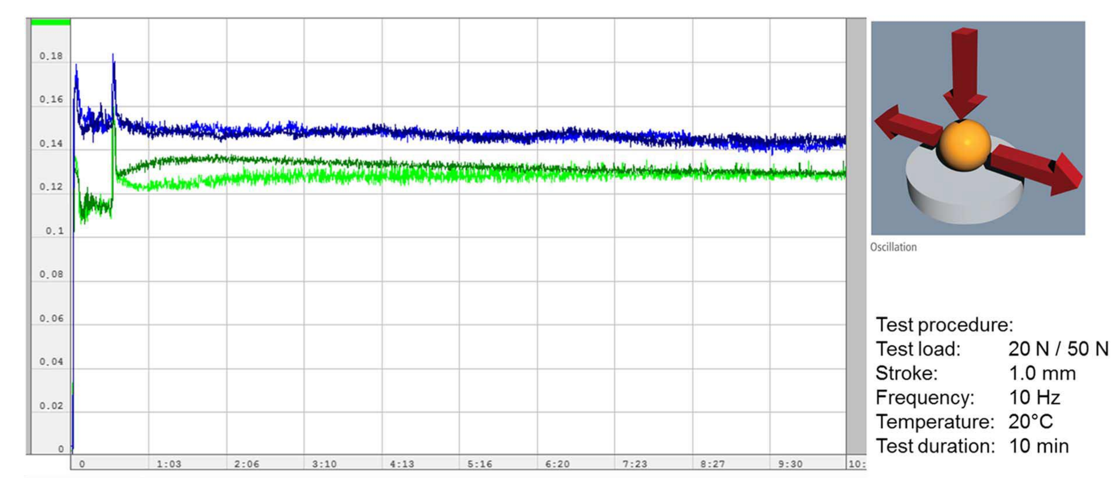
ASTM D7594 – Standard Test Method for Determining Fretting Wear Resistance of Lubricating Greases Under High Hertzian Contact Pressures Using a High-Frequency, Linear-Oscillation (SRV) Test Machine

ASTM D7420 – Standard Test Method for Determining Tribomechanical Properties of Grease Lubricated Plastic Socket Suspension Joints Using a High-Frequency, Linear-Oscillation (SRV) Test Machine

EFFECT OF WEAR PARTICLES ON THE LUBRICITY

It is important for lubricating greases to maintain a constant coefficient of friction throughout its service life. As an example, considering greases used in steering systems, a change in the coefficient of friction can disrupt the sensitive measurement and control equipment in a modern steering system, which can affect the performance of the system. Therefore, it may be useful to see how the frictional behavior of a grease changes. The coefficient of friction of a newly applied grease was compared to the same grease after a certain service life. To simulate realistic operating conditions, the test parameters were modified. These results are shown in Figure 1.

Figure 1. Coefficient of friction for new and used greases.

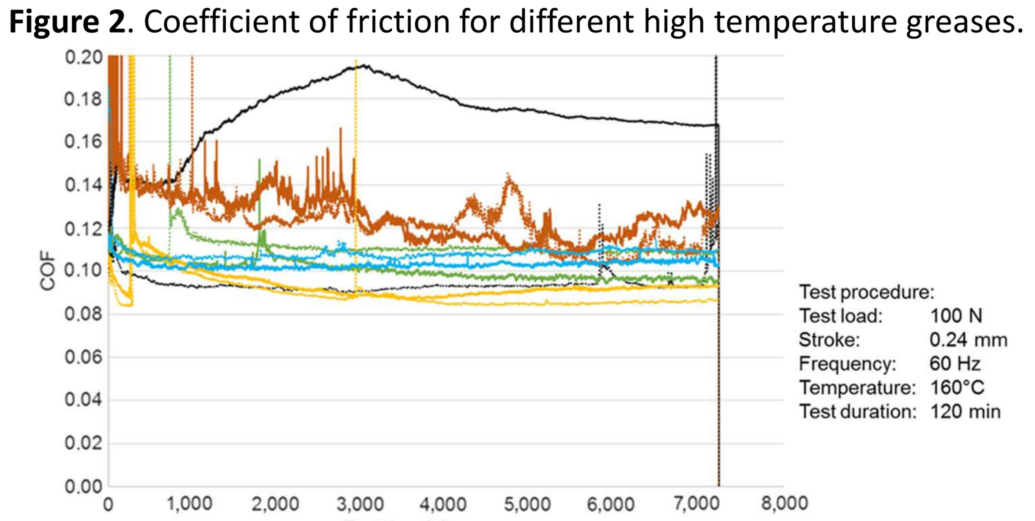


In Figure 1, the bottom two lines (green lines) represent the coefficient of friction of the new grease throughout the test, and the top two lines (blue lines) represent the same grease after use with wear particle contaminants. The introduction of wear particle contaminants increases the coefficient of friction by about 110%, resulting in more significant frictional losses.

HIGH TEMPERATURE FRETTING BEHAVIOR

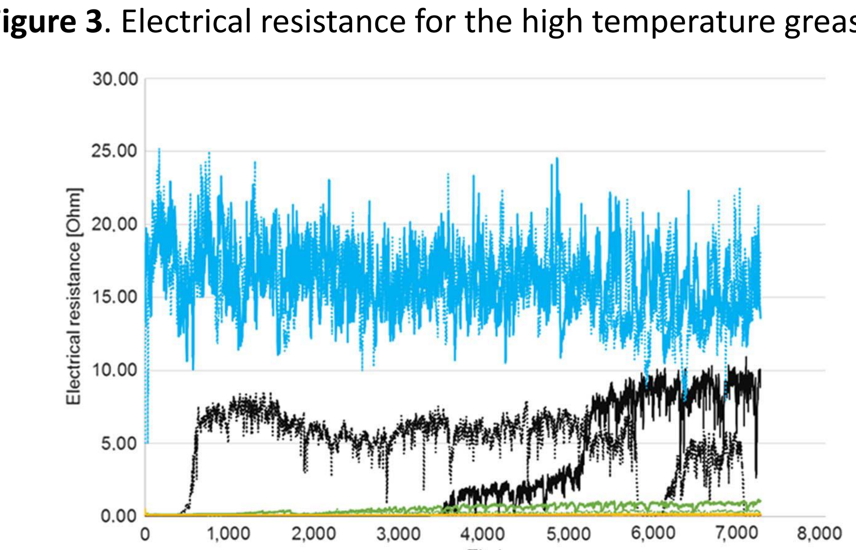
Some industrial environments may be interested in analyzing the high-temperature fretting wear behavior of specialty greases. In these special cases, the real operating parameters like the swivel angle and frequency of a reference operating point can be isolated, and transferred into load parameters in the SRV model test environment. By testing a variety of these competing special greases for the same application, they can be examined to see their behavior in these test load environments, as seen in Figure 2.

Figure 2. Coefficient of friction for different high temperature greases.



In Figure 2, there are some greases that show a stable and repeatable coefficient of friction development, while others are more unpredictable. This shows that greases competing in the same market can react significantly differently under similar tribological conditions. Figure 3 shows the electrical resistance of the same greases. The variance in the electrical resistance between the greases indicates different grease chemistries. Analysis of the electrical resistance indicates that greases with similar frictional performance can be chemically different.

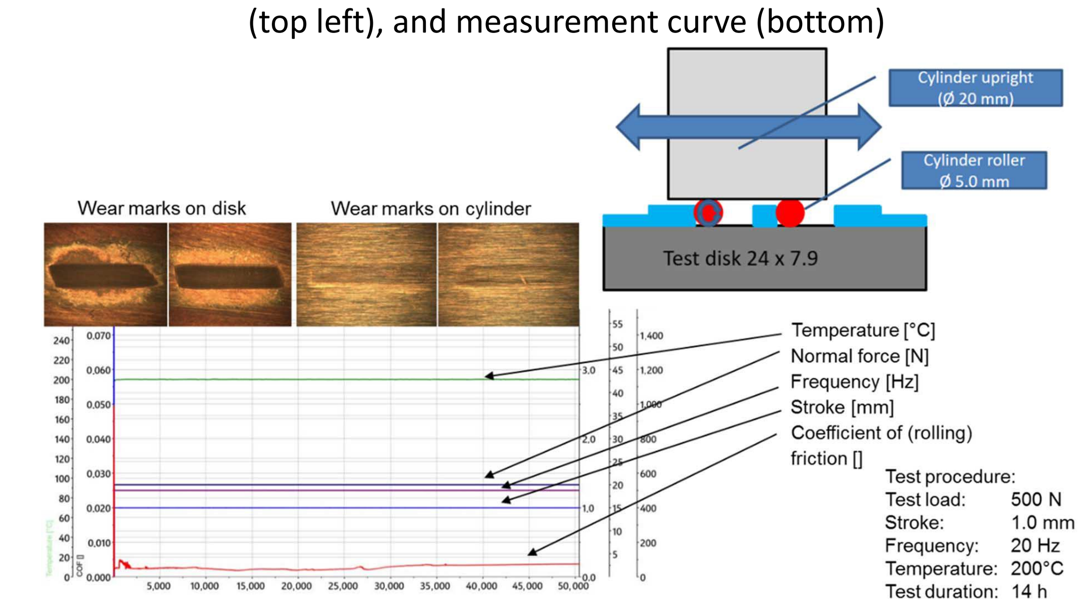
Figure 3. Electrical resistance for the high temperature greases.



FE8/FE9 ROLLING BEARING PRE-SCREENING TEST

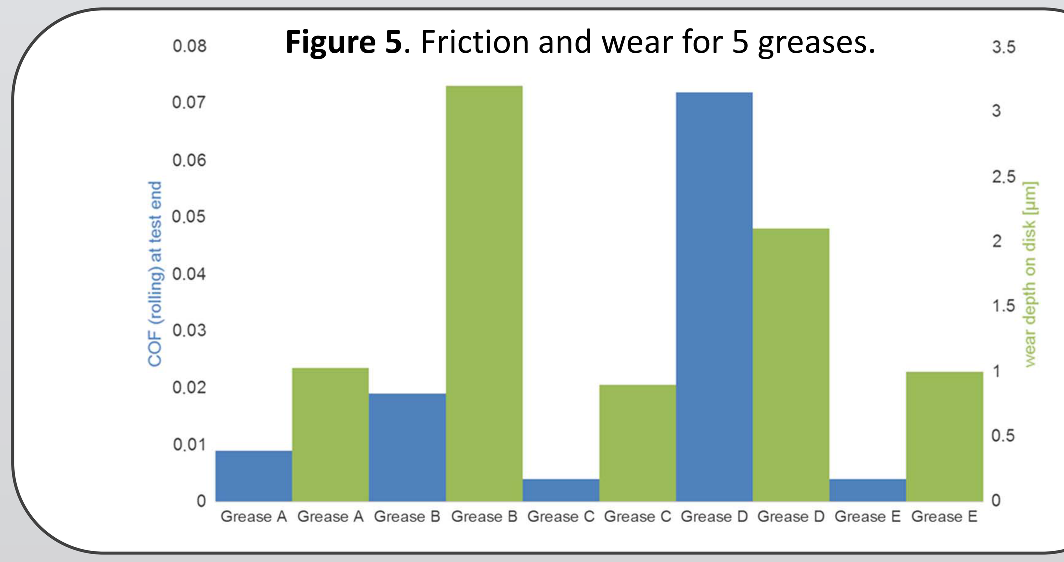
Some variants of greases do not produce useful results under these oscillating sliding stress tests, typically greases with thick consistency of poor flow behavior. For these greases, a slip-rolling motion allows a quick screening test, with improved results. In this setup, the translatory movement of the SRV system is converted into a rolling motion of two cylinders. The cylinders roll over the surface of a test disk, which is confined by a grease filled cage. Throughout the test, the rolling friction and wear scares are monitored. A schematic of the test is shown in Figure 4.

Figure 4. Diagram of the rolling friction setup (top right), wear scars (top left), and measurement curve (bottom)



Five different greases were testing with the rolling friction setup, and the results are shown in Figure 5. Grease C and Grease E show promising behavior here, due to a relatively low coefficient of friction, and small wear depth on the disk.

Figure 5. Friction and wear for 5 greases.



CONCLUSIONS

As seen in this poster, it is clear that standards-based tribological examination of lubricants can only be the developer's first step in experimentation, as there are many parameters to analyzer to investigate the behavior of a lubricant. To represent a meaningful performance profile of a lubricant, more parameters besides the typical friction and wear must be monitored throughout testing. By limiting the analysis to a small amount of test contact geometries and only the analysis of friction and wear, lubricant developers will miss valuable information regarding the performance and behavior of the lubricants. The SRV test system is one that is capable of analyzing a lubricant's performance outside these two characteristics. This poster showed how wear particles that may be introduced into a used lubricant can increase the coefficient of friction, how the high temperature fretting behavior of industrial greases can vary even for competing greases, and explained a simplified examination of rolling/sliding friction of high performance greases that can be used as a FE8/FE9 rolling bearing prescreening test.

REFERENCES

- **Patzer, G.,** "Evaluation of High Performance Lubricating Greases on the Translatory Oscillation Tribometer (SRV)," *Materials Performance and Characterization*, Vol. 7, No. 3, 2018, pp. 340-354. ISSN 2379-1365.

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