White paper

The impact of nanoparticle removal on gear oil performance

How RecondOil's Double Separation Technology (DST) restores gear oils to near-new performance.

The hidden cause of gearbox degradation

Gearboxes operate under extreme stress – high loads, high temperatures, and constant metal-to-metal contact. Reliable lubrication is essential to prevent wear, dissipate heat and maintain efficiency.

Gear oils eventually degrade due to oxidation, contamination and additive depletion. These processes increase friction, accelerate component wear, and lead to unplanned downtime. While conventional filtration removes larger particles, it leaves behind the smallest – submicron and nanoparticle debris – that silently drive further degradation.

This study explores how SKF RecondOil's Double Separation Technology (DST) restores the performance of used gear oil by removing contaminants down to the nanoscale.

The results demonstrate that DST not only improves oil cleanliness but also regenerates its protective properties – reducing wear, lowering friction and extending gearbox reliability in demanding applications.

Nanoparticles – small particles, big impact

Traditional oil monitoring focuses on particles above 4 µm. Yet research shows that the most reactive contaminants are much smaller – nanoparticles, defined as all particles below 1 µm, formed through wear, oxidation and additive breakdown.

In gear systems, these ultra-fine particles concentrate at contact zones, embedding into surfaces and catalyzing further oxidation.

Over time, this leads to loss of film strength, micro-pitting and accelerated wear.

Because nanoparticles are invisible to standard filtration, they accumulate continuously, shortening both oil and component life. DST directly addresses this by removing even the smallest contaminants, breaking the cycle of degradation and restoring oil stability.

Study design:

New, used, and DST-treated gear oils

To quantify the effect of nanoparticle removal, three samples were analyzed:

- New oil – baseline condition.
- Used oil – collected from a mining gearbox operating at 70 °C.
- DST-treated oil – used oil regenerated using RecondOil's DST process

93%

DST reduced nano contaminant particles by 93%

Physicochemical results:

Restoring oil health to near-new condition

Laboratory testing included physico-chemical and tribological evaluations to measure cleanliness, stability and performance.

DST-treated oil showed a dramatic decrease in wear metal contamination, along with reduction of oxidation and acidic degradation – all while maintaining essential additive balance.

Analysis	Unit	Method	New	Used	DST	Effect
Particle count		ISO 4406	17/14/11	19/16/12	**16/13/11**	Cleaner than new
TAN	mg KOH / g	ASTM D974	0.67	0.78	**0.59**	Lower acidity
Oxidation	A / cm	FTIR	0.8	1.8	**1.6**	Reduced oxidation compounds
Iron (Fe)	ppm	XRP / ICP	0	57	**15**	Reduced wear
Phosphorus (P)	ppm	XRP / ICP	308	302	**263**	Anti-wear protection not compromised

Performance evaluation:

Reduced friction, restored protection

1. Friction and tribofilm formation (MTM test)

Using the Mini Traction Machine (MTM), oil samples were tested under rolling-sliding conditions simulating gear contacts:

- DST-treated oil exhibited significantly lower friction than used oil.
- Post-test surface analysis confirmed restored tribofilm formation, indicating that cleaned oil regained its ability to protect metal surfaces.

2. Wear and micropitting (MPR test)

The Micropitting Rig (MPR) evaluated wear and surface fatigue under load.
Results showed:

- Lower wear rates and less micropitting in DST-treated oil compared to used oil.
- Despite a minor decrease in phosphorus content, anti-wear performance remained stable or improved.

40%

Oil can account for 5% of your maintenance budget, but affects 40% of maintenance costs.

Findings:

Nanoparticle removal restores gear oil performance

DST treatment demonstrated measurable restoration across multiple key properties:

- Cleaner oil – nanoparticle and metal contamination significantly reduced.
- Improved oxidation stability – lower TAN and oxidation levels.
- Reduced friction – restored tribofilm and smoother operation.
- Enhanced wear protection – less wear and micropitting under stress.
- Sustainable performance – extended oil life and reduced waste.

Together, these findings confirm that removing nanoparticles is essential to restoring gear oil health and maintaining gearbox reliability.

73%

DST-treated oil showed up to 73% lower iron contamination compared with used oil.

Implications for industry:

A new standard for gear oil maintenance

With this evidence, DST proves to be more than just a filtration system – it can:

- Extended oil life – delaying replacements and reducing total consumption
- Improved gearbox reliability – less friction, heat, and wear
- Lower maintenance costs – fewer oil changes and unplanned repairs
- Sustainable operations – less waste oil and reduced environmental footprint.

DST enables operators to treat oil as a renewable performance medium rather than a disposable consumable – supporting both operational and environmental goals.

Conclusion:

Cleaner oil, stronger gears

This study confirms that RecondOil DST effectively removes nanoscale contaminants responsible for oil degradation. The regenerated gear oil not only regains its protective properties but performs comparably to new oil – reducing friction, wear, and oxidation.

By restoring oil function at the nanoscale, DST helps gearboxes run cleaner, cooler, and longer – turning lubrication into a sustainable performance asset rather than a cost of maintenance.

Curious about the details?
Download our “circular use of oil” brochure here.

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