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NEW APPROACH TO INTERPRETING SEIZURE TESTS ON THE TRANSLATORY OSCILLATION TRIBOMETER(SRV®)

TRACK OR CATEGORY

Tribotesting 3J

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When looking in detail at analyses of the tribological load carrying capacity of lubricants, it becomes apparent that an exclusive evaluation of the development of the coefficient of friction cannot provide any sufficient criteria for determining the occurrence of adhesive failure. This is due on the one hand to the increasing complexity of lubricant formulae, and on the other hand to the increasing frictional power capacity of modern drive and control concepts in the construction of tribometers.

For this reason, it is urgently needed to examine the adhesive processes and their detection in more detail with the help of appropriate tribological values and criteria.

1. Introduction

The tribological load carrying ability of lubricants is determined on the translatory oscillation tribometer (SRV®) through load increasing tests employing standardized test methods and parameters in accordance with ASTM standards.

With the increasing complexity and performance of lubricants and tribometers, the reproducible recognition of a tribo-system's failure time and the interpretation of the effects bringing about failure is placing ever higher demands on the technical and tribological expertise of the experimenter.

The present paper provides ideas and discussion approaches on how the interpretation of load increasing tests can lead up to new knowledge beyond standardized result quantities in tribological research and development.

2. Experimental procedure

Under the framework of this study, ten lubricants which had also served as reference samples in the latest international SRV® round robin tests, were subjected to the tribological load-carrying test for greases according to ASTM D 5706 and to ASTM D 7421 for oils respectively. On top of the customary measurement and result quantities such as normal force, temperature, frequency, stroke and coefficient of friction – additional measurement and results quantities were recorded during the tests: electrical resistance, acoustic emission, drive current of the oscillation motor, movement zero position, coefficient of friction effective value, and, as high-speed data: position, coefficient of friction, sliding speed, electrical resistance and acoustic

emission. From the recorded measuring data, frictional energy, friction power and the crest factor were also determined.

2.1 Recorded measurement and result quantities

Temperature, frequency, normal force, stroke, stroke zero-position, position, coefficient of friction (peak value), coefficient of friction (effective value, coefficient of friction (high-speed data), sliding speed, electrical resistance between the specimens, acoustic emission at the lower specimen, drive current as a measure of motor power.

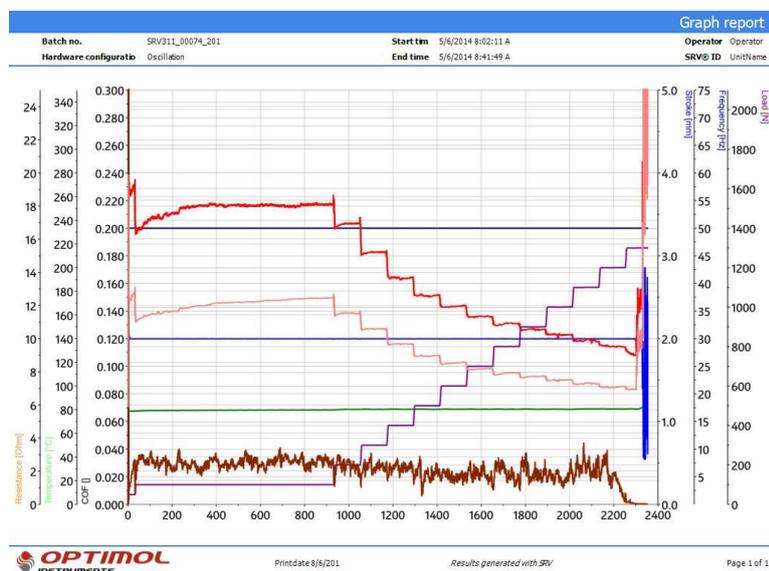


Fig.1 Example of a step load test according to ASTM D 7421 with additional measured values: effective value of the coefficient of friction and electrical resistance between the tribopartners. It can be observed that the resistance value drops down shortly before seizure occurs.

3. Evaluation methods

For evaluating the tests, a program is developed which converts the measurement and result quantities into tribological quantities and recognizes and evaluates effects during the test.

The following secondary tribological quantities are calculated:

Mean friction power per period [Watt, W], mean friction energy per period [Joule, J], friction power [N], crest factor, smoothed coefficient of friction curve, noise bandwidth of the coefficient of friction.

The following criteria are used to automatically recognize and evaluate adhesive effects:

Evaluation of the running smoothness of the coefficient of friction, recognition of fluctuations in stroke, recognition of strong changes of the coefficient of friction, recognition of adhesive failure.

4. Evaluation of the load increasing tests by means of new methods

The new measurement and result channels can, in varying significance, be used as a further interpretation aid for seizure load tests and particularly for recognizing adhesive failure.

4.1 Measurement of the electrical resistance

The electrical contact resistance prevailing between the two specimens is predominantly determined by the chemical composition of the lubricant and the reaction layer produced on the surfaces of the friction partners.

Hence the electrical resistance can be used as a measuring quantity only for a particular group of lubricants whose chemical components are not electrically

conductive and which also do not produce electrically conductive reaction products on the surfaces of the friction partners.

If these conditions are satisfied, it can be noted that

1. after test start, the electrical resistance initially rises and then stabilizes on a certain level.
2. with some lubricants, the electrical resistance briefly drops after test start and increase of normal force and then stabilizes again
3. some lubricants hardly react at all to the increase of normal force
4. the electrical resistance goes towards zero shortly before adhesive failure occurs.
5. the electrical resistance in the friction contact may change considerably during one oscillation period. The minimum resistance value usually lies at the return points and the maximum value at the zero passage of the movement (maximum sliding speed). This behavior will change depending on the normal force which has been applied.

4.2 Measurement of the Stroke Zero Position

When analyzing high-speed position data it shows that adhesive moments in the tribo-contact bring about a displacement of the position signal around the zero position. By means of suitable integration of the position signal, the zero position signal can be extracted and evaluated as a tribometrical result quantity.

This analysis shows that, in certain tribo-systems, adhesive failure announces itself by an increased zero point displacement. However, for most of the analyzed tribo-systems, a significant zero point displacement only occurs after an initial adhesion event. A fluctuation of the zero position by more than 0.01 mm can be considered as significant.

4.3 Effective value of the coefficient of friction

Due to its integrative character, the effective value of the coefficient of friction – as compared to the peak value which is usually evaluated as an SRV® result quantity – weights the sliding portion of friction behavior stronger than the adhesive portion. The effective value therefore provides information on the power consumption of a frictional system. The comparison of effective and peak value for one provides information on the strength of the adhesion behavior at the turning points of the movement, for another it enables a rough mathematically derived evaluation of the signal shape of the original friction signal.

In all tests, it can be noticed that the ratio of peak and effective value decreases with the increase of load which indicates that adhesive and sliding portion of friction behavior are increasingly converging.

4.4 Sliding speed

In regard to Stribeck's theory of the coefficient of friction being dependent on speed, sliding speed usually plays an important role in tribological analyses. In the SRV®, it is mainly determined by stroke and movement frequency due to the sinusoidal movement.

However, as a differential of the position signal, looking at the sliding speed enables clarifying statements on movement continuity. Taking into account the search for adhesive effects, it can easily be assumed that an impaired movement will be observed together with an adhesion event.

5. Automated analyses

Automated analysis algorithms are a means of increasing the knowledge gained from a test series by calculating data allowing further correlations.

The analysis algorithm used here determines the pass load of the load increasing test by means of the current seizure load criteria (3) and correlates them with the calculated values from the original measuring data. These are i.e.:

- Cumulated friction energy [J]
- Mean friction power [W]
- Mean friction force [N]
- Temperature at seizure [°C].

The result quantities obtained in this way can be correlated in to draw further conclusions.

By way of example, the correlation of a temperature rise against the set value and the cumulated friction energy shows that the temperature in the friction contact often rises with the increase in energy. Apparently not all tribo-systems equally convert frictional energy into thermal energy.

The correlation of frictional energy and respectively friction power with the reached pass load (Fig. 1) provides new approaches for evaluating lubricants:

The highest possible pass load should coincide with as little frictional energy as possible.

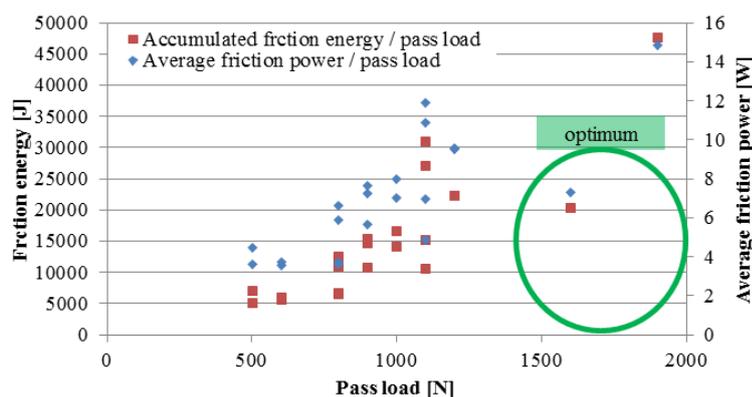


Fig.2 Correlation of friction energy and mean friction power with the reached pass load

6. Summary and Outlook

The presented study makes it clear that the SRV® tribometer is able to provide results which by far exceed the evaluation in accordance with standardized methods and provide vital conclusions for research and development.

For Optimal Instruments as a tribometer manufacturer, the study proves that the further development of software and hardware can help gather more findings on tribological systems.

REFERENCES

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KEYWORDS

SRV®, seizure load capacity, pass load, automated interpretation, tribometry