HYDAC FILTER SYSTEMS
Justus-von-Liebig-Straße - Plant 20
D-66280 Sulzbach / Saar
Phone: +49 (0) 6897 509 – 01
Fax: +49 (0) 6897 509 – 9046
E-mail: filtersystems@hydac.com
Web: www.hydac.com

Oil degradation products in hydraulic and lubricating oil

Introduction

Oil degradation products or "varnish" in hydraulic and lubricating oil units can lead to malfunctions and increased warehouse temperatures. The result is unplanned downtime and high costs. The oil degradation products can be like gels or resins or be present in the unit as solid residue - the color scale here ranges from gold-yellow to dark black.

The main cause for the formation of oil degradation products is oxidation, that is, the reaction of the oil with oxygen in the air. Furthermore, contaminants in the oil, regardless of whether they are solid, liquid or gas, accelerate oil aging. Here, the oil reacts either directly with the contaminants or the contaminants function as catalysts. Electrostatic discharges can crack the oil or additives in it. These cracked oil components react chemically to the larger molecules, which then deposit as oil sludge in the unit.

There are numerous problems with oil degradation products in hydraulic and lubricating oils. They settle at different areas in the unit. For example, if deposits should collect at valves, the valves may fail completely. Since the oil degradation products deposit to a greater degree on cold surfaces, crusts can often build up in the cooler, which then prevent heat transfer. If the oil can no longer be cooled with the full power, the oil temperature in the unit will rise. In addition, oil degradation products will collect at areas which are under compressive stress. This phenomenon often means that warehouses are affected. In them, deposits roughen up the surfaces, thereby leading to increased wear.

In the past, the life expectancy of one oil filling, depending on use, was between 15 and 30 years. With modern hydraulic oils, it is considerably shorter; usually under ten years. The life expectancy of the filling nowadays depends more than ever on oil maintenance. Alongside the classic maintenance measures like the removal of particulate contamination using oil filters or dehydration by vacuum dehydration units, the removal of oil degradation products is receiving more and more focus.

Whether or not oil degradation products exist, and if they do, to what extent, can be determined in oil analyses. In general, they can be detected by measuring the contamination class using particle counters at different temperatures. If the oil is cold, it has low solubility for oil degradation products - they are then present in free form. If the oil is heated, the solubility will increase and they will dissolve.

An optical particle sensor also only detects free oil degradation products as small particles. Dissolved oil degradation products cannot be detected using an optical particle sensor. If the particle counter shows considerably more particulate contamination when it is cold compared to when it is warm, it can be assumed the oi contains oil degradation products.

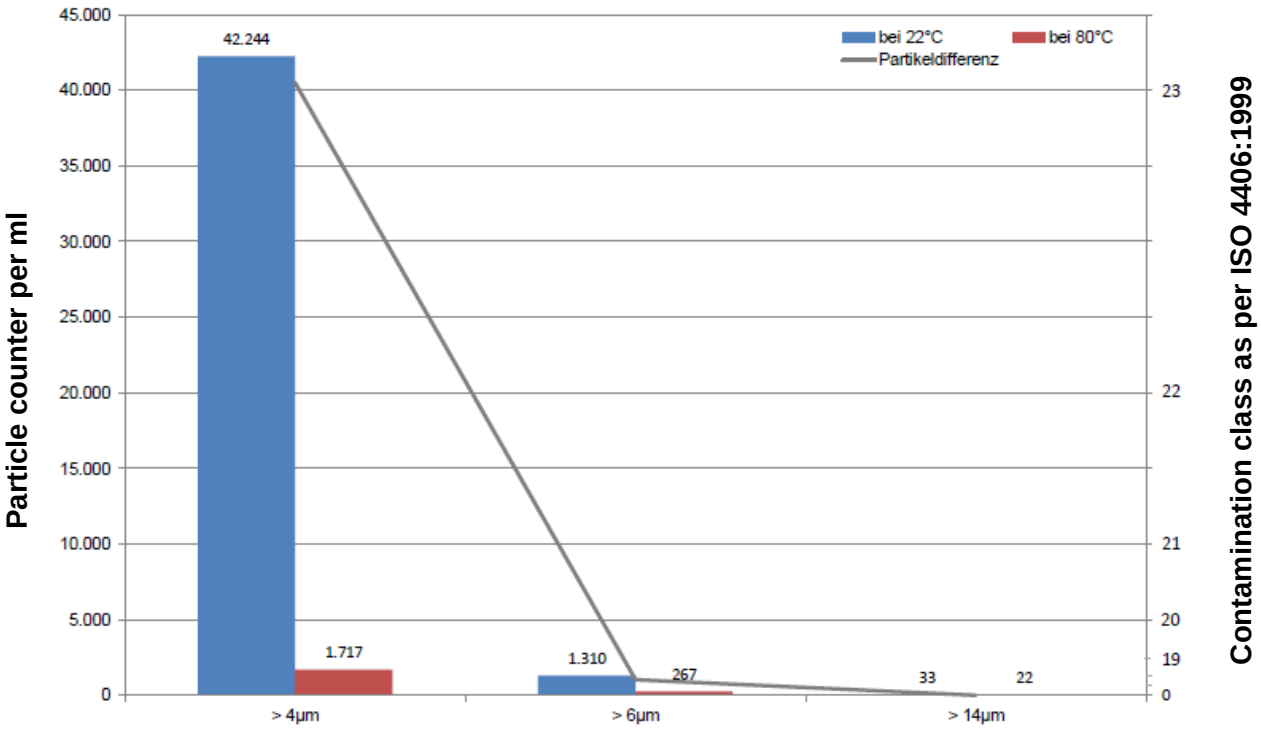


Figure 1: Number of particles in 1 ml of oil at 20 °C and 80°C

In the case of turbine lubrication, the content of oil degradation products can be determined from the color of the oil residue. With the MPC test, oil will be drawn across a diaphragm, the color of the residue on the diaphragm analyzed and a non-dimensional derived: The MPC value.

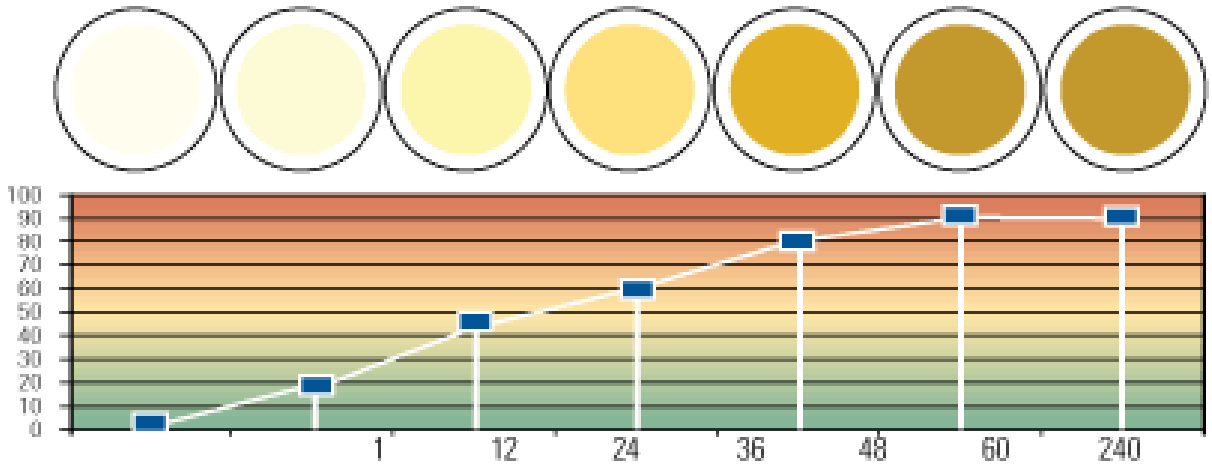


Figure 2: Color scale with the MPC test

Antioxidants

Antioxidants like phenols and amines are additives which slow down the time deterioration of the oil. One cause of oil aging is radical substances which chemically attack the oil. Antioxidants react with the radical substances in the oil and render them harmless. In this reaction, the antioxidants

consume themselves and their concentration in the oil sinks over time. Once all of the antioxidants have been used up, the oil aging will proceed very quickly and oil degradation products will swiftly start appearing in the oil. In this case, maintenance measures for removing oil degradation products are no longer efficient as too many oil degradation products come about for the time unit. For this reason, the VGB, in its VGB-S-416-00-2014-08-DE standard, recommends replacing the oil as soon as the residual content of antioxidants drops below 25% phenols and 40% amines. As long as the concentration of antioxidants is above this limit value, oil maintenance for removing oil degradation products is the most economical and safest method to keep the oil in good condition.

Removal of oil degradation products

With conventional hydraulic or lubricating oil filters, it is difficult to remove the oil degradation products from the oil to any great degree. Hydraulic and lubricating oil filters are designed in such a way as to remove particles from the oil. With the subsurface structure, the particles, depending on their size, are retained within the structure of the filter medium. Gel-like oil degradation products already stick to the surface of the filter element, thereby blocking the subsurface structure of the filter medium. In this case, the differential pressure increases quickly. In some cases, the life expectancy of the filter element will drop to just a few hours. For this reason, there are more suitable options applicable for the removal of oil degradation products from hydraulic or lubricating oil.

1. Removing oil degradation products with ion exchangers

Ion exchangers have a similar structure to bypass filters and work 24 hours/day, 365 days/year. The separation of oil degradation products is done via the accretion of a specific type of resin. Once the adsorption capacity of the resin is exhausted, the number of oil degradation products in the oil rises again. If an increase in the quantity of oil degradation products is detectable in the oil analysis, the resin-filled elements will be replaced. With this, a zig-zag profile come about over time (see Figure 3).

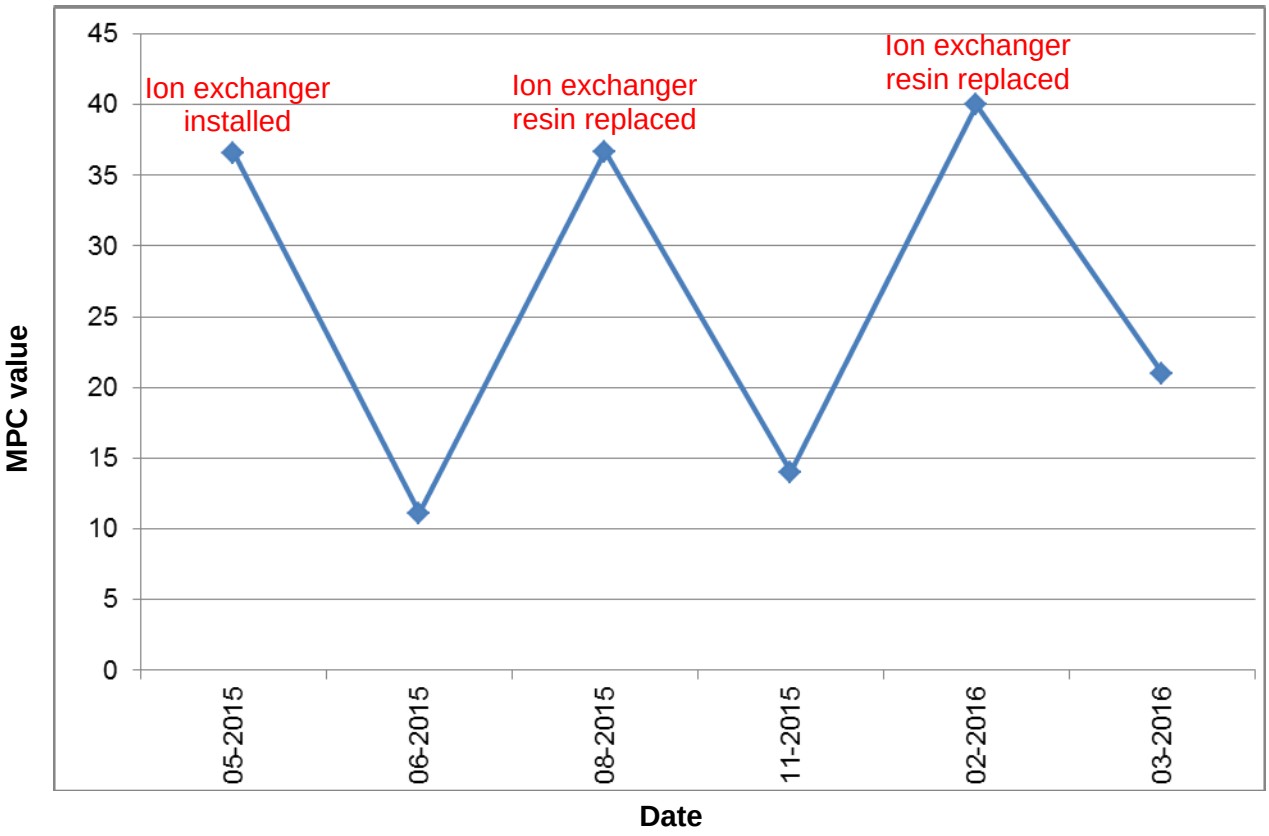


Figure 3: MPC profile over time when using an ion exchanger

Due to the increasing fluctuations in the MPC value or the high fluctuations of the particle counts when cold as well as the high oil analysis requirements connected with this method, a different procedure for clearing the oil of degradation products is finding greater and greater usage.

2. Removing oil degradation products by reducing solubility and subsequent filtration (VEU-F)

With this technology, the solubility of oil degradation products decreases with the cooling down of the oil. Subsequently, these can be separated through filtration. This method can be applied in all hydraulic and lubricating oil applications which are run on mineral oils. This type of purification functions in a similar way to offline filtration and works 24-hours/day, 365 days/year. The oil is cooled down to below 30 °C in a single run. There are various options available when it comes to cooling. The most efficient option is cooling with cooling water in a plate heat exchanger, but cooling with a cooling unit is also common practice.

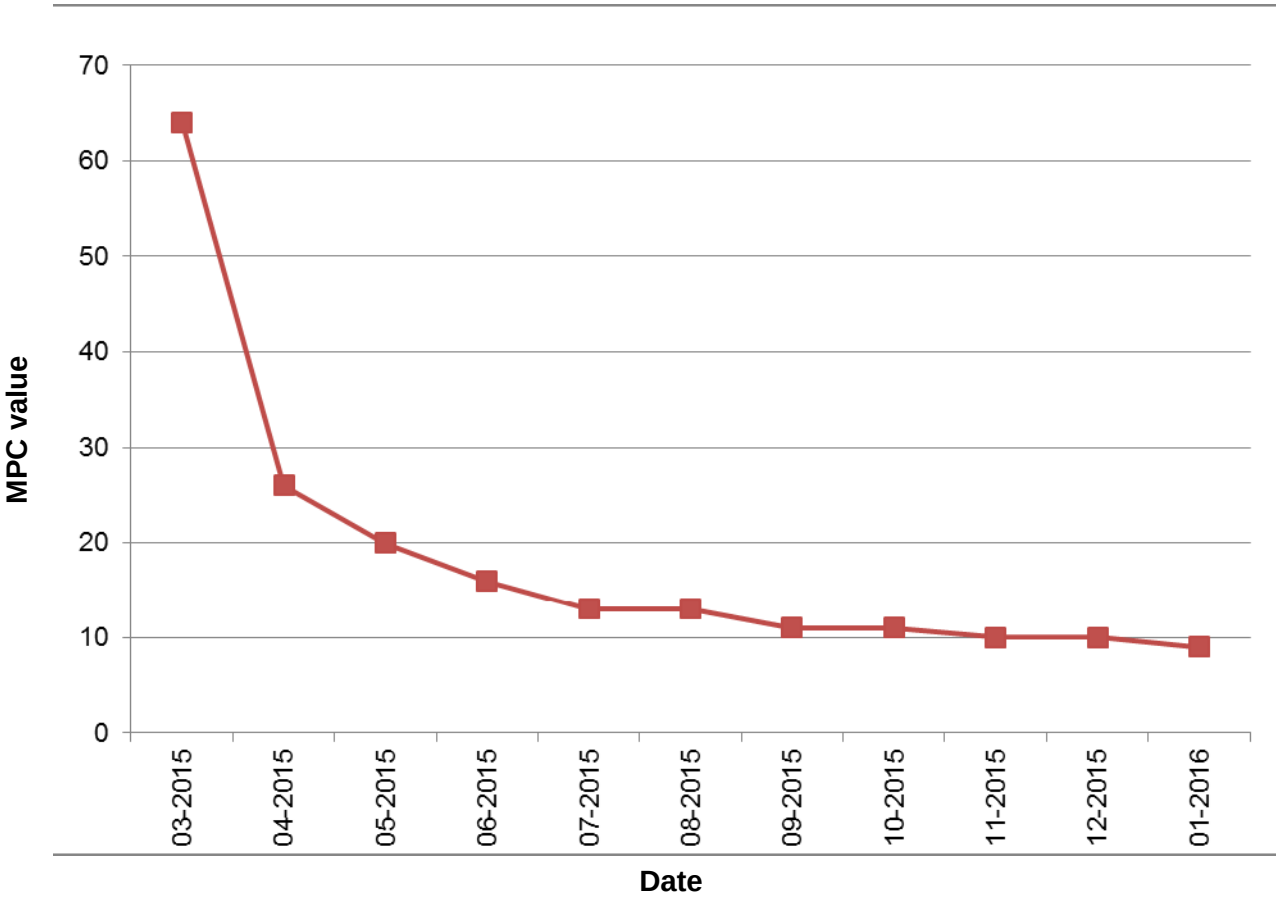


Figure 4: MPC profile of the amount of runs through the filter when reducing the solubility by cooling and subsequent filtration

This separating procedure has distinct advantages compared to the ion exchangers. Like with normal hydraulic filters, a required element change is detected by the rise in the differential pressure at the element. In contrast to this, complex oil analyses are required with ion exchangers in order to find out the optimum moment to change the element. Thanks to its greater efficiency, the "cooling & filtering" technology is asserting itself more and more on the market.

Application example

Varnish in a solid forming press

INITIAL SITUATION

Solid forming press
- Problems with varnish in the oil
- Malfunctions
- Deposits
- Oil clouding / ageing

OBJECTIVES

- Reduction of fault-related standstills
- Safe plant operation
- Extension of oil change intervals

HYDAC SOLUTION

Actual status
- The press's tank volume is 8,000 litres.
- Varnish in the system will cause problems in valves

Effects of varnish

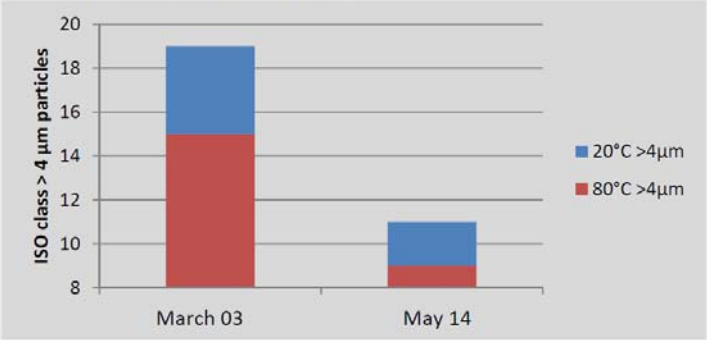
A large difference in the particle classes between particle measurements at 20°C and at 80°C indicated increased varnish formation. This causes deposits to form in the system with the consequences:
- malfunctions in valves
- Reduced working life for valves, pumps and oils
- Heat transfer hindered in coolers
- Filter elements clogged

HYDAC solution

Continuous use of VEU-F makes it possible to reduce varnish efficiently.

RESULT

The varnish concentration was determined by means of particle analyses at 20°C and 80°C. The 4µm particle size during VEU-F use is shown:



Summary

Oil ages with time. The speed of oil aging depends on various factors like, for example, the oil's operating temperature, the concentration of particulate, liquid or gas contamination in the oil as well as the presence of electrostatic discharges. If the oil ages, oil degradation products will come about. Oil degradation products are polar substances, which can barely be dissolved at all in modern oils. Due to their poor solubility in oil, oil degradation products separate and deposit in the hydraulic and lubricating unit. There, they block the valves or filters and deposit on heat exchangers, thereby preventing heat transfer in the cooler.

To prevent downtime caused by the deposits of oil degradation products, it is recommended that maintenance units be used. There are a number of different methods that can be applied here. One is the separation of oil degradation products with ion exchangers (VMU), which do however exhibit some technical and efficiency-related weaknesses. Another is the separation of oil degradation products via cooling down (lowering solubility) and subsequent filtration (VEU-F). In practice, this method is being used more and more due to its ease of handling and very high levels of efficiency.

To avoid critical operating conditions in the hydraulic or lubricating unit, regular oil analyses must be performed in order to test the contamination class and water content as well as check for oil degradation products. The corresponding maintenance measures can be introduced if necessary in order to guarantee the fault-free operation of the unit.

Additional information:
HYDAC International GmbH
Industriegebiet
66280 Sulzbach / Saar - Germany
Phone: +49 (0)6897-509 01
E-mail: info@hydac.com
Internet: www.hydac.com