

Effects of Foaming on Transmission Fluid for Hybrid Vehicles

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Hybrid vehicles have widely adopted drive systems that integrate the motor into the transmission, with a single type of oil providing both cooling and lubrication. As motor RPMs increase and transmission oil viscosity declines, however, air can more easily penetrate the oil and residual bubbles may more readily occur, making it essential to help ensure effective defoaming performance.

Transmission oil may degrade during use due to such factors as shear, heat, and contamination with foreign particles, which can lower defoaming performance. Air bubbles remaining within the oil can reduce lubrication and cooling performance and increase agitation resistance. This in turn may affect vehicle performance, for example by producing unusual noise or lowering fuel efficiency.

This study therefore focused on defoamers contained in the oil and examined how enhancing them can affect transmission performance.

While silicone-based defoamers are commonly used as one type of oil-compatible additive, partially fluorinated silicone-based defoamers are also becoming widespread, with reports indicating that they offer enhanced shear stability and heat resistance. This study used two types of oil, referred to herein as “Fluid_BASE” (oil containing a conventional silicone-based defoamer) and “Fluid_NAF” (oil containing a fluorinated silicone-based defoamer), both with the same base oil and additive composition.

Oil-only evaluations also confirmed improved thermal durability and shear stability. Friction loss torque was verified in an actual transmission. The results showed a decline in friction loss torque in the high-temperature range, particularly under high-RPM conditions. It is inferred that at high temperatures, the formation of bubbles is inhibited due to a decline in oil viscosity and a reduction in the amount of dissolved air. It is further inferred that, under high-RPM conditions, bubbles become finer, making it easier for defoamers to reach the bubble interfaces, thereby encouraging the bubbles to rupture. Moreover, it is believed that the modified defoamer’s ability to penetrate the interface is enhanced by its tendency to become more active in high-temperature environments, thus resulting in a more pronounced defoaming effect.

An actual vehicle was used to evaluate cooling performance, including towing performance. Since motors generate large amounts of heat due to the high RPMs when the vehicle is traveling at high speeds, it is essential that the oil provides efficient cooling. The test results showed a decline in cooling performance compared to the conventional oil during high-speed driving tests and towing and hill-climbing performance tests.

To investigate the reason why no cooling performance advantage was observed, beaker tests were conducted using the oil alone. Temperature changes were measured after agitating and heating under identical conditions. The results indicated that the oil containing a fluorinated defoamer tended to cool more slowly than the conventional product, and this difference became more pronounced with increasing temperature.

The use of fluorinated silicone-based defoamers is expected to greatly contribute to extending transmission oil maintenance intervals through enhanced foam suppression performance. On the other hand, as the bubbles in the oil become finer, bubble retention increases and heat dissipation performance declines. These results suggest a negative impact on transmission cooling performance.

It is believed, however, that this can be offset by low-cost thermal management measures that can be implemented within the scope of vehicle design. These could include increasing the volume of airflow drawn in while traveling by optimizing the front grille openings and enhancing heat exchanging efficiency with an integrated layout of existing cooling units.

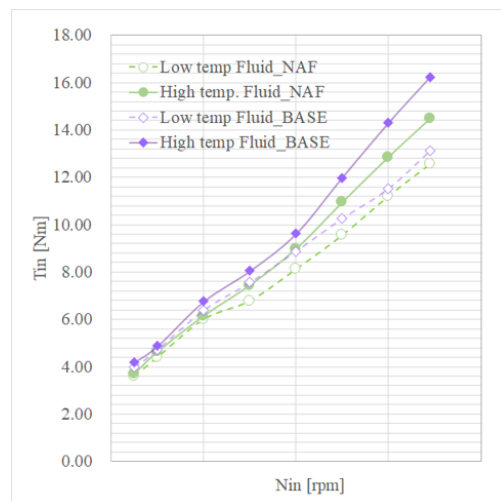


Fig. Transmission friction test

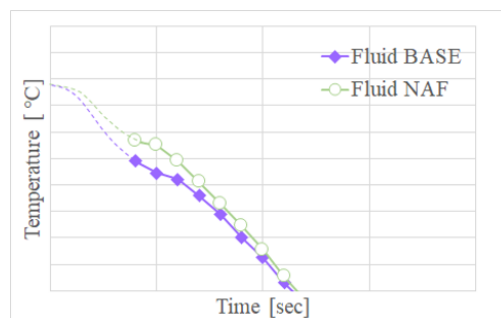


Fig. Temperature in the cooling test