Development of a screening method using a translatory oscillation tribometer (SRV®) to test extreme pressure and anti-wear properties of gear oils

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ABSTRACT

Gear oils are used in a wide range of applications and depending on the application, different performance factors of the lubricant are important and must be evaluated. For many applications, including industrial machinery and automotive driveline components, it is ideal to have an anti-scuff gear lubricant, or an extreme pressure (EP) type of lubricant. These types of lubricants typically have additives to enhance their load-carrying capacity making them ideal for heavy load, slow speed conditions.

Testing the scuffing load and extreme pressure properties of a gear oil is not a simple test. A test rig was developed by F2G (the Technical Institute for the Study of Gears and Drive Mechanisms of the Technical University in Munich, Germany) to measure the scuffing load capacity of lubricants as per ISO 14635. While this test provides vital information in regards to scuffing load, it is a very expensive and time consuming test to run and is not feasible to test every gear oil formulation that one might need. To help narrow down which gear oils should be tested using the F2G rig, a test was developed using the Translatory Oscillation Tribometer (SRV®) to screen gear oils and in addition, give complementary information by measuring the coefficient of friction, wear scar, and load carrying capacity.

The SRV® Tribometer is an invaluable tool for evaluating friction and wear properties which can now be applied to EP and Anti-Wear (AW) testing of gear oils. The method used is based on DIN 51834-4 and is done on a translatory oscillation tester equipped for parallel movement. The results of the EP and AW tests on the SRV test rig are able to help characterize and differentiate gear oils in minimal time. The results are a good indication of how the lubricant will behave and serve as a pre-screener to determine which oils should go on for further bench tests and field use. In addition to the pre-screening results, this method will also yield results of coefficient of friction, wear volume and estimations for the load carrying capacity. This poster will show how the tests were developed, how the results compare to the F2G test and how the SRV can be used to provide a meaningful evaluation of gear oils.

INTRODUCTION

For tribological evaluation of gear oils, current testing generally follows two methods:

1) Evaluating gear oils using a 4-ball seizure load and wear test
2) Application-oriented bench tests on F2G loaded gear test systems

There are motivations to develop a quick and cost-effective method for an application oriented screening of gear lubricants and associated additive packages. This new method would allow easy screening of new alloys and coatings. The new approach is to evaluate the seizure load-carrying capacity using step load tests on the SRV instrument. The SRV test system uses DIN 51834-4 for the evaluation of friction and wear for Hertzian contact pressures, between F2G load stages 3 and 14 and beyond.

SPECIMENS USED

- Lower specimen: Disk with a diameter of 24 mm and a height of 7.9 mm
- 100 Cr6 rolling bearing steel, hardened G250
- Surface: Lapped with Rz of around 0.05 µm

- Upper specimen: Cylinder 6 mm x 8 mm
- Crowned profile with a supporting length of 4 mm
- Polished Surface

GEAR OILS USED

The following oils were used with their F2G load stages according to F2G A/B, 3/90.

<table>
<thead>
<tr>
<th>Sample</th>
<th>ISO VG</th>
<th>Kin. Visc. (mm²/s)</th>
<th>Kin. Visc. (cSt)</th>
<th>VI</th>
<th>Density (kg/m³)</th>
<th>Base Oil</th>
<th>F2G Test</th>
<th>F2G Gear Scuffing Test A/B/3.90</th>
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<tr>
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<td>1075</td>
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</table>

INSTRUMENTATION

Evaluation of the gear oils was done with the SRV 5 tribometer. The same basic principles apply throughout all five generations of the SRV system. It uses a state-of-the-art electronics system which allows a high resolution and great depth of data.

STEP TESTS PARAMETERS AND RESULTS

The testing implements the ISO 14635-1 (F2G A/B, 3/90) test parameters to the SRV tribometer where possible. There are some restrictions to this:

- Load step duration: the SRV frequency is 50 Hz, which is half of the number of rotations for F2G test parameters
- Maximum sliding speed is set to 0.63 m/s
- Temperature is 98°C at the bottom of the lower specimen, bringing the surface temperature to around 90°C

- An increasing load duration results in increased wear.
  - This indicates there may be less surface pressure than calculated.
  - At shorter step durations, higher seizure loads are achieved.
  - The load durations are too short to provide a real contact.

EVALUATION OF FRICTION AND WEAR BEHAVIOR

To evaluate the friction and wear behavior of the gear oils, a modified DIN 51834-4 procedure is used, with the following variations:

- Test temperature: 38°C
- Running-in phase: load-increasing steps until test load is reached
- Test duration: 120 min, after running-in phase
- Test force: last load step without adhesive failure
- If adhesive failure occurs during the test, the next lower load step is selected.
- Positive result after completing test with the same test load without failure.
- 2.0 mm stroke at a frequency of 50 Hz
- The test is assessed in terms of friction parameters and wear scar width on the cylinder.

CONCLUSIONS

The results show that the test environment of the SRV tribometer is suited to characterize and differentiate gear oils with regard to their end point characteristics and their friction and wear. The results of these tests are a first indication for the behavior of the lubricants when in use in real applications. Additionally, the SRV test system can act as a pre-selection for further bench testing and field trials. However, to assess its full capability in these tests, more testing is needed with a large amount of samples.

REFERENCES

- DIN 51834-4 “Testing of lubricants – Tribological test in the translatory oscillation apparatus – Part 4: Determination of friction and wear data for lubricating oils with cylindrical roller-disk geometry” (German National Standard)

ACKNOWLEDGEMENTS

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