SKF RecondOil Box:

Customer Experiences

Part II

RecondOil®

Contents

More customers, more data

The RecondOil Box is the latest addition to the growing family of oil regeneration technologies from SKF. We believe it will change the way that industry perceives oil, transforming it from a costly carbon footprint into a sustainable asset that also improves mechanical performance.

The RecondOil Box was launched officially in April 2022. Before that, several customers joined a trial programme, and a year ago we published a short summary of the results from two of these trials – one in Mexico, one in Finland (details below). Since then, dozens of customers have trialled or purchased the technology. The purpose of this new report is to collate all that experience, present some data, and draw some tentative conclusions.

SKF also has a laboratory research programme seeking to deepen our understanding of the circular use of oil. We are communicating the results, together with industry reports, via a brief email newsletter to a growing community of industry professionals interested in this technology. You can sign up for the newsletter here: recondoil_customerservice@skf.com

But our customers are our biggest laboratory. The real test for a new technology is how it performs when applied to the many different problems and conditions encountered by industry. Sector-specific cases studies follow later in this report.

Some common drivers are causing customers to seek the benefits that RecondOil provides. Every customer has specific conditions and requirements, but they are all looking for carbon reduction and clean oil. However, we often find that the search for lower carbon is just a starting point. When we get to know the customer, a deeper conversation ensues about how oil quality is affecting their business in various ways, depending on specific applications, type of oil, maintenance behaviour and so on. RecondOil delivers benefits beyond the solution of immediate problems. Carbon reduction is often a trigger for a thorough reassessment of oil as an industrial asset that raises efficiency, quality and performance.

Typical behaviour for the RecondOil Box appears to be that it first removes the degradation products in oil, so that in the early stages we see a sharp drop in varnish, oxidation and gravimetric measurements. For companies facing an urgent crisis in production, when oil degradation threatens to cripple a crucial application, this is a lifeline. When the short-term crisis is over, then the focus switches to what ultra-clean oil means for the company in the longer term. Filters are typically changed after the first three months, and with a clean filter we can then start fine-tuning the oil with the removal of nanosized contaminants using RecondOil's Double Separation Technology. With hydraulics in particular the improvements can be dramatic; with other applications, the same results can take longer to achieve.

Eliminating the need for new oil in industrial processes delivers direct cost savings connected with purchase, transport and disposal. In addition, machines and processes that run on oil that is constantly filtered down to the level of the tiniest nanoparticles also see improved performance with respect to maintenance, operational availability, reliability, machine longevity, energy efficiency and overall productivity. Our guiding vision is ambitious, but we believe entirely realistic: to achieve circular use of oil.

This is Part II in a series of reports.
You can read Part I here.

Circular use of oil

Today's linear approach, where oil is used until it degrades and then is discarded and replaced, is extremely inefficient and unsustainable. Besides the implications for the environment and climate, it generates both direct and indirect costs for the application's owner. In addition to the direct cost of purchase and logistics, the traditional approach to oil is also associated with indirect costs such as repair, maintenance and parts replacement, and reduced productivity from process interruptions.

What then is required to enable circular use of oil? The starting point is to eliminate the three main causes of oil degradation – contamination, oxidation, and additive depletion.

- Oil becomes contaminated by small particles such as dirt, swarf, fibres, water, air and so on
- Particles, water and heat create oxidation, a chain reaction that accelerates exponentially once it has begun, causing viscosity to change and forming varnish and sludge
- Additives that give the oil its specific properties are consumed in the application's processes.

When oil has degraded to an extent that it loses its functionality, it must be replaced to prevent damage to the application or process. The RecondOil Box removes these causes of degradation. Through our monitoring programme, we have followed the status of oil over time for our customers, and we see the following common results:

- Significantly improved ISO 4406 cleanliness levels
- Drastically reduced varnish
- Improved oxidation stability
- Decreased water content
- Stable acid levels
- Stable viscosity.

These initial findings demonstrate that the RecondOil Box has the potential to maintain oil "as new" at a level of cleanliness that allows it to be used over and over again without affecting performance. This is an essential condition for achieving the circular use of oil.

Abbreviations used in this report:

MPC – Membrane Patch Colorimetry (measurement of varnish potential)

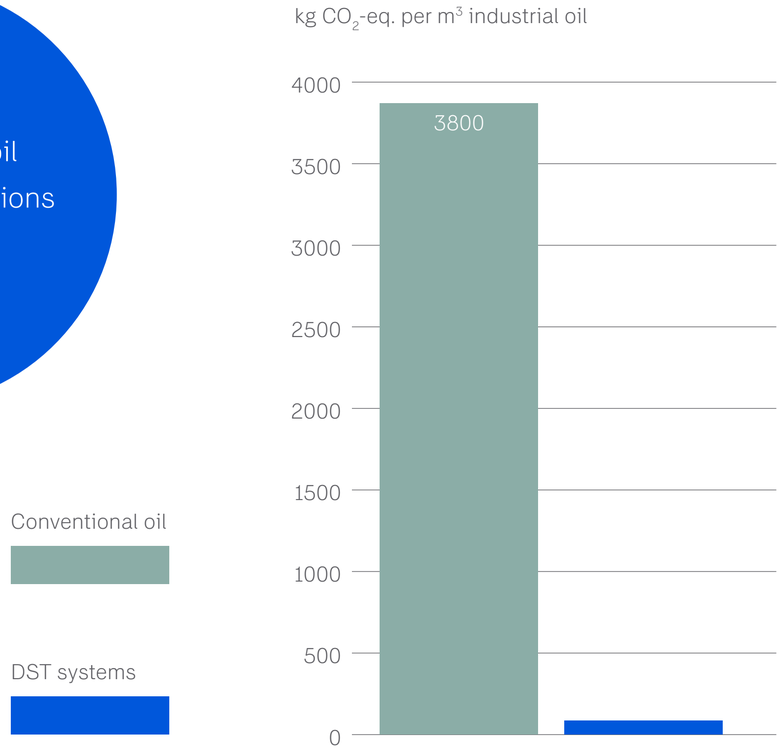
TAN – Total Acid Number (measurement of acid components in the oil and ongoing oxidation)

DST – Double Separation Technology (patented chemical booster used by RecondOil to remove nanosized contaminants)

KPI – Key Performance Indicator

ISO 4406 – particle count (measures the size and quantity of particles in the oil)

Circular use of oil reduces CO_2 emissions by up to 99%



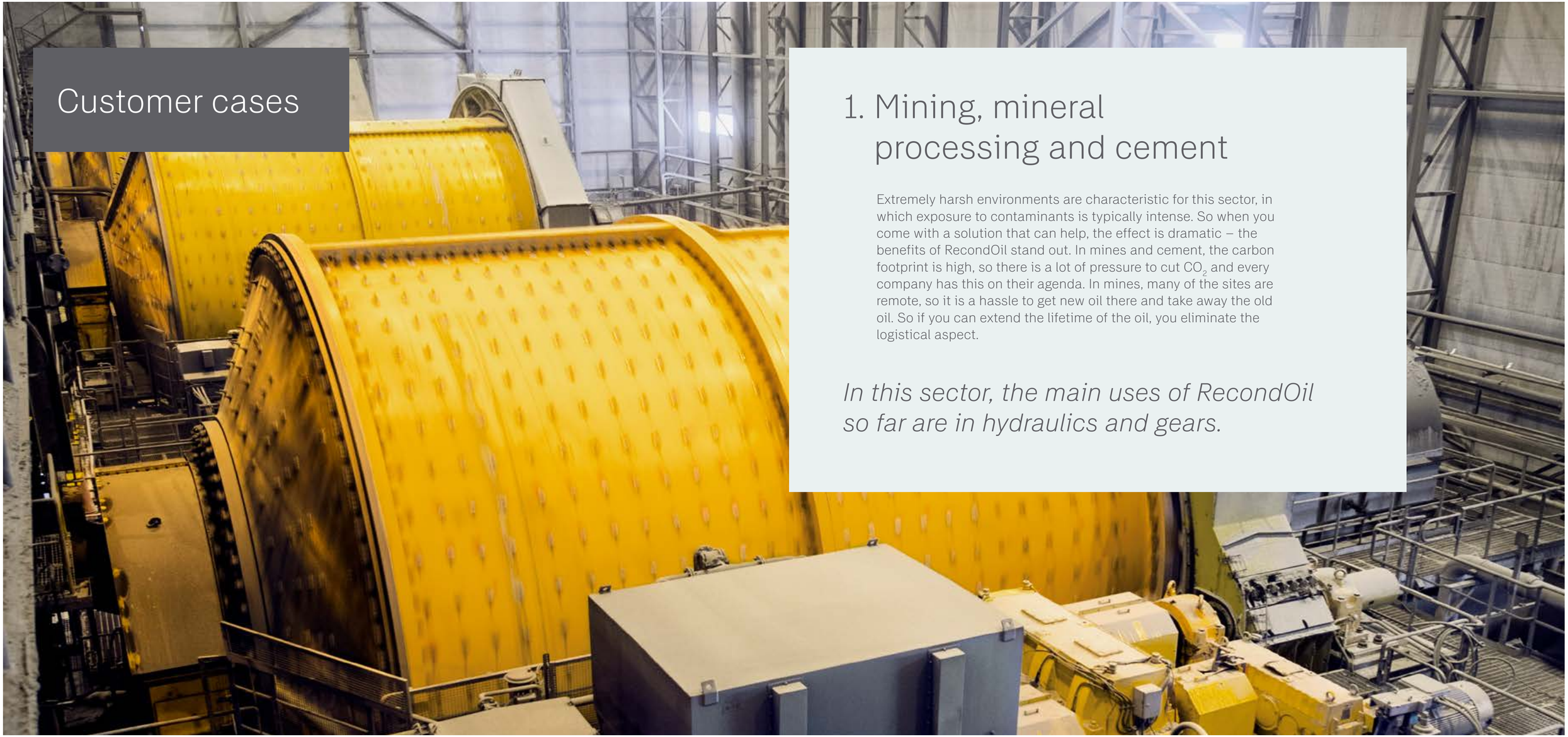
CO_2 emissions reduced by up to 99%

Life cycle analysis* demonstrates that the climate footprint associated with SKF RecondOil is far lower than that of the conventional approach to oil. By regenerating oil, less needs to be produced, and therefore less needs to be disposed of and incinerated.

The climate impact of the conventional oil cycle is 3 830 kg CO_2-equivalent per m^3, compared to 8.2 kg CO_2-equivalent with the RecondOil Box. The RecondOil Box therefore reduces carbon emissions by up to 99%, depending on the energy mix.

*CO_2 reduction when compared with traditional oil cycle.
Source: Life cycle analysis performed by IVL Swedish Environmental Research Institute (2021).

Customer cases



1. Mining, mineral processing and cement

Extremely harsh environments are characteristic for this sector, in which exposure to contaminants is typically intense. So when you come with a solution that can help, the effect is dramatic – the benefits of RecondOil stand out. In mines and cement, the carbon footprint is high, so there is a lot of pressure to cut CO_2 and every company has this on their agenda. In mines, many of the sites are remote, so it is a hassle to get new oil there and take away the old oil. So if you can extend the lifetime of the oil, you eliminate the logistical aspect.

In this sector, the main uses of RecondOil so far are in hydraulics and gears.

With the installation of a RecondOil Box, Spanish cement manufacture Cementos la Unión managed to reduce maintenance activities and the risk of unplanned stops after only three months. In the long run, it hopes to avoid oil changes altogether

Cementos la Unión, Spain

Cementos la Unión turned to RecondOil Box to help cope with heavy contamination of gear oil in a milling machine used to crush the raw materials of cement. The company installed a RecondOil Box in June, 2022, on a three-month trial. Following the trial's successful conclusion, Cementos decided to permanently install the RecondOil Box and purchased two more units for parallel installations.

The application is lubricated with 1,000 litres of synthetic gear oil. There is severe contamination from the production environment with constant ingress of dust, silicates, water and iron, creating abrasive wear on the gear teeth and risking damage to the gear itself. The gears are large and expensive.

The machine had standard filters built in, but these were not sufficient to control contamination. The company had experimented with several offline filtration systems, but even with these, after five years the gear teeth were in such bad condition they had to be replaced, along with the oil. Meanwhile there was always the risk of an unplanned halt to production.

"We have tested a lot of different solutions but never reached such good cleanliness levels before"

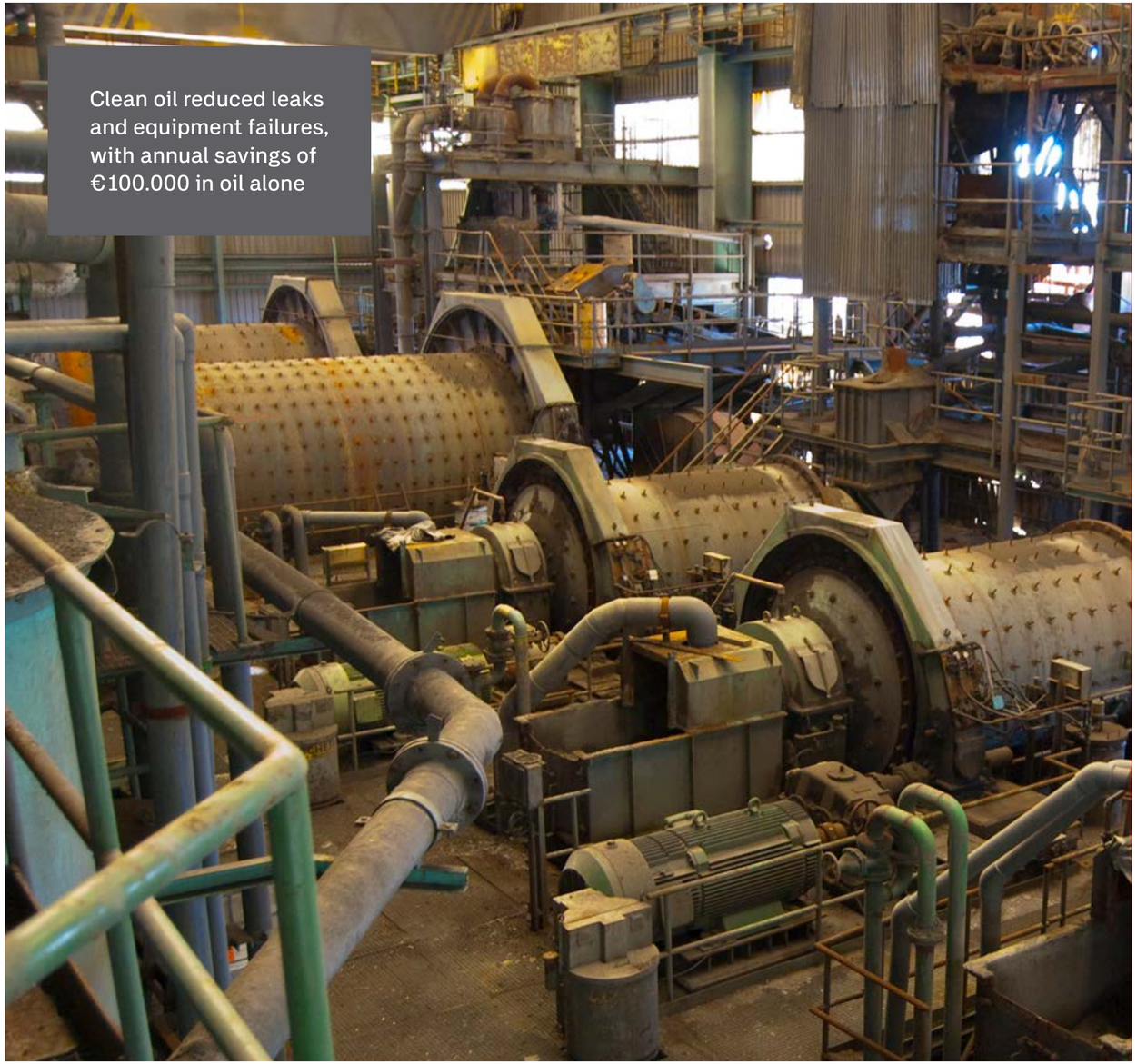
This background led to the decision to try the RecondOil Box. The viscosity of the lubricant oil was high, so a RecondOil Box with two housings was installed with depth filters. The aim here was to extend the life of the oil.

According to Pedro Martin, Maintenance Manager for Cementos la Unión, it was a surprise that the oil became so clean in just three months. "We have tested a lot of different solutions but never reached such good cleanliness levels before," Pedro says. "Other solutions could keep it in an acceptable condition, but now it is clean at a new level. We never had these results with other offline filters."

At the end of the three-month trial, the results for the RecondOil Box were as follows:

- Maintenance activities decreased, going from the normal two hours per week to every second week
- Consumption of built-in standard filters fell significantly
- There was no need to replace the RecondOil filter insert (for other offline filters they tried, they had to be changed monthly)
- Reduced risk of unplanned stops due to component wear

In the longer term, Cementos la Unión hopes that the RecondOil Box will mean that it can avoid oil changes altogether, while extending the service life of the gear from five to as long as eight years.



Clean oil reduced leaks and equipment failures, with annual savings of €100.000 in oil alone

Mining company in northern Europe

SKF has had rolling service contracts with this company since 2011. When the contract was last renegotiated, a RecondOil Box was included to regenerate the hydraulic oil of a secondary cone crusher. This oil was being contaminated by harsh conditions and humidity, and the dirty oil was in turn causing leaks and equipment failures. The oil volume was 1,000 litres, and it had to be changed every two years.

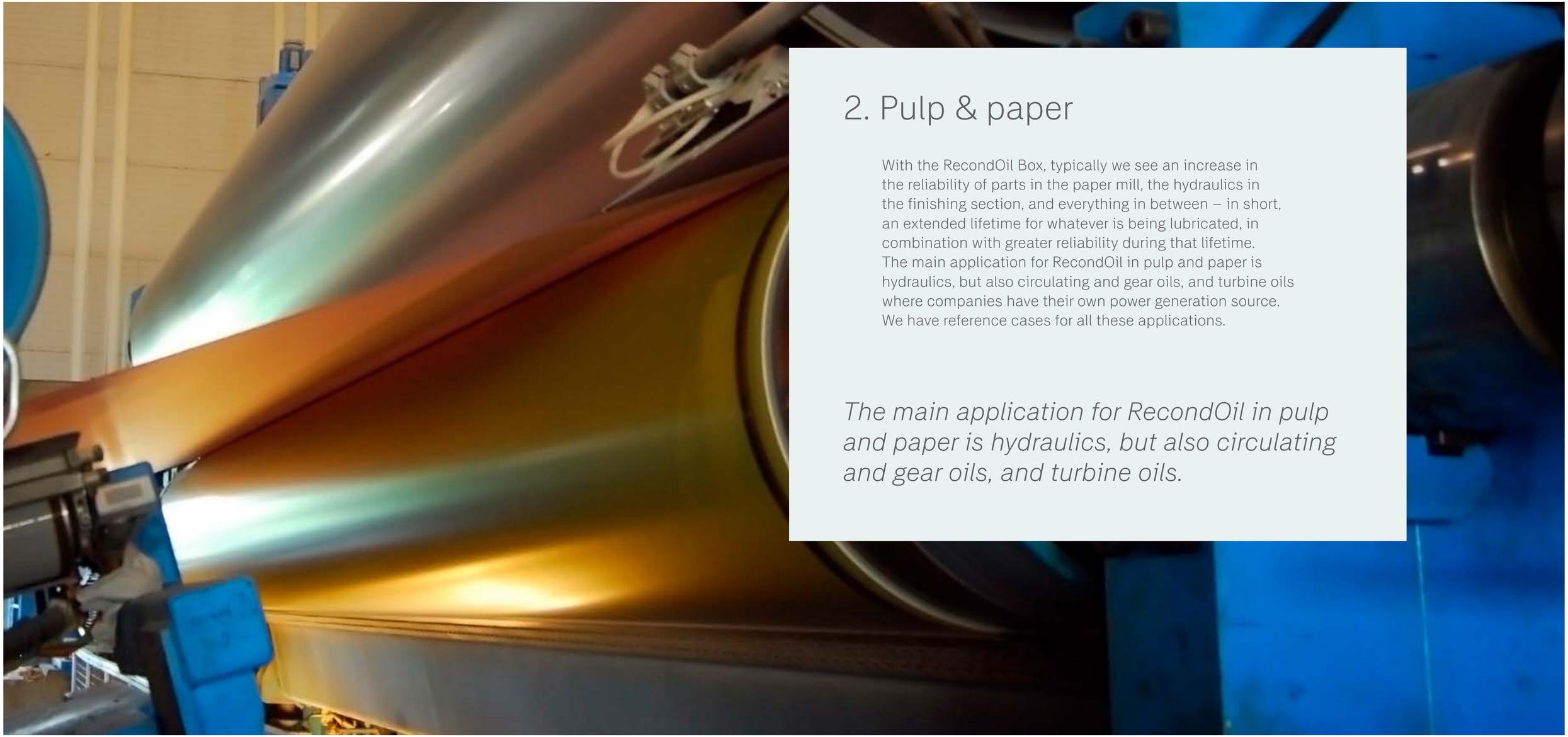
The RecondOil Box, with two housings and depth filtration, started operation in January, 2022. After just one month, the oil was already seven ISO levels cleaner.

On the strength of this performance, the company ordered five more RecondOil Boxes, to be applied to clean the oil in three hydraulic excavators (oil volumes 6 m^3, 7 m^3 11.5 m^3), a truck with a 900 litre hydraulic oil tank, and to pre-filter 8,5 m^3 of virgin oil stored in a warehouse.

The customer estimates that the annual savings in oil costs as a result of these six RecondOil Boxes is in the region of €100,000.

Key points:

- Hydraulic oil much cleaner after one month
- Consequently, RecondOil extended to other applications
- Major savings achieved



2. Pulp & paper

With the RecondOil Box, typically we see an increase in the reliability of parts in the paper mill, the hydraulics in the finishing section, and everything in between – in short, an extended lifetime for whatever is being lubricated, in combination with greater reliability during that lifetime. The main application for RecondOil in pulp and paper is hydraulics, but also circulating and gear oils, and turbine oils where companies have their own power generation source. We have reference cases for all these applications.

The main application for RecondOil in pulp and paper is hydraulics, but also circulating and gear oils, and turbine oils.

The installation of a RecondOil Box in a critical asset in bleached softwood pulp production led to a reduction in oil-related costs of 65%

European pulp manufacturer

This wood pulp producer had been changing the hydraulic oil in its bale presses every five years due to oil degradation. High temperatures, water and air in the system were causing varnish build-up, shortening the lifetime of valves, cylinders, pumps and seals, and increasing the risk of unplanned downtime in this critical application.

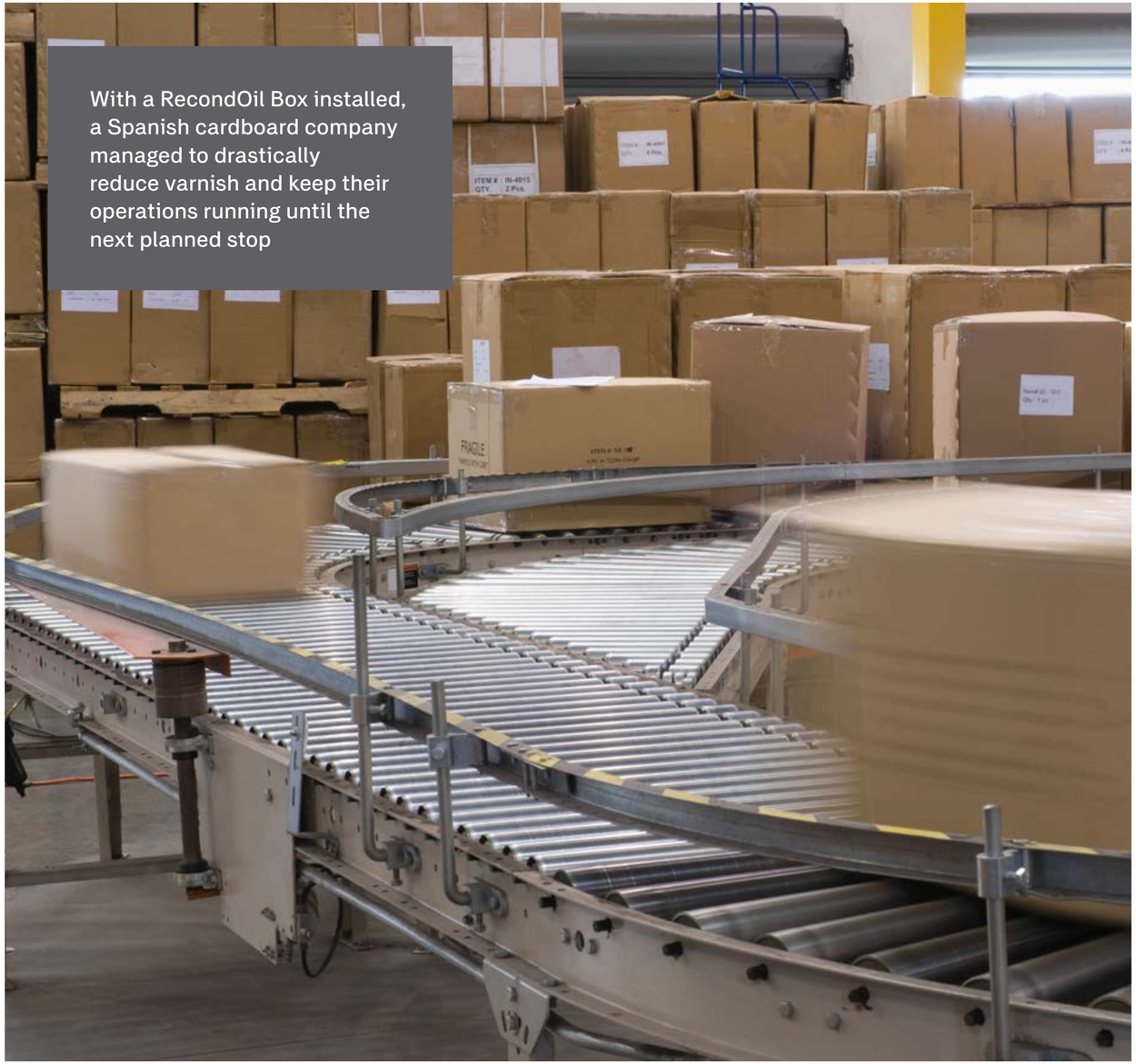
The oil was significantly degraded, as evidenced by high TAN and MPC values and low viscosity, indicating that the oil had partly lost its performance. The company installed RecondOil Boxes in 2021 for the hydraulic mechanism in two bale presses, each with an oil volume of 4,000 litres. Under a five-year contract, the oil was first changed to an SKF RecondOil DST oil and the system was thoroughly cleaned.

The KPIs agreed between the customer and SKF included increased productivity, significantly reduced CO_2 emissions, improved safety in production and improved availability. Half way through the contract period, the KPIs have been met and the company is exploring the use of the RecondOil Box at other sites and in other applications. The hydraulics are no longer leaking, there have been no oil changes and fewer top-ups, and there are no signs of mechanical wear. The press cycle is faster than before, with less friction and therefore lower energy consumption. MPC and TAN for the oil are consistently very low.

Over the full five-year contract period, the customer's costs are expected to go from €57,000 to €20,000 owing to lower oil consumption, zero waste oil storage and treatment, lower consumption of filters and lower maintenance costs. Less maintenance also means better health and safety for employees. Total annual reduction of carbon dioxide emissions is expected to be 24 tons – a significant decrease.

Key points:

- No more leaks
- No oil changes
- No signs of wear
- Low acid and varnish content
- Lower costs and CO_2



With a RecondOil Box installed, a Spanish cardboard company managed to drastically reduce varnish and keep their operations running until the next planned stop

Paper-based packaging company, Spain

This European manufacturer of cardboard packaging materials was experiencing a major problem with the oil in a steam turbine generating power for the factory. Varnish was forming in the cylinders of the hydraulic system controlling the turbine, creating a film that was damaging a key component. However, the turbine could not cease operation, nor the oil be changed, until the next scheduled stop in 18 months – a shutdown would bring the whole factory to a halt. An unscheduled shutdown due to varnish formation would have the same impact.

A RecondOil Box with Double Separation Technology was installed in April 2022. The oil volume was 6,600 litres. After only one month, varnish had been significantly reduced. Within three months the oil was certified to be in good condition, according to an external certified oil condition monitoring laboratory. A year later the oil condition was unchanged. Maintenance engineers and the factory's senior management recognized the benefits of ultra-clean oil and are promoting the technology elsewhere inside the Group.

Key points:

- Varnish removed
- Stable oil quality
- Unscheduled shutdown avoided

Degraded oil and varnish formation were leading to blocked valves and threatened to stop production. A RecondOil Box kept oxidation under control so production could continue until the next planned stop

Pulp and paper company, Germany

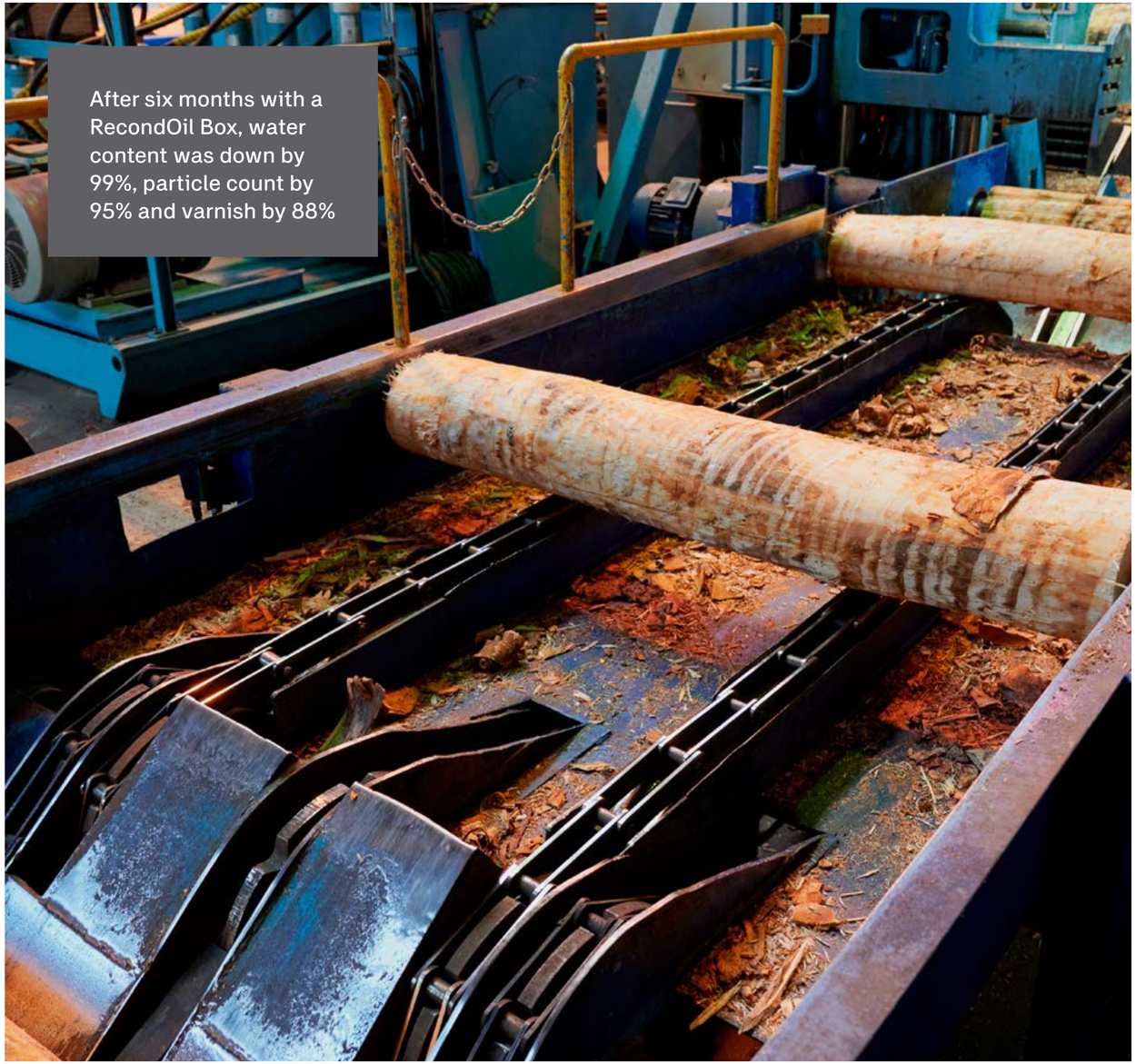
A paper machine at this company was experiencing blocked valves with runaway varnish formation in the circulating oil, which showed an acid component level (TAN) of 4.5. The company knew it could expect weekly stoppages when the TAN reached 5.0. Just an hour of downtime would cost between €20,000 and €50,000 in production losses. So in November 2021, the company turned to RecondOil to keep the degradation under control, curb varnish formation, and prolong the oil's lifetime until it could be changed six months later during the summer break. The oil volume was 2,500 litres.

With such high levels of oxidation, cleaning the oil would be like bailing out a leaking boat – new oxidation products would be created as fast as they were removed. Moreover, the oil was four years old. So achieving circular use of the oil by returning it to its virgin condition was ruled out while the machine was still running. The company installed four RecondOil Boxes with Double Separation Technology. These were successful in keeping the machine running until the scheduled oil change in the early summer of 2022.

With younger oil, RecondOil will have the potential to prolong its life indefinitely. The cost of replenishing the reservoir is €25,000, while flushing, cleaning and checking the machine takes time and is labour intensive. With circular use of oil, these costs are removed.

Key points:

- Runaway varnish formation curbed
- Production maintained without stoppages



After six months with a RecondOil Box, water content was down by 99%, particle count by 95% and varnish by 88%

Pulp and paper company in northern Europe

In a plywood production process, this company was struggling with high water content in the lubricating oil of a veneer peeling machine. The oil in the 600-litre tank was highly contaminated and oxidated. The company was using a rented kidney loop filter for offline filtration, but this was costly and not performing adequately.

A RecondOil Box was installed in April, 2022, on a six-month trial. At the start of the trial, water content was very high. Varnish (MPC) was at a critical value, while the level of contaminants obtained by gravimetric analysis was also high. After six months, these values were down by 99%, 88% and 95% respectively (see table). The customer is exploring implementation of the RecondOil Box in other factories and applications.

	April, 2022	October, 2022
MPC	68.9	8.1
Gravimetric (mg/kg)	440	23
Water content (ppm)	930	10

A RecondOil Box removed particle contaminants and varnish, saving this company €50-60,000 during the first four months only

Pulp and paper company, Spain

This company faced a problem with varnish formation in the lubricating oil of a drying machine. The application environment was very wet, with temperatures around
80 °C and a high risk of oil degradation. The dryer used 6,600 litres of synthetic oil, which had degraded to the point that it needed to be changed.

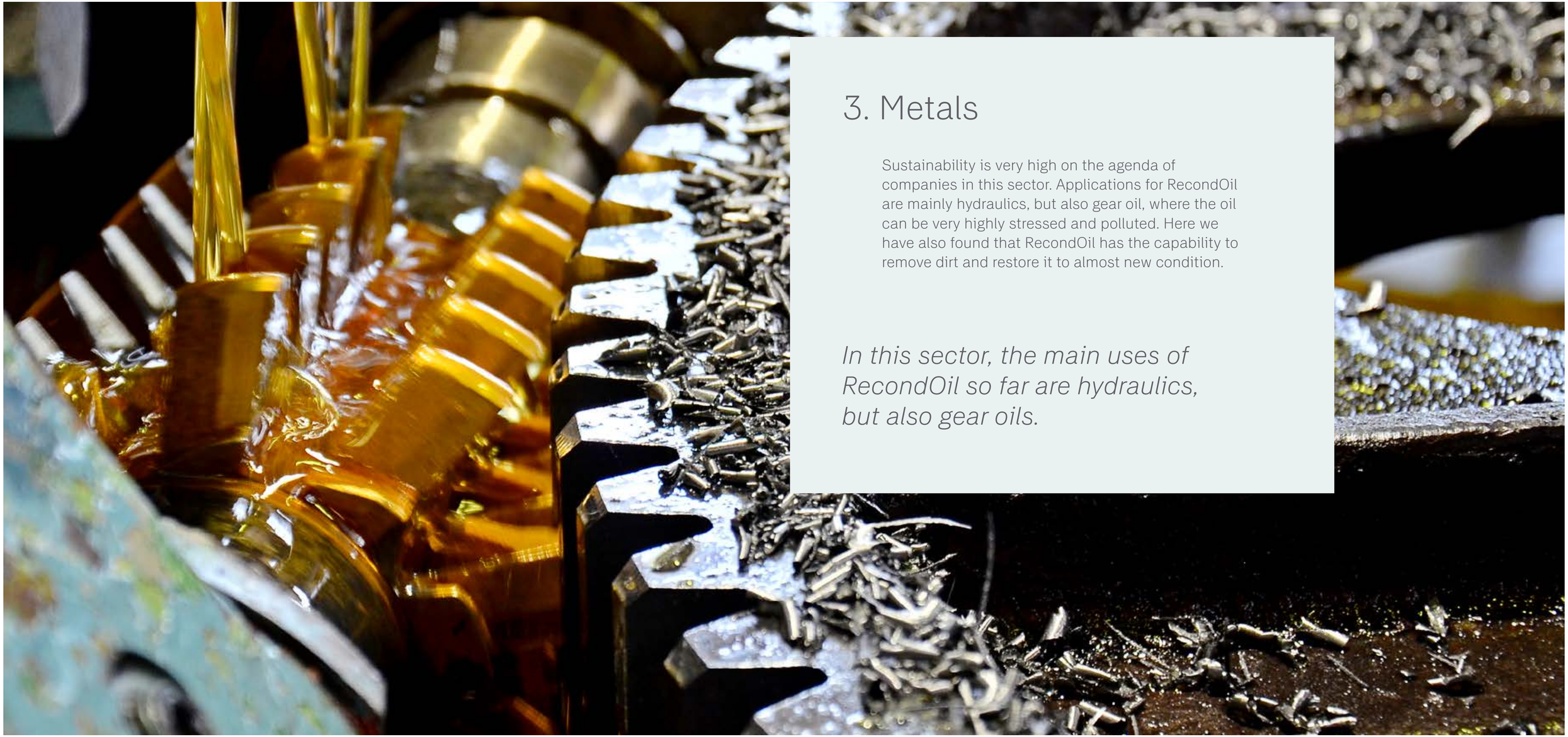
SKF agreed a pilot aimed at removing varnish, lowering the particle count (ISO 4406), prolonging the oil life and cutting carbon emissions. The pilot began in November 2022, using a RecondOil Box with four standard filter housings.

The trial ended in March, 2023. The oil was now in good condition and there was no longer any need to change it. This saved the customer €50,000–€60,000 in oil costs during the trial period alone, plus €2,500 in reduced CO_2 emissions and €1,400 in labour, according to the company's own estimates. The lifetime of the oil has been doubled, the company says.

The company also saved the cost of cleaning the varnish off the machine's rotameters during each maintenance shutdown – around €7,200. It calculates that it saved a further €5,000–€6,000 by avoiding unplanned shutdowns due to damage resulting from varnish formation. As much as 24 tons of CO_2 emissions were avoided. The company has signed a two-year contract for the RecondOil Box.

Key points:

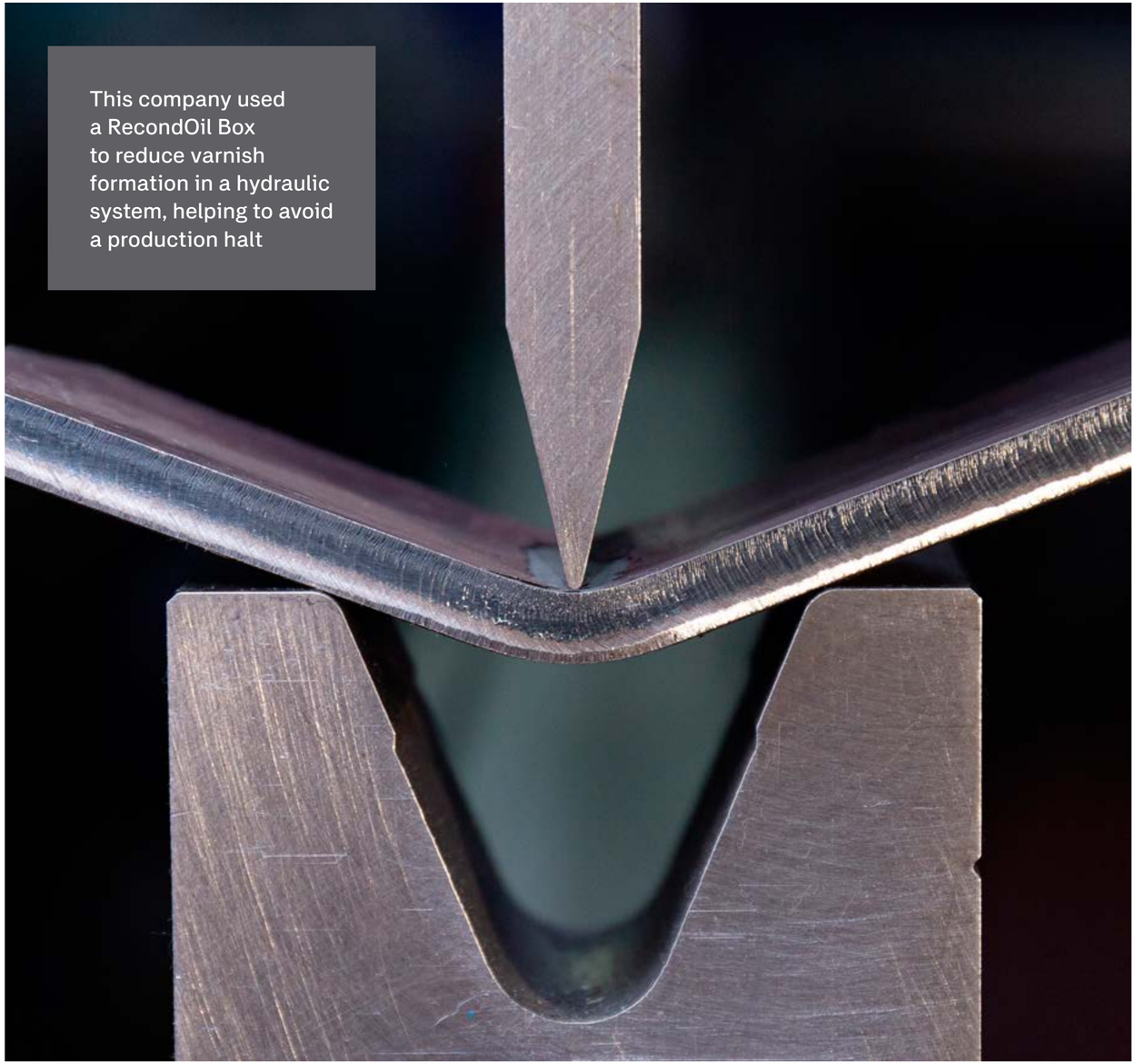
- Varnish removed
- Improved oil quality
- No need to change the oil
- Major costs savings
- Lower CO_2



3. Metals

Sustainability is very high on the agenda of companies in this sector. Applications for RecondOil are mainly hydraulics, but also gear oil, where the oil can be very highly stressed and polluted. Here we have also found that RecondOil has the capability to remove dirt and restore it to almost new condition.

In this sector, the main uses of RecondOil so far are hydraulics, but also gear oils.



This company used a RecondOil Box to reduce varnish formation in a hydraulic system, helping to avoid a production halt

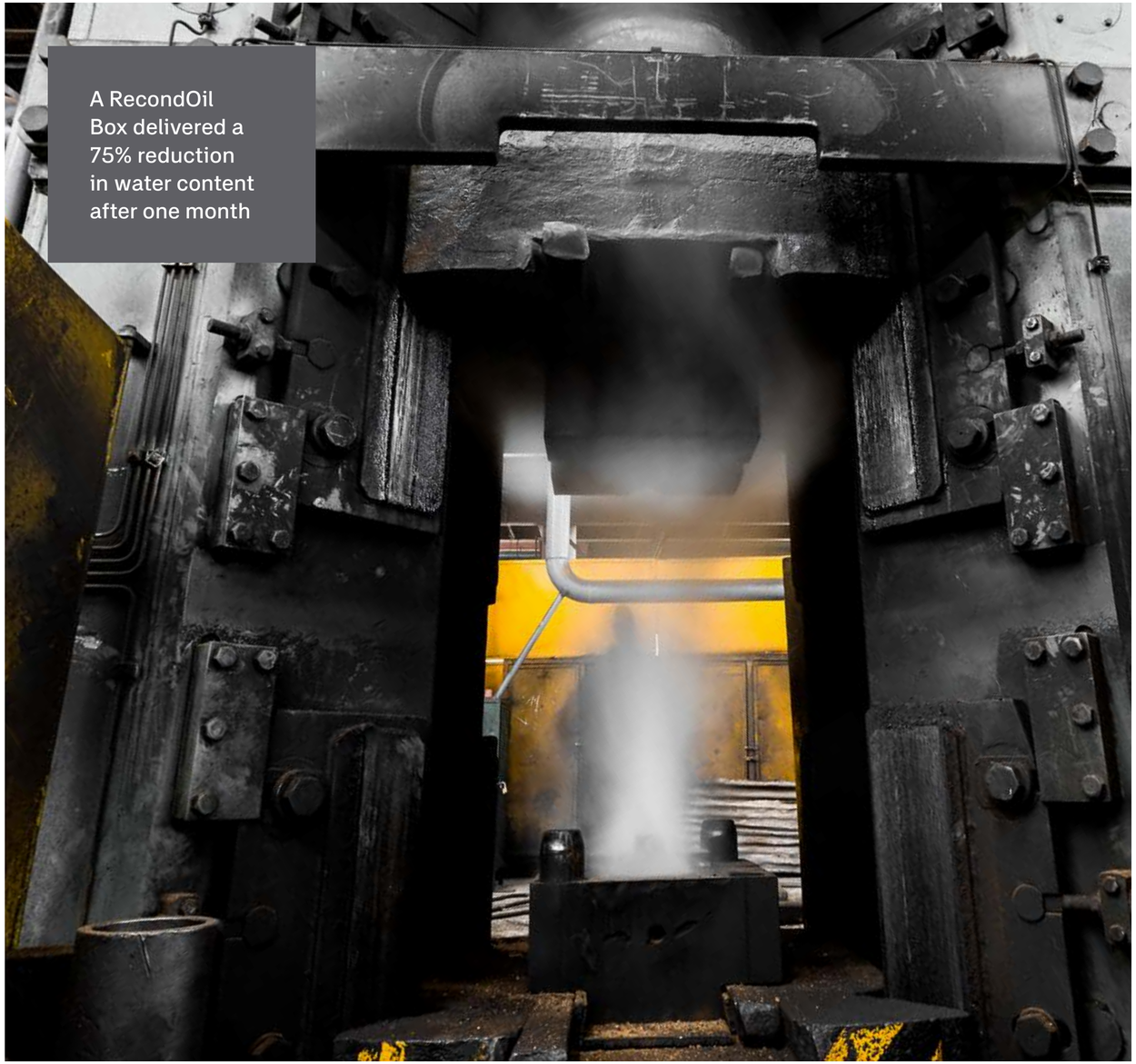
Steel producer in northern Europe

A major steel producer installed a RecondOil Box in January, 2023, to tackle varnish formation in the hydraulic system of a sheet metal flying shear. Varnish had become a serious problem in this application. Moreover, the machine could not be stopped – any interruption would mean a fall in the oil temperature, with the consequent danger that varnish would then become so bad that it would be difficult to restart the machine. The oil volume is 8,000 litres.

The aim was to improve overall oil health and to reduce shutdown times and maintenance costs. The latest oil analysis shows a rapid improvement on key KPIs related to oil degradation, solid contaminants and varnish levels. Other KPIs include reduced shutdown times and maintenance costs. Results have exceeded expectations, with significant reductions in varnish formation after only a few months.

Key points:

- Rapid improvement in acid, varnish and particle count
- No interruptions to production



A RecondOil Box delivered a 75% reduction in water content after one month

Metalworking and forging company, Italy

This company uses an ester-based oil in the hydraulics of a very large forging press, where temperatures are high. Ester-based lubricants are hydroscopic – they absorb moisture – which triggers hydrolysis, which in turn generates corrosive acid compounds. The system uses sophisticated valves which require very low contamination, so the goal was to control the level of water contamination in the hydraulics.

In February 2023, the company installed a RecondOil Box on a 36-month contract. After one month, water content had been reduced by more than 75%. Varnish and solid contaminant levels, which were already good, were further improved.

	February, 2023	March, 2023
MPC	13.3	4.6
Gravimetric (mg/kg)	1.6	0.4
Water content (ppm)	427	156

SKF's RecondOil Box solution improves oil quality, supports cost savings and reliability

Aluminium products manufacturer in Europe

This global leader in the development and manufacturing of high value-added aluminium products and solutions relies on large hydraulic extrusion presses. The main press operates 24/7, with an oil tank of 7 cubic metres. Oil quality is a major factor in the reliability of this machine.

Contact with the company began through a RecondOil webinar during the Covid pandemic. The company was dissatisfied with its current offline oil filtration system. On a trial basis, SKF installed a RecondOil box with three housings and depth filtration.

Improvements in oil quality on the extrusion press were rapid across several parameters. The particle count (ISO 4406) went from 19/17/11 at the start in January, 2023, to 16/14/12 after one month, and subsequently 13/11/7. The varnish level went from abnormal to normal (MPC 37.3 to 1.7). Oil quality is now stable and high.

All new oil for the plant is delivered by truck into a large tank of 10 cubic meters. Tests revealed that the oil was already contaminated on delivery – a common problem. Pre-filtering this oil with a RecondOil Box also delivered positive results.

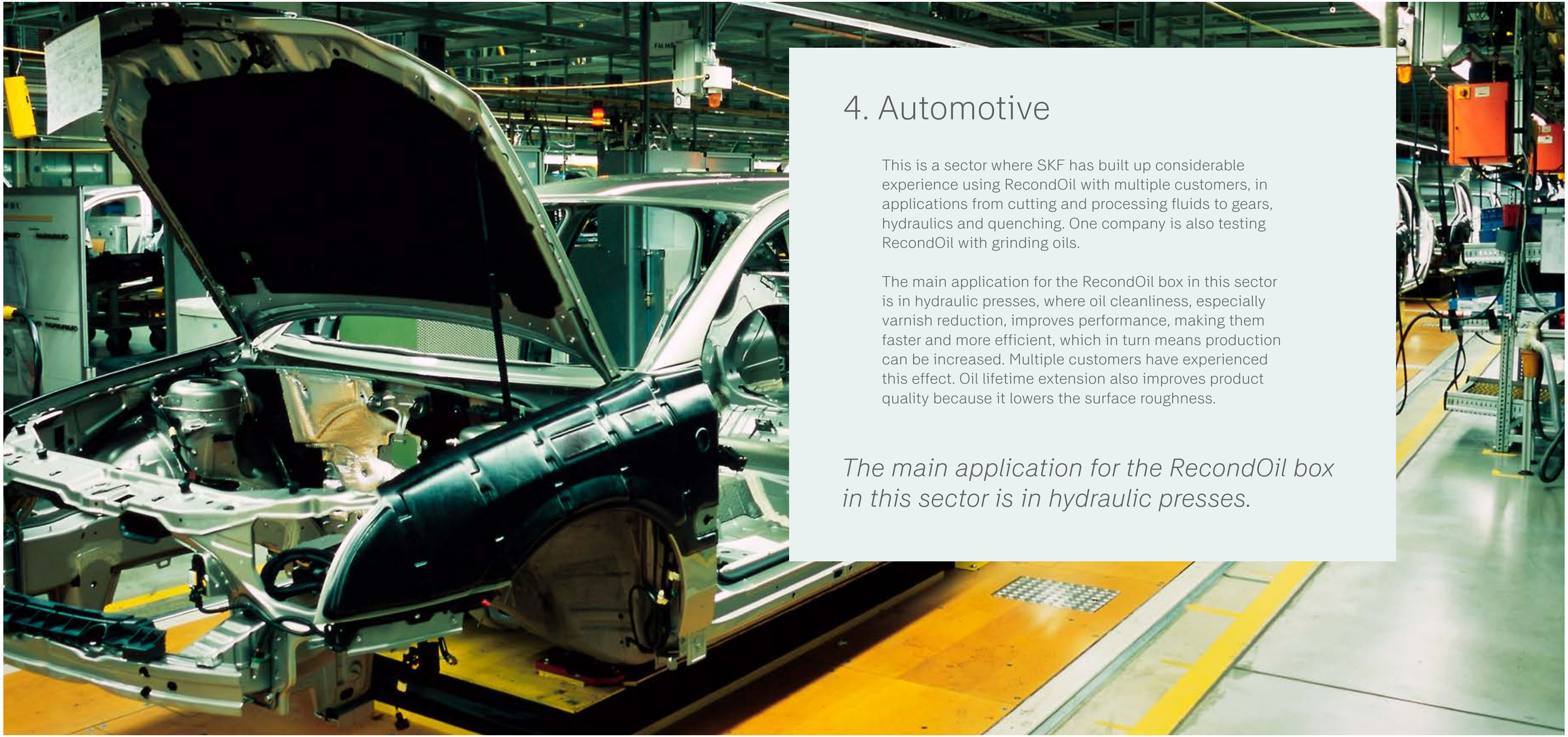
Finally, there was a major problem with leakages at the plant. The challenge was to save this oil, stored in a leakage tank, which was highly polluted with water and dirt. After one month with a RecondOil Box, the leakage oil was restored to sufficiently high quality to be re-introduced into the main tank.

ISO 4406 was not initially measurable but is now down to 19/18/11. Oil analysis after six weeks showed the water content had gone from 14,000 ppm to 86 ppm. So far, 1 cubic meter of oil has been rescued in this way; the target is to treat 2,000 litres per month of leakage oil, which will represent a substantial saving for the customer.

The trial period has concluded successfully and the customer has signed a contract for the RecondOil Boxes.

Key points:

- Rapid improvements in hydraulic oil quality
- Positive results from pre-filtering virgin oil
- Substantial savings from regenerating leakage oil

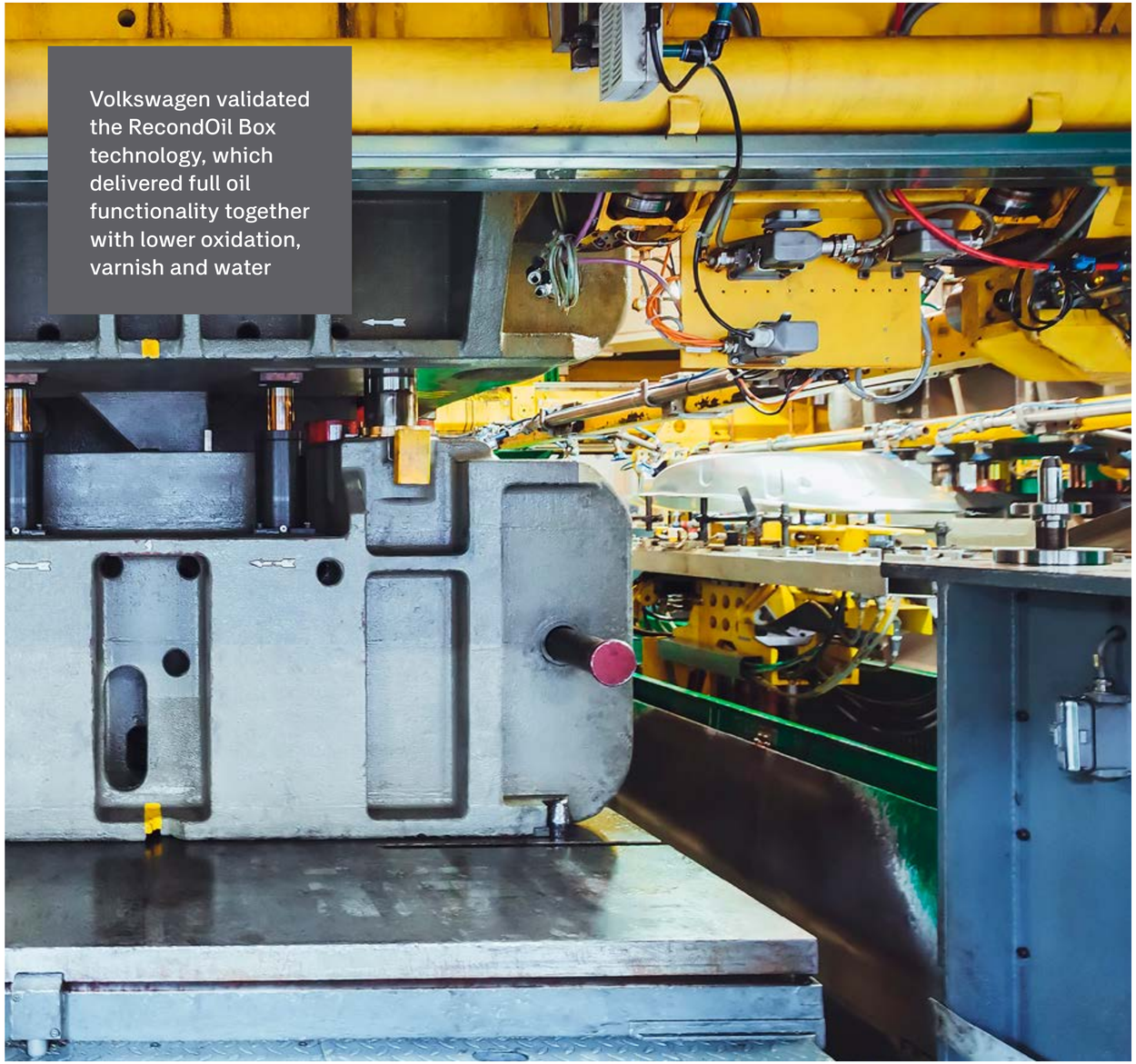


4. Automotive

This is a sector where SKF has built up considerable experience using RecondOil with multiple customers, in applications from cutting and processing fluids to gears, hydraulics and quenching. One company is also testing RecondOil with grinding oils.

The main application for the RecondOil box in this sector is in hydraulic presses, where oil cleanliness, especially varnish reduction, improves performance, making them faster and more efficient, which in turn means production can be increased. Multiple customers have experienced this effect. Oil lifetime extension also improves product quality because it lowers the surface roughness.

The main application for the RecondOil box in this sector is in hydraulic presses.



Volkswagen validated the RecondOil Box technology, which delivered full oil functionality together with lower oxidation, varnish and water

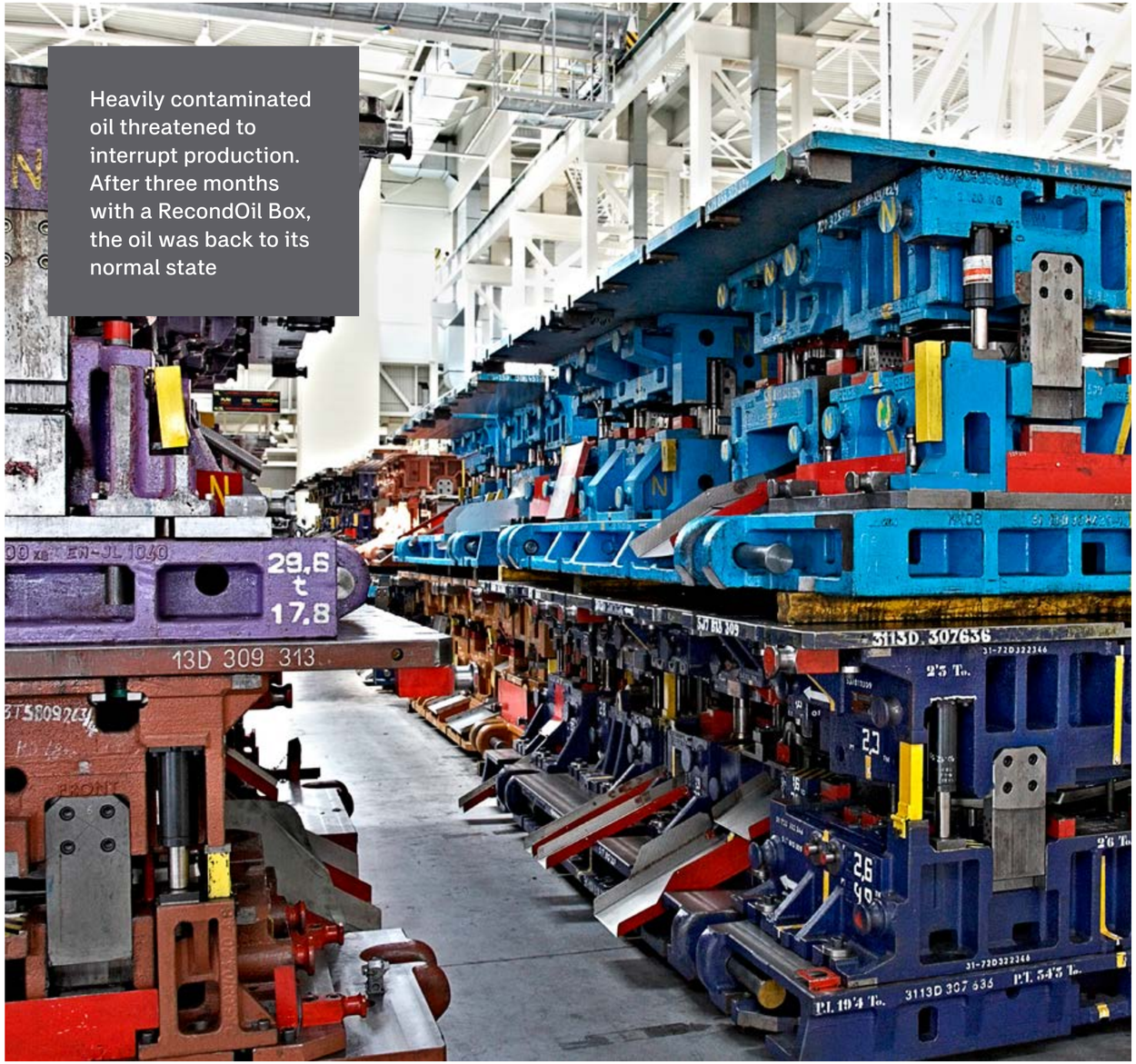
Volkswagen, Spain

Since the summer of 2022, Volkswagen's plant in Navarra, Northern Spain, has been using RecondOil to recover and regenerate oil from the company's huge hydraulic presses, which are bigger than a house. The oil becomes contaminated with wear metals and varnish. It is periodically monitored and, when a certain level of degradation is detected, it is sent in large batches to SKF's factory in Tudela, where it is regenerated to be used again. The batches of oil are up to 20,000 litres in volume.

Volkswagen has also validated the technology using a RecondOil Box on a less critical application to see how the oil performed after treatment with DST. This six-month trail was a success in terms of oxidation, additives, varnish and water; the amount of lead in the oil almost halved. SKF has now performed the batch regeneration of hydraulic oil from Volkswagen several times. We calculate that Volkswagen will avoid the emission of 15,000 tons of CO_2 over 10 years with this initiative.

Key points:

- Large volumes of contaminated oil regenerated
- Trial validates RecondOil for reductions in varnish, water and lead



Heavily contaminated oil threatened to interrupt production. After three months with a RecondOil Box, the oil was back to its normal state

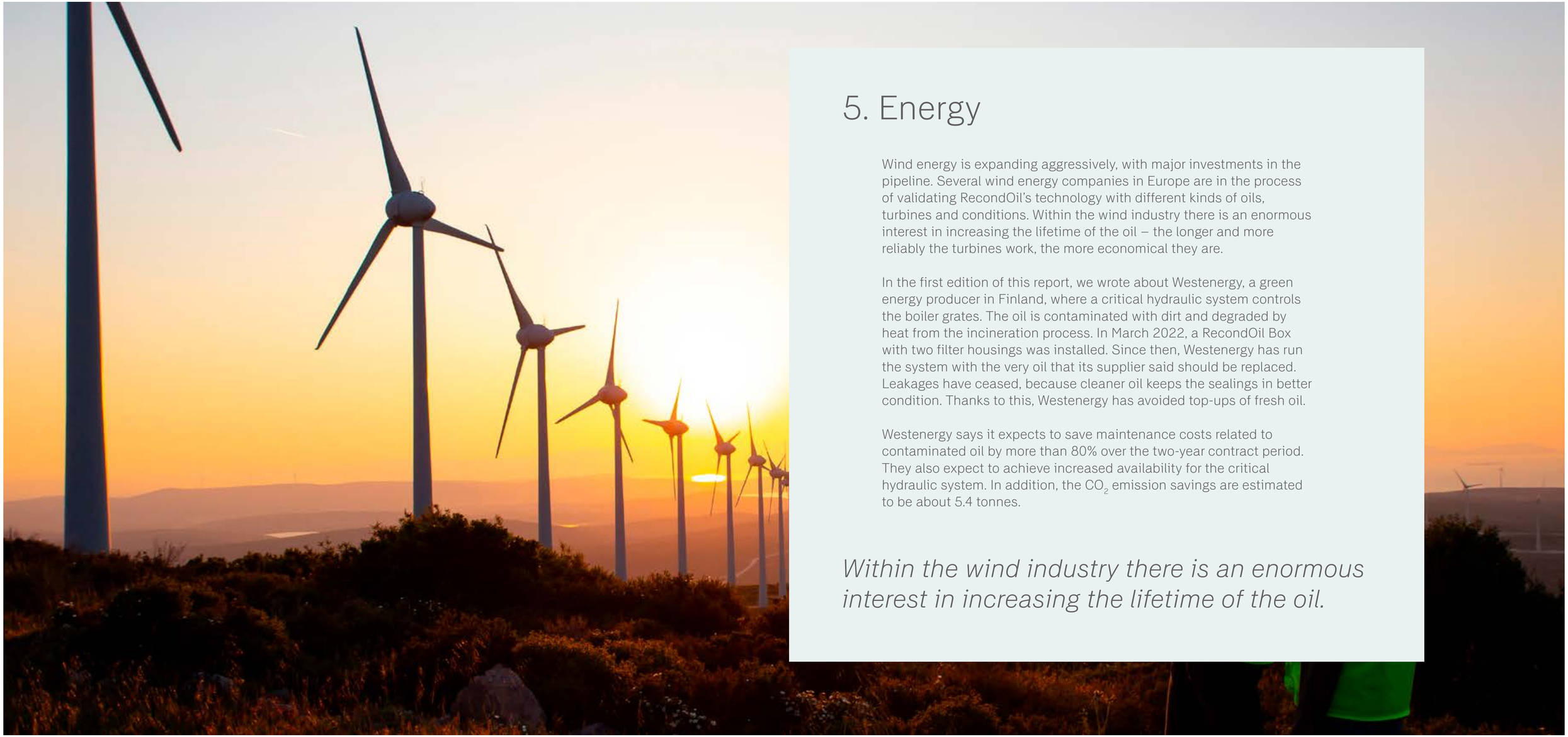
Vehicle parts manufacturer, Italy

In January, 2023, this vehicle parts manufacturer faced a situation in which oil contamination in its hydraulic forging press was out of control. A faulty manifold was releasing metal particles into the system, causing valves to fail, but production could not be interrupted to replace the manifold.

As a byproduct of degradation, the varnish content was very high: MPC showed a value of 67.7 – anything over 35 is considered critical. A gravimetric test showed 19.4 mg of particles per hundred millilitres, or 10 times the normal value. The ISO 4406 contamination level was 25 / 23 / 15 — extremely high. The ideal value should have been 500 times lower, or 16 / 14 / 12.

The company installed four RecondOil Boxes. After three months, the oil was back to its normal condition. Varnish had been reduced to normal (MPC < 16) and the overall number of particles in the system had been cut by more than 99% (per ISO 4406). The following month, the company was able to halt production and replace the faulty manifold. But it has retained the RecondOil Boxes, convinced that oil cleanliness will continue to have a major impact on productivity and reliability.

	January, 2023	April, 2023
MPC	67.7	15.3
Gravimetric (mg/kg)	19.4	2.7
ISO 4406	25/23/15	18/15/12



5. Energy

Wind energy is expanding aggressively, with major investments in the pipeline. Several wind energy companies in Europe are in the process of validating RecondOil's technology with different kinds of oils, turbines and conditions. Within the wind industry there is an enormous interest in increasing the lifetime of the oil – the longer and more reliably the turbines work, the more economical they are.

In the first edition of this report, we wrote about Westenergy, a green energy producer in Finland, where a critical hydraulic system controls the boiler grates. The oil is contaminated with dirt and degraded by heat from the incineration process. In March 2022, a RecondOil Box with two filter housings was installed. Since then, Westenergy has run the system with the very oil that its supplier said should be replaced. Leakages have ceased, because cleaner oil keeps the sealings in better condition. Thanks to this, Westenergy has avoided top-ups of fresh oil.

Westenergy says it expects to save maintenance costs related to contaminated oil by more than 80% over the two-year contract period. They also expect to achieve increased availability for the critical hydraulic system. In addition, the CO_2 emission savings are estimated to be about 5.4 tonnes.

Within the wind industry there is an enormous interest in increasing the lifetime of the oil.

Looking ahead

These findings are very encouraging, and support our conviction at SKF RecondOil that circular use of oil offers significant benefits across a range of industrial sectors, including:

- Improved sustainability
- Reduced total oil costs
- Better system performance and availability.

It is still early to assess the full cost and performance benefits of the ultra-clean oil that can be achieved using the RecondOil Box for various applications and under different circumstances. The technology needs to be tailored to specific needs and conditions. As our understanding grows together with our customers' experience, can we better calibrate the KPIs – productivity, downtime, energy use and other relevant parameters – that we establish to ensure that customers maximise the benefits for their machinery's productivity, reliability and efficiency.

As more customer experience becomes available, we will keep you updated. Make sure you receive the further reports in this series, and our email newsletter, by signing up for them here: recondoil_customerservice@skf.com

Improved sustainability

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PUB LS/S2 19732 EN · October 2023