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

Dr. Raj Shah, Cindy Klager, Philip Iaccarino

Koehler Instrument Company, Inc. Holtsville, NY

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 antiscuff 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 FZG (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 FZG 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 FZG 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 FZG 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 FZG load stages 3 and 14 and beyond.

SPECIMENS USED

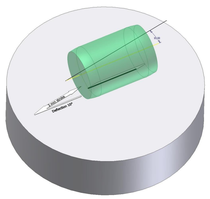
Lower specimen:

- Disk with a diameter of 24 mm and a height of 7.9 mm
- 100 Cr6 rolling bearing steel, hardened Q&T
- Surface: lapped with R_a of around 0.05 µm

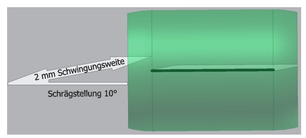
Upper specimen:

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

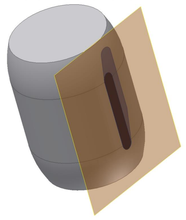
View from above



View through the roller to the disk



View through the disk to the roller



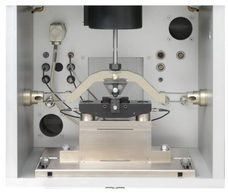
GEAR OILS USED

The following oils were used with their FZG load stages according to FZG A/8, 3/90.

Sample ID	ISO VG	Kin. Visc. at 40°C, cSt	Kin. Visc. at 100°C, cSt	VI	Density, kg/m³	Base Oil	FZG-Test, A/16.6/90, Failure Step	FZG Gear Scuffing Test A/8.3/90
4.12						Mineral Oil	7	
1.14	320	320	37.4	166	860	Synthetic	>13	
2.14	320	320	56	240	1060	PAG		>12
1.15	320	321	52.7	230	1069	PAG	>12	
2.15	320	320	54.4	237	1075	PAG	>14	>12

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.

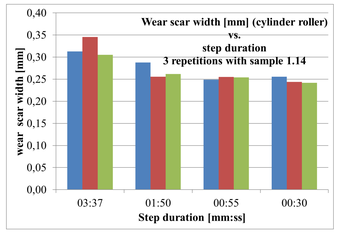


1 Oscillation block
2 Head plate with
2a Friction force sensors
2b Receiving device for the lower specimen
3 Device for parallel movement of the upper specimen, in extension of the oscillation drive axle
3a Upper specimen holder
4 Loading device axle

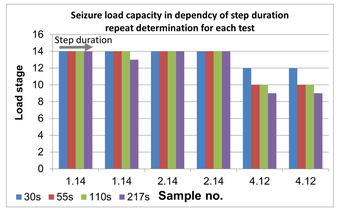
STEP TESTS PARAMETERS AND RESULTS

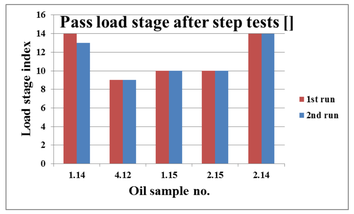
The testing implements the ISO 14635-1 (FZG A/8, 3/90) test parameters to the SRV tribometer where possible. There are some restrictions to this:

- Load step duration: the SRV frequency is 50 Hz, which is half of the number of rotations for FZG 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 provoke a reaction.

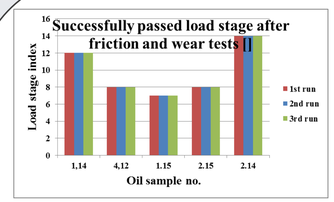


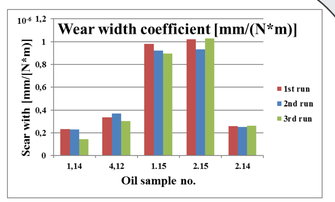


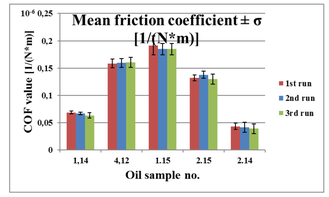
EVALUATION OF FRICTION AND WEAR BEHAVIOR

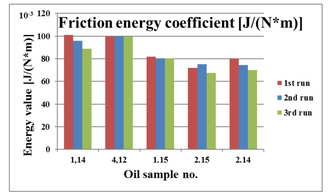
To evaluate the friction and wear behavior of the gear oils, a modified DIN 51834-4 procedure is used, with the following variations:

- Test temperature: 98°C
- Running-in phase: load-increasing steps until test load is reached
- Test duration: 120 min, starting 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 three tests 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.

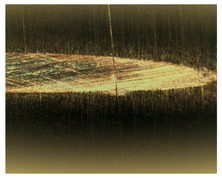




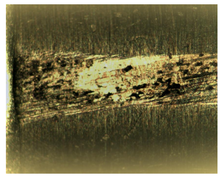




Sample 1.14



Sample 4.12



For good friction behavior, the edges of the wear scar taper off.

For bad friction behavior, the cylinder roller tilts due to adhesive events, resulting in a widened wear scar.

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 from 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

- **ISO 14635-1** "Part 1: FZG test method A/8, 3/90 for relative scuffing load-carrying capacity of oils (International Organization for Standardizations; Geneva, Switzerland)
- **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

Koehler Instrument Company, Inc. 85 Corporate Drive Holtsville, NY 11742 (631)589-3800
rshah@koehlerinstrument.com, cklager@koehlerinstrument.com,
philip.iaccarino@stonybrook.edu