APPLICATION NOTE (MPT-3000)

> Micropitting Accelerated Test for Tribo-Elements Sliding Parts of EV

Introduction:

Electric vehicles have grown in popularity in the current landscape of increasing environmental concerns. Transitioning from traditional internal combustion engines to electric motors has spurred a heightened demand for high-speed reduction gear operation in automotive transmissions. Often there is fatigue damage on the transmission, specifically micropitting and pitting on the gear surface. Pitting manifests as noticeable hole-shaped damage near the tooth root, visible to the naked eye. In contrast, micropitting is characterized by fine, frosted conditions, discernible only through microscopic observation, shown in Figure 1. This fatigue damage emerges from repeated stress and generates vibration and noise, reducing the powertrain's efficiency and durability.

Micropitting:

Micropitting is characterised by the presence of fine surface pits, the occurrence of local plastic deformation, and shallow surface cracking. Pitting develops from micropitting, so the suppression of micropitting is essential to prevent pitting.

In Figure 1, captured using an Rtec-Instruments WLI microscope, discernible cracks and pits are evident, which are characteristic of micropitting.

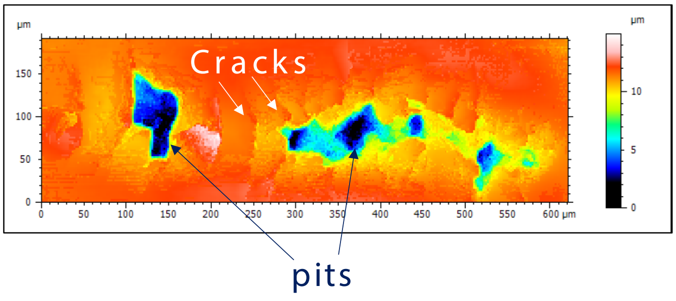


Figure 1: Micropitting data by Rtec-Instruments White Light Interferometer

Pitting Testing Rig (MPT-3000):

To combat the issue of rolling contact fatigue, Rtec-Instruments has developed a three-roller testing machine (MPT-3000) designed specifically for the testing of pitting wear, as depicted in Figure 2. This innovative system offers two primary variants: the standard type, capable of applying forces up to 2000N, and the high-load type, with an impressive capacity of up to 5000N. The SRR (Sliding to Rolling Ratio) spans from 0 to +/- 200% maximum, and the entrainment speed is 5.5 m/s. This high-load system enables line contact testing with high surface hertz pressure.

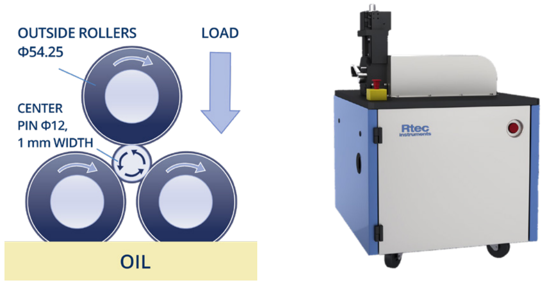
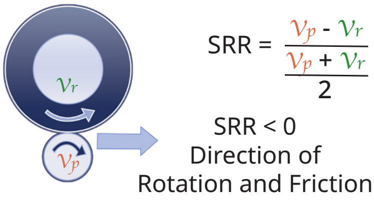


Figure 2: Micropitting tester MPT-3000

Test Conditions:

The micro pitting rig (MPT-3000) conducted rolling fatigue contact tests under three types of slip rate conditions (-0.5%,-2%, and -5 %) with EV gear oil. The negative value of SRR means the outside roller speed is faster than the center pin, so the rotation and friction directions are the same (Figure 3). The specimen materials were SAE 4130H, which is widely used for gears. The surface roughness of the center pin is Rz=0.8 μm, and the outside roller is Rz=2.0 μm.



$$SRR = \frac{V_p - V_r}{\frac{V_p + V_r}{2}} = \frac{2(V_p - V_r)}{V_p + V_r}$$

Figure 3: SRR calculation

Lubricant	-	EV Gear oil
Volume	mL	90
Temperature	℃	60
Test duration	h	1.5
Entrainment speed	m/s	3
Number of contacts	times	1.28×10^6
SRR	%	-0.5, -2, -5
Load	N	1638
Hertzian Pressure	GPa	3.50 (MAX)

Figure 4: Test confitions

After rolling fatigue contact tests, we observed the pitting on the surface of the center pin using Rtec-Instruments' white light and confocal microscope (Figure 5) and acquired surface images. Then, we evaluated the pitting parameters quantitatively by pitting depth and size parameters, X, Y, and Z direction analysis (Figure 6).

Figure 5: 3D profiler UP series

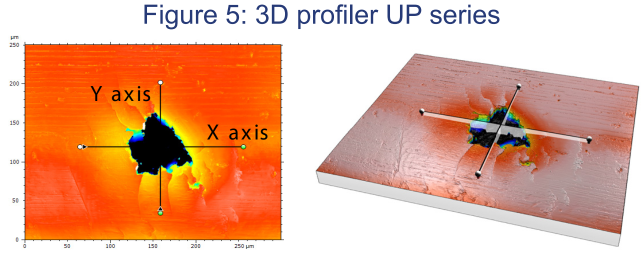


Figure 6: micropitting size analysis

Results :

Figure 7 presents the surface profiling results of the test specimens. These images showcase the height information of the test specimens' surfaces after each SRR value test, utilizing EV gear oil lubrication. Notably, observations reveal the presence of cracks and some pits, each exhibiting distinct shapes and areas from one another. This micropitting examination sheds light on the varied manifestations of surface damage, enhancing our understanding of the tribological performance under these specific test conditions.

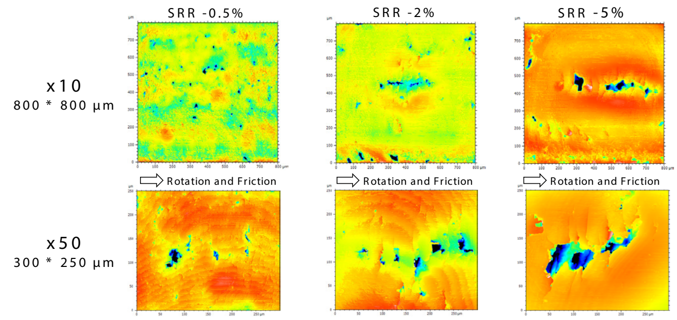


Figure 7: Surface profiling of each SRR

Figure 8 presents the micropitting size and depth calculated from 4 surface images acquired at each slip ratio. When the SRR was -5%, both micropitting damaged area and volume percentage was maximum. There was minimal variation observed between the values at -0.5% and -2%.

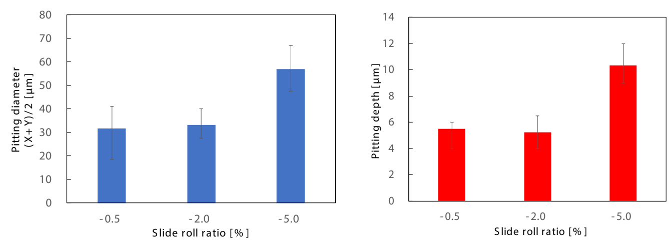


Figure 8: Micropitting size and depth for each SRR

Summary :

We confirmed micropitting with several SRR values (-0.5%, -2%, -5%) with discernible differences in both size and depth across these SRR values. The Micropitting Rig, MPT-3000, proves invaluable in efficiently evaluating micropitting within a condensed timeframe, offering accelerated testing capabilities. The MPT-3000 provides nuanced and comprehensive insights into micropitting phenomena, contributing to a more efficient and precise tribological assessment quickly.

Should you require further information, please contact

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