

Effect of Lubricants on Tooth Surface Damage Behavior of Gears in e-Axle Reduction Units

Takashi Yanagihara ¹⁾

1) Idemitsu Kosan Co.,Ltd, Lubricants Research Laboratory
24-4 Anesakikaigan, Ichihara-shi, Chiba, 299-0107, Japan
(takashi.yanagihara.7260@idemitsu.com)

KEY WORDS: power transmission, lubricating oil/transmission oil, gear/gear system, lubrication/tribology (A2)

As e-Axles become more compact and powerful, motor-connected high-speed gears operate under severe conditions. Micropitting can cause wear and tooth profile changes, adversely affecting durability and noise performance. This study investigated the influence of lubricant formulation on tooth surface damage in a commercially available e-Axle.

Three lubricants were evaluated: commercial oil M-1, in-house reference oil S-1, and S-2, prepared by modifying the additive formulation of S-1. All were low-viscosity e-Drive Fluids, with kinematic viscosities of 2.8–3.3 mm²/s at 100 °C. Metal-to-metal friction coefficients measured by an LFW-1 block-on-ring test at 100 °C were 0.089 for M-1 and S-1 and 0.011 for S-2. New same-model units were used.

A 500 h durability test was conducted using a repeated pattern including maximum-torque acceleration and maximum-speed operation. Oil temperature was maintained at 100 ± 3 °C. Every 100 h, the unit was disassembled to evaluate drive-flank appearance, tooth profile, and surface roughness. Three M-1 tests confirmed repeatability; representative results are presented.

After 500 h, widespread micropitting was observed with M-1 and S-1, mainly on the root side of the pitch line (Fig. 1). In contrast, S-2 retained machining marks over most of the surface. Although local pit-like damage was present, widespread micropitting comparable to that with M-1 and S-1 was not observed.

M-1 and S-1 showed tooth profile changes mainly on the root side of the pitch point (Fig. 2). The maximum change for M-1 was approximately 10 µm, whereas S-2 showed little change. Overall, the arithmetic mean roughness (R_a) and reduced valley depth (R_{vk}) increased with M-1 and S-1 but decreased and remained below their initial values with S-2. These results indicate that micropit formation and surface roughening progressed with M-1 and S-1, whereas surface smoothing through running-in predominated with S-2.

The low friction of S-2 may have contributed to damage suppression; an equivalent formulation also improved efficiency previously. However, LFW-1 and actual gear contacts differ, and additive-derived surface reactions may influence damage. Further work will clarify the mechanism and support EDF development balancing friction, protection, cooling, electrical properties, and material compatibility.

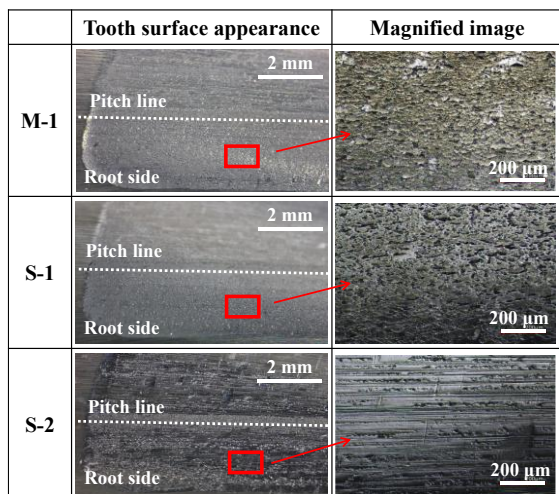


Fig.1 Tooth surfaces and confocal laser microscope images after 500 h

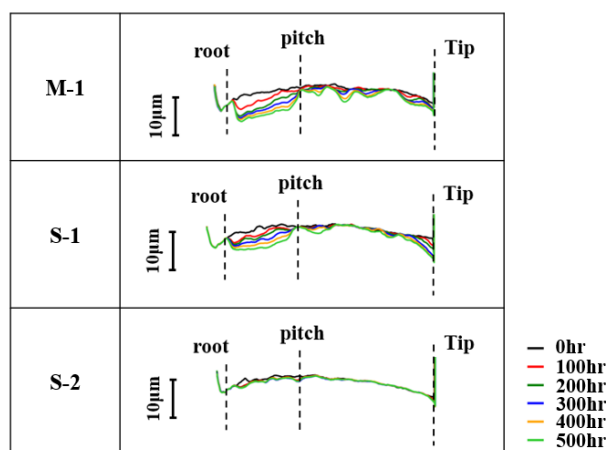


Fig.2 Changes in tooth profiles with test time