Next generation Group V base oils for electric vehicle fluids

David Gillespie[1)*] and Gareth Moody[2)]

[1)]Croda Europe Ltd., Snaith, United Kingdom
*Corresponding author: david.gillespie@croda.com

Next generation lubricants for EV drivetrains will require fluid optimization in both the additive package and the base fluid. Increasing the efficiency of the EV drivetrain means increasing the focus on efficiency losses in the gear system and its lubricating fluid. Along with thermal management of both the motor and battery, as well safety aspects such as low electrical conductivity and high electrical breakdown voltage values, there are significant challenges to formulating improved fluids for high efficiency and low wear.

Here, next generation group V fluids are evaluated for their efficiency and cooling ability whilst also tested for other critical parameters such as oxidative stability, fluid and material compatibility and wear performance.
Keywords (from 3 to 5 max): electric vehicle, traction, gear efficiency, extended driving range

1. Introduction

The rapid move towards electrification of vehicle powertrains has accelerated beyond the understanding and current gear oil specifications of OEM's and regulators. Current generation hybrid and electric vehicles still use standard automatic transmission fluid (ATF) formulations which were not specifically designed for this application. Barriers to widespread adoption of BEVs are many but the top cited concerns are [1]: driving range; charging time; and vehicle cost.

Advanced driveline fluids can help to address these concerns. Fluids which offer increased efficiency can offer a direct increase to driving range or reduction in battery weight and cost. They can also enable the use of advanced technologies and hardware (such as direct oil cooling of electrical components) that in turn provide the required improved performance. There is therefore a need to understand how next generation base fluids perform in these key areas.

2. Methods

2.1. Base fluids and formulations

Model electric vehicle transmission fluids (EVTFs) were prepared from a high-performance Group V ester base fluid and a commercially available Group III base fluid. An EV-specific additive package was used at the manufacturers recommended treat rate. Standard viscometric properties of the formulations are shown in Table 1.

Table 1: Kinematic viscosity (KV) at 40°C and 100°C of EVTFs prepared from Fluid 1 and a Group III base oil

Formulation	KV40 / cSt	KV100 / cSt
Fluid 1	11.4	3.4
Group III	14.1	3.2

2.2. Tribological testing methods

A PCS mini-traction machine (MTM) was used to assess the traction coefficient of the model EVTFs. The traction was measured at high entrainment speed to ensure a full film of lubricant in the contact.

3. Discussion

The traction coefficient as a function of slide-roll ratio (SRR) of EVTF formulations prepared from Fluid 1 and the Group III base oil were measured using the MTM. As can be seen in Figure 1 the ester fluid has significantly lower traction than the Group III base oil. The magnitude of the reduction is such that the traction of the ester-based formulation at 40°C is similar to the performance of the Group III at 100°C despite a substantial difference in viscosity (11.4 cSt for Fluid 1 vs 3.4 cSt for Group III). This has important benefits not only in terms efficiency but also potentially in component lifetime. There is a general trend towards reducing the viscosity of lubricants to improve efficiency. This is because generally, within a specific class of base fluid a lower viscosity will result in lower traction and less energy loss. This must be balanced, however, against the potential for increased wear due to lower lubricant film thickness[2]. The advantage of Fluid 1 is therefore that the same low level of traction can be achieved with a higher viscosity fluid.

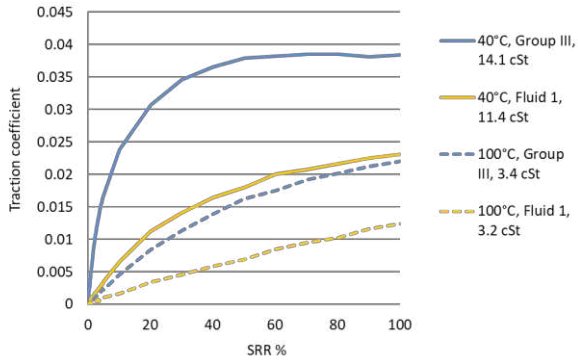

Figure 1: Traction curves of model fully formulated EVTFs prepared from Fluid I (Group V) and a Group III base oil at 40°C and 100°C

4. References

[1] https://www2.deloitte.com/uk/en/insights/focus/future-of-mobility/electric-vehicle-trends-2030.html

[2] Kurihara, I. and Kurosawa, O., SAE Transactions, Vol. 116, Section 4: Journal of Fuels and Lubricants (2007), pp.805-812