Oil Degradation [Varnish]

CJC™ Fine Filters and CJC™ Filter Separators not only remove particles and water from oils - they also remove degradation products

Degradation products known as "soft contaminants", are the precursors of varnish deposits on metal surfaces of machines and components

Oil Maintenance

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Introduction

[Varnish]

"A thin, insoluble, nonwipeable film deposit occurring on interior parts, resulting from the degradation and polymerization of oil"

(source: Noria)

Any lubricant in service or in storage will degrate over time, depending on the type of oil, the operation conditions and the environment. When the oil deteriorates, it will change its composition and functional properties. During the degrading process, a number of unwanted products are formed, which can lead to varnish deposits, all of which will result in costly consequences for machinery, such as corrosion, sticking valves, varnish, etc.

In this brochure you can read about the consequences of oil deteriorating, as well as finding solutions on how to remove and monitor degradation products.

HDU 15/25 PV

HDU 27/27 P

PTU 15/25 PV

PTU2 27-27 PV

CJC™ Fine Filters and CJC™ Filter Separators

Oil Maintenance

Removal of degradation by-products from oil

Oil degrading is a common problem in both lubrication and hydraulic systems

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1 The Problem

Oil degrading is a common problem both in lubrication and hydraulic systems. The main causes of this are typically oxidation (oxygen), hydrolysis (water) and thermal degradation (high temperature). In many cases it is a combination of all three.

Process	Oxidation	Hydrolysis	Thermal degradation
Reagent	Oxygen	Water	Heat
Process catalysed by:	Temperature / Water	Oxygen / Temperature	Water / Oxygen
	Transition metals (wear particles, Cu, Fe, Al) Contaminants (contamination in general, oxidation products) Pressure		

The degradation process is catalysed by:

Oxygen

Oxidation

Oxidation is the breakdown of the oil with oxygen as reagent. The oxidation process involves a series of reactions forming acid compounds and polymerized compounds. Oxidation leads to insoluble products (sludge) that may precipitate as a thin film, forming lacquers or varnish deposits on hot or cold metal surfaces.

Water

Hydrolysis

Hydrolysis is the breakdown of the oil with water as reagent. Like oxidation, hydrolysis can result in acid compounds and varnish. Oxidation products such as: hydroperoxides, carboxyl acids, ketones, aldehydes and others, usually possess increased solubility in water and therefore often accelerate the hydrolysis process.

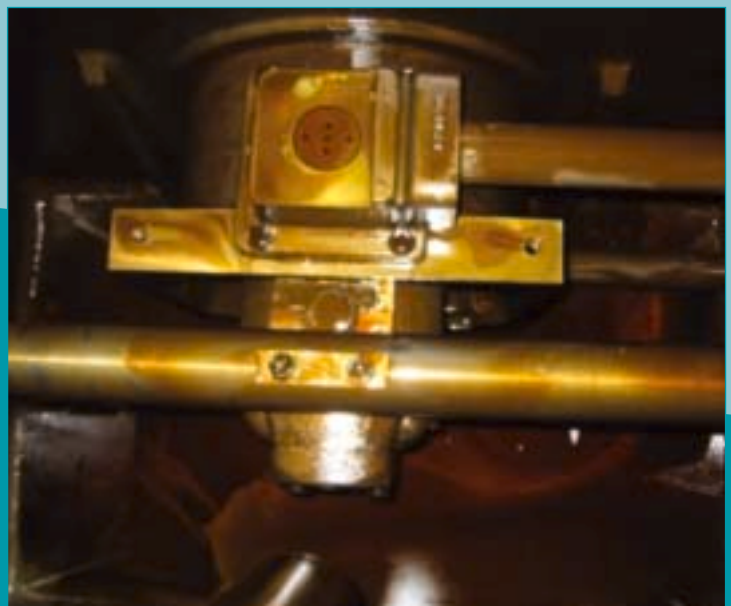
High temperature

Thermal Degradation

Thermal degradation is the breakdown of the oil activated by heat (high temperature). Typically thermal degradation occurs in the hot spots of the system. It can also result in polymers and insoluble compounds, which lead to varnish formation as occurs in the oxidation process.

Wear particles

Contaminants



Example of varnish formation on steering gear

Oil degradation and Consequences

Oil degradation will result in:

- **Formation of acidic compounds:**
  Acid promotes corrosion, for example pitting. This leads to increased wear in the internal surfaces of the machine.

- **Increase in oil viscosity:**
  The oil´s resistance to flow will increase, which will result in friction, wear and loss in efficiency of equipment.

- **Decreased additive performance:**
  Additives (antioxidants and detergents) also react with the degrading by-products. The result is that the additives lose their effect - and instead accelerate the deterioration process.

- **Varnish formation:**
  Varnish deposits are "sticky" and will trap hard contaminants, creating a "sandpaper surface". This "sandpaper" causes accelerated wear in components. In addition, varnish can result in filters and valves blocking, and orifices clogging. Furthermore varnish acts as an insulator, reducing the effect of the heat exchangers, resulting in higher temperatures and accelerated reaction speeds.

  Once the varnish deposits have formed on the metal surfaces, it is very difficult to dissolve them.

Examples of varnish:

Oil reservoir (Plastic Moulding Machine)

Machine components

Steering gear

Consequences of the oil degrading:

- **Shorter oil life**
  An increase in the level of oil degradation
  Degradation products act as a catalyst
  A reduction of additive performance

- **Reduced oil performance**
  Loss of lubricity
  Valve failure
  Restricted oil flow

- **Reduced productivity**
  Monday morning problems: slow start-ups
  Increased downtime
  Reduced machine performance

- **Higher energy consumption**
  Friction and wear

- **Increased maintenance costs**
  Increased filter change frequency
  Increased wear of components
  Acidic corrosion in metallic components
  Component failures
  Cleaning of the oxidation deposits

- **Environmental pollution consequences**
  Greater disposal costs of oil and filter changes
  Leakages

2 The Solution

Removal of by-products before they have time to react further and form insoluble sludge and varnish deposits

Oil degradation by-products cannot be removed with conventional mechanical filters because they are submicron particles. It is a fluid in a fluid - like when sugar is dissolved in coffee.

These by-products can be removed by CJC™ Fine Filters and CJC™ Filter Separators through a combination of **ad**sorption and **ab**sorption processes.

Adsorption is the physical or chemical binding of molecules to a surface (like getting a cake thrown into your face). In contrast with **ab**sorption, in which molecules are absorbed into the media. See illustrations.

CJC™ Filter Inserts, made of cellulose fibres, have a high surface area and can be effective as **ad**sorbents and **ab**sorbents. In addition, due to their chemical nature, they are highly suited to pick-up oxygenated organic molecules, such as oil degrading products.

Absorption
can be illustrated by this drawing: The chemical substances (the cake) is absorbed by the media (the man)

Absorption

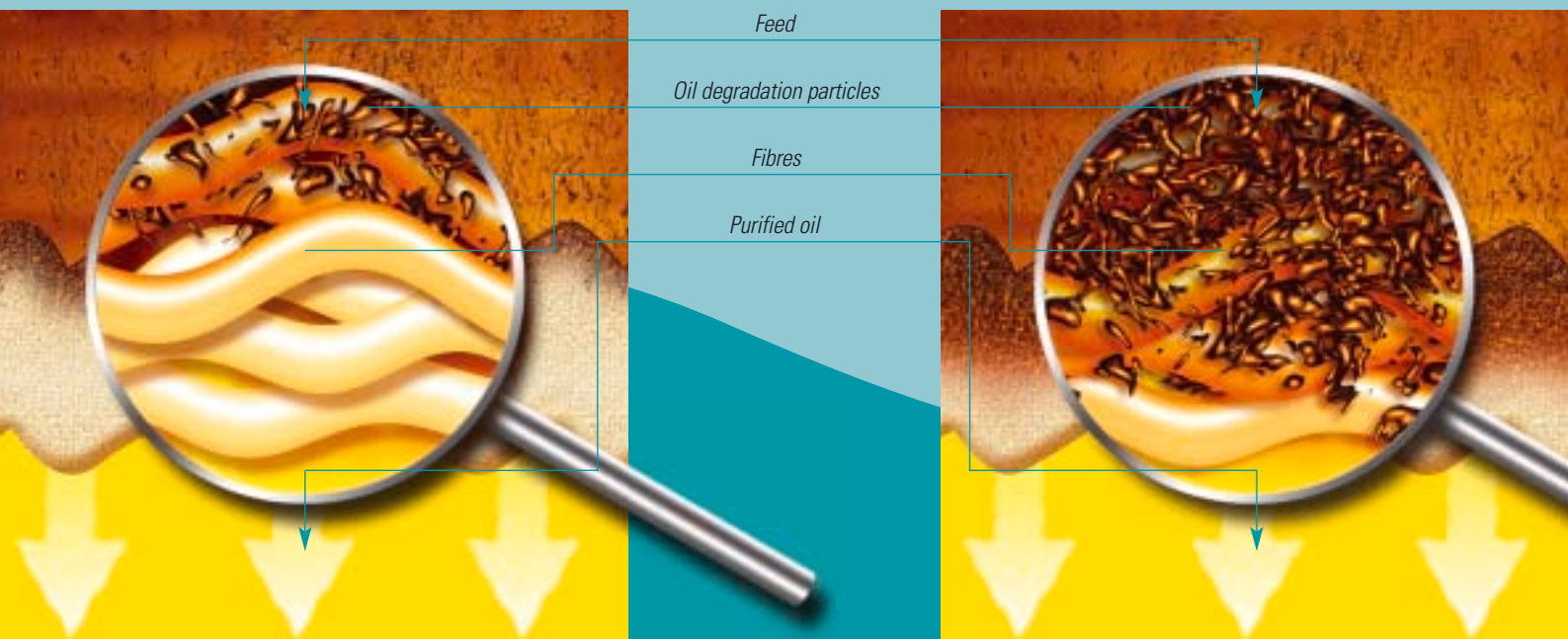
Adsorption
can be illustrated by this drawing: The chemical substances (the cake) is binding to a surface (the man)

Adsorption

The CJC™ Solution

Filter insert consisting of cellulose fibres treating the oil
This illustration shows the contaminated oil approaching the cellulose fibres in an almost new filter insert

Filter insert near saturation
This illustration shows that the filter insert is still producing clean oil even though the cellulose fibres are nearly saturated



Absorption and Adsorption by CJC™ Filter Inserts

Cross-section of a cellulose fibre
Each cellulose fibre consists of millions of cellulose molecules. Each strand of cellulose molecules has a diameter of 10^{-6} cm (0.000001cm)

*Degradation products are **ab**sorbed and **ad**sorbed into the cellulose material*

Film diffusion:
Transport from the oil to the boundary of the adsorbent (fibre). The resistance is pictured as a fictitious film

Macropore diffusion:
Transport within the adsorbent (fibre). This can be viewed amongst the subfibres

Micropore diffusion:
Transport from the pore fluid to the adsorption sites at the adsorbent surfaces. This can be viewed amongst the molecules

CJC™ Filter Inserts remove contaminants of any kind and size

- **Hard contaminants:** Wear particles, debris, dirt
- **Soft contaminants:** Varnish / oxidation
- **Water**

Before

Millipore membrane

*Sample taken **before** off-line filtration*

After

Millipore membrane

*Sample taken **after** off-line filtration*

CJC™ Filter Insert before use

CJC™ Filter Insert after use

3 The Result

CJC™ oil filtration will maintain both oil and system cleanliness

- Longer oil life
- Increased oil performance and lower energy consumption
- Increased productivity
- Less maintenance
- Environmentally friendly

An oil system free from varnish deposits

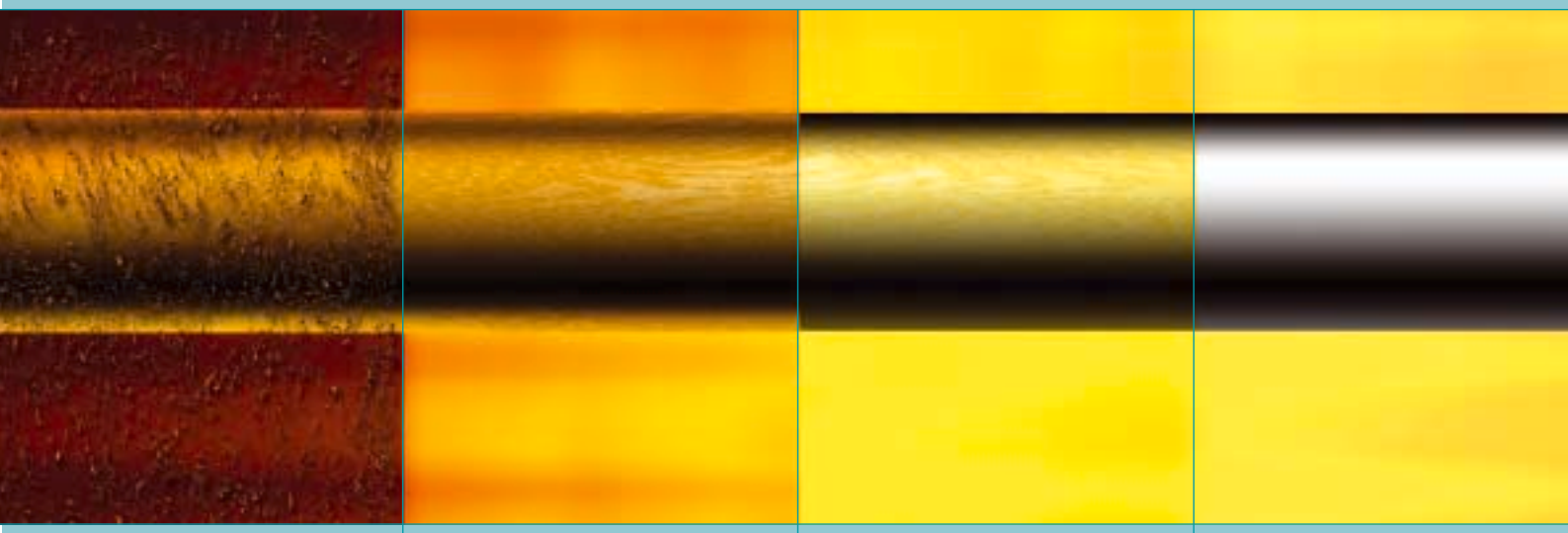
Removal of varnish deposits from metal surfaces

Removal of varnish deposits from metal surfaces

By using CJC™ Off-line Filters, the amount of varnish deposits on metal surfaces will be reduced. It is explained by the adsorption equilibrium behaviour.

There is an equilibrium between the two phases, i.e. the fluid (oil) and varnish on the surfaces. When the oil becomes cleaner, the deposits from the system become unstable because the concentration of oil degradation products in the oil has decreased. This will result in a decrease of the amount of adsorbed substance. In other words, this means that the oil degradation products on the metal surfaces are released. The oil functions as a system cleaner.

Summary



Problem: *The oil is contaminated by hard contaminants, water and soft contaminants, which lead to varnish deposits*

Solution: *Removal of the contaminants by CJC™ Off-line Filters before they will form sludge and varnish deposits*

Result: *Lower levels of contamination, which will prevent deposit formation. Futhermore the deposits, once formed, will be reduced by using CJC™ filtration*

Maintenance: *By CJC™ oil filtration you will maintain both oil and system cleanliness*

Problem

Solution

Result

Maintenance

How to monitor oil degradation?

Soft contaminants are compounds of molecular sizes, which cannot be measured by conventional particle counting methods

There are several methods that measure different aspects of the deteriorating oil. These methods generally measure the amount of certain degradation products from oil or the amount of additives in the oil.

The following are indications of oil deteriorating:

- **Dark colour**
- **Sour and putrid odour**
- **Increase in oil viscosity**

Sour and putrid odour indicates oil degradation

Increase in oil viscosity

Indications of oil deterioration

Dark colour

Methods to monitor oil degradation

Methods to monitor the level of degradation in the oil:

Viscosity test

Viscosity Test:
This test measures the oil resistance to flow. It can be used as an indicator of oil degradation.

TAN analysis

TAN (Total Acid Number):
This analysis measures the level of acid compounds. It can also be used as an indicator of oil degradation.

Colourimetric analysis

Colourimetric Analysis:
This analysis can determine the level of oil degradation by using the colour of the contaminants.

Millipore membrane analysis

Millipore Membrane:
This analysis is an indication that the oil contains degradation products. The varnish is captured in the white millipore membrane (0.45 micron cellulose membrane), and shows as a yellow, brownish or dark colour depending on the amount of varnish present in the oil. A microscopic magnification shows if the colour comes from varnish or hard particles.

Ultracentrifuge Test:
This test uses the gravitatory forces to extract and settle the contaminants of the oil. The sediments are compared with a sedimentation rating system to determine the degradation of the oil.

Ultra-centrifuge test

Gravimetric Analysis:
This analysis can determine the level of oil degradation by measuring the weight of residual components.

Gravimetric analysis

Infrared Spectroscopy:
(FTIR Analysis -Fourier Transformation Infrared Spectroscopy)
This analysis is based on the principles of molecular spectroscopy. It can verify the level of oil degradation by the identification of the functional groups (e.g. ketones, carboxylic acids) in molecules.

Infrared spectroscopy

Methods to monitor the consumption of additives:

- **FTIR Analysis**
  (Fourier Transformation Infrared Spectroscopy)
  It can monitor the additive depletion.
- **RULER Test** (Remaining Useful Life Evaluation Routine)
  It measures the remaining antioxidants by voltammetric analysis.
- **RBOT Test** (Rotating Bomb Oxidation Test)
  It measures the oil's resistence to oxidation under prescribed conditions.

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C.C.JENSEN all over the World

The CJC™ Off-line Filters are distributed by our own international sales organisation and designated distributors

CJC™ stands for reliable supply all over the world

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Your local CJC™ distributor

Oil Maintenance

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