How to remove varnish in your mining equipment

When Varnish strikes in hydraulic systems, mobile mining equipment etc, the costs associated with a production outage are often very high. The precursors to varnish, the so-called soft contaminants, are created in the hot spots in the oil system, and might cause damage to bearings, pumps and high flow in-line filters.

To treat and remove Varnish, installation of a CJC™ Fine Filter is highly profitable. When installing a CJC™ Fine Filtration unit to treat a system that has an issue with Varnish, it is important to take an individual approach to monitoring and maintaining the unit and the system. In establishing this approach and procedure it requires a clear understanding of some key areas:

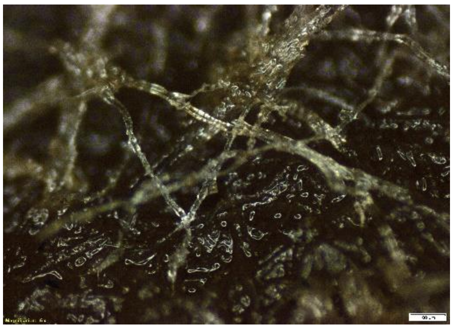
CJC™ Fine Filter HDU 27/27

- What is varnish and how is it formed
- Why each system is different
- How the CJC™ Fine Filter removes Varnish
- Ways to monitor the performance of the CJC™ Fine Filter and the saturation of the CJC™ Filter Inserts

What is Varnish and how is it formed

Varnish build up in a system is different to other contaminants that are usually present in a hydraulic system such as particles and moisture contamination. The Varnish deposits are a result of both oxidation and degradation of the oil, as the oil degrades the by-product of that degradation is the Varnish deposits that are found in the system. As the system oil degrades the oil molecules affected by this degradation, will remain dissolved or suspended in the oil, until the oil reach's a maximum saturation level at this point the oil will begin to shed the degraded oil molecules as particles. As these particles are shed from the oil they adhere to internal surfaces of the system and form a layer of Varnish which will build up in the hydraulic system over time. Another important factor to consider is that the temperature of the hydraulic oil has a dramatic effect on the maximum saturation level of the oil. The higher the temperature - the higher the maximum saturation level and the lower the temperature - the lower the maximum saturation level. This variation in maximum saturation level is the reason why cooler areas of the hydraulic system will see higher levels of Varnish build up. System coolers and tanks will be the first parts of the system to show Varnish deposits and in turn the last place to remove the Varnish deposits. There is an equilibrium between varnish in oil and varnish deposits on components, so once the degraded oil molecules start to shed from the oil and are deposited in the system as Varnish, the oil has been saturated. Of course, there are other factors which have lead operators to discover that they have an issue with Varnish deposits in their hydraulic system, e.g. slow and sluggish operation, sticky valves etc., but probably the most obvious indication of Varnish deposits is higher operating temperatures of the hydraulic system. As mentioned above the system coolers are one of the first place to show Varnish deposits and as these Varnish deposits will, over time, insulate the cooler and harm the efficiency greatly. As the cooling efficiency of the cooler decreases and the system temperatures increase this will have a massive effect on the rate of thermal degradation of the oil and in turn the generation of Varnish deposits. For every 10^{o}C increase in oil temperature above 50^{o}C the affective oil life is halved due to thermal degradation of the oil.

Membrane, hydraulic oil under microscope, particle visualisation



Cellulose in the filter insert with Varnish formations

Why each system is different

Due to the fact that even identical hydraulic systems on the same machinery will almost always operate under different conditions the rate at which the oil degradation occurs and therefore the level of Varnish deposits will be different from one machine to the next.

This will be a result of many different factors, which may include, but are not limited to, the following:

- The age of the machine in question
- The number of oil changes over the life the machine
- The number of system component changes over the life of the machine. Components such as coolers will have a large effect on the level of Varnish deposits present as every time a cooler is changed a potentially large amount of Varnish deposits could be removed
- During any maintenance or breakdowns were components and the tank cleaned to remove Varnish deposits
- The geographical location of the machine and variations in ambient temperature
- The operating hours of the machine does the machine operate 24/7 or does the machine operate 8 hours a day, 5 days a week

- Different machine operators will always operate the machine differently
- The load placed on the system during operation, does the machine operate at 100% of capacity 100% of the time
- The level of other forms of contamination in the system such as particles, moisture and air will all influence the operating temperature of the machines

As a result, the rate of oil degradation will vary and the level of Varnish deposits for each machine will require an individualised approach to monitoring. This will also influence the time required to reach a satisfactory result, as well as an impact on the number of replacement CJC™ Filter Inserts required to achieve those results.

How the CJC™ Fine Filtration unit removes Varnish

When installing a CJC™ Fine Filtration unit on a hydraulic system with Varnish issues, the unit will clean the oil from degradation products and shift the equilibrium. The clean oil will slowly clean system components, where varnish has settled out.

CJC™ Fine Filters uses adsorption as the varnish particles adhere to the outside of the CJC™ Filter Inserts, as with any normal particle contamination such as wear metals, silica etc. The advantage of this adsorption of particles onto the outside of the filter insert, is that this will influence the differential pressure across the filter insert and will therefore indicate on the differential pressure gauge when the filter insert reaches saturation. The disadvantage of this adsorption of particles on the outside of the filter insert, is that if the temperature of the oil increases or the saturation level of the oil is decreased in the case of an oil change these particles can be washed or dissolved from the surface of the filter insert back into the oil.

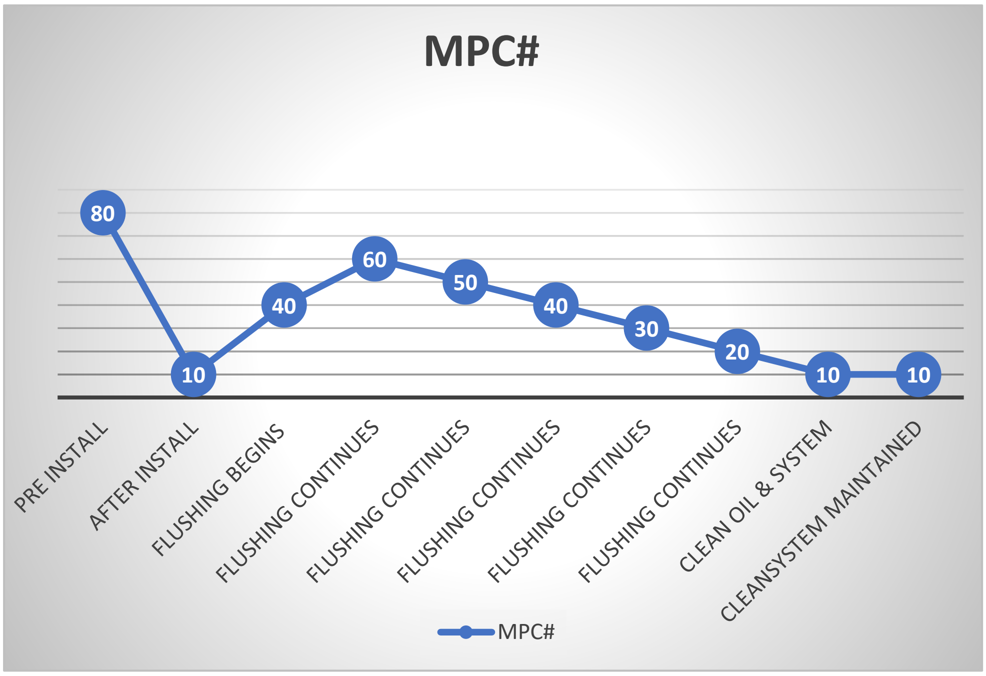
Therefore, CJC™ Fine Filters also uses absorption to hold on to the degradation products, which is why the installation of CJC™ Fine Filtration unit is so effective on a hydraulic system. Natural cellulose fibres used in the CJC™ Filter Inserts will also remove the degraded oil molecules known as soft contaminants, whilst they are still dissolved in the oil. The filter insert uses polar attraction to absorb the soft contaminants whilst they are still dissolved in the oil. This absorption of the soft contaminants will lower the saturation level of the oil, so as the oil washes over the already deposited Varnish in the system it will dissolve the deposits back into the oil allowing for further filtration of the soft contaminants via absorption. The advantage of removing the soft contaminants via absorption into the core of the cellulose fibre is once the soft contaminants are absorbed they will not be removed with temperature change or any other means. The disadvantage of removing the soft contaminants via absorption into the cellulose fibre is that the cellulose fibre does not swell or block the pores of the filter insert and therefore you will not see any change to the differential pressure across the filter insert, but different methods to show saturation of the CJC™ Filter Inserts are required.

Ways to monitor the performance of the CJC™ Fine Filtration unit and the saturation of the CJC™ Filter Inserts

Because the CJC™ Fine Filtration unit removes mostly the soft contaminants that cause Varnish to form, it requires establishment of a different set of protocols to measure the effectiveness of the unit, the saturation of the CJC™ Filter Inserts and the stages of Varnish removal.

The best and most cost-effective way to monitor all these areas is Membrane Patch Colorimetric (MPC) testing. Whilst the MPC testing indicates the Varnish potential of the oil, it does not indicate the level of Varnish that has been deposited in the hydraulic system. Another area that the MPC testing can be used for is as an indication of filter insert saturation with soft contaminants via absorption (into the core of the cellulose fibres). To effectively monitor these areas an MPC test of the system oil is carried out prior to the installation of the CJC™ Fine Filtration unit with MPC testing continued at regular intervals after the installation. The intervals for this continued testing will vary depending on the conditions of each system and the stages of Varnish removal.

Once the CJC™ Fine Filtration unit has been installed it is expected that during the initial oil cleaning the soft contaminants are removed from the oil, and the first MPC test will show a dramatic drop in MPC, compared to the pre-installation MPC test. After this initial drop in MPC the clean oil will begin to flush and dissolve the Varnish deposits from the system and subsequent MPC tests will show a sharp increase to approximately 60-80% of the pre-installation MPC test. After this increase the MPC will begin to fall slowly as the process of removal of soft contaminants via absorption and dissolve Varnish deposits. This continues until all the Varnish deposits are removed an equilibrium is achieved between the oil and the system. The continued MPC testing will enable tracking of this process but it will also indicate the saturation of the CJC™ Fine Filtration CJC™ Filter Insert with soft contaminants. Any plateau or rise in MPC during this phase of Varnish removal will indicate the saturation of the CJC™ Filter Insert with soft contaminants and the CJC™ Filter Inserts should be changed at the next scheduled service for the equipment.



Graph: MPC values, varnish cleaning process

Above graph represents the expected progression of the system being cleaned of varnish. It is virtually impossible to determine the exact time it will take to complete the process as was indicated earlier that all systems will vary based on several key factors particular to the actual system being cleaned.

Furthermore, it is impossible to determine the life expectancy or number of CJC™ Filter Inserts required to carry out this process. These will both be affected by the pre-installation conditions, the operating conditions of the machinery and the MPC# at the time. The pre-installation conditions will determine the level of Varnish deposits present and could also affect the system temperature and the generation of additional soft contaminants. The operating conditions will also affect the running temperatures and the rate of generation of soft contaminants. The MPC# at the time will influence the speed that the Varnish deposits are dissolved, the higher the MPC the slower the stripping process will be, and it will also influence the time it takes it saturate an CJC™ Filter Insert even if the flow rate remains constant.

Other areas to observe during this process that will help in evaluating the success and the stages of Varnish removal would be through visual inspection and system operating conditions. When the system is shut down for maintenance, if possible, dismantle components that are known to have Varnish deposits and evaluate based on previous inspections. Possibly the easiest way to evaluate, if the system is having an effect is by observing how the machine is operating. Is the system operating quicker and smoother than before? Is the system running more efficiently? Are the operating temperatures dropping compared to the same time of the year prior to installation? Any of these factors could be a result of lower level of Varnish deposits in the hydraulic system.

Procedure for installing a CJC™ Fine Filtration unit

After understanding the key factors of how Varnish is formed and removed, it is then possible to look at the steps to preparing for installation, installation and monitoring of the CJC™ Fine Filtration unit installed.

- Take a pre-installation oil sample to perform MPC testing to establish a base line
- Visually inspect any components accessible that are known for Varnish deposits and document the level of Varnishing
- Observe how the machine is operating (sluggishness etc.) and the running temperatures
- Changing the oil will aid and speed up the process, but is not necessary, as the CJC™ Fine Filtration unit will filter the oil. It is best to compare the cost of CJC™ Fine Filter, CJC™ Filter Inserts and the replacement oil
- Changing or cleaning components like coolers will also aid the process, as it will potentially remove an area with high levels of Varnish deposits and will also lower the system operating temperatures and decrease the rate of oil degradation. Again, this is not necessary as the filtered oil will start to dissolve these Varnish deposits
- Ensure that the suction line to the filter is being supplied with the coolest possible oil from the system
- Update maintenance procedures to include oil sampling and MPC analysis at regular intervals. If possible set the initial intervals every one to two weeks to establish a baseline for saturation of CJC™ Filter Inserts for each system. This can be modified as the system is cleaned of the Varnish deposits, and as saturation of CJC™ Filter Inserts will slow down when the MPC lowers
- Any plateau or rise in MPC after the initial steep climb back to 60-80% of pre-installation value will indicate CJC™ Filter Insert saturation of soft contaminants and CJC™ Filter Insert change should be scheduled for the next available service or maintenance work
- Any rise above 2.5 bar on the pressure gauge at operation temperature, will indicate saturation of particle or water contamination and CJC™ Filter Insert change should be scheduled
- Compare current system operating conditions against historical pre-installation data collected
- After the system is cleaned of all Varnish deposits and the MPC reaches an acceptable level (below MPC 15), continue regular oil sampling and MPC analysis to establish rate of CJC™ Filter Insert saturation under normal operating conditions

For further info, please contact IQ Oil Australia, Justin Quinn, Sales Manager CJC™ Mining at IQ Oil Australia, justin@iqoil.com.au or visit www.iqoil.com.au.