



Dipartimento di
Ingegneria Industriale



Master Executive Course
Management of
Industrial Maintenance

**SYSTEMS FOR
MAINTENANCE
DIAGNOSTICS:**

**CHARACTERISTICS,
FUNCTIONALITIES AND
FIELDS OF USE OF
LUBRICATING OIL
ANALYSIS**

MeTIM

Dalmine, 16/03/2007



Premise

If **human life expectancy** (in developed countries) has almost doubled over the last century, the cause is to be found in the progress of medicine, as the prevention and treatment of diseases at an early stage.

NUOVE ASPETTATIVE DI VITA



Nel corso dell'ultimo secolo le aspettative di vita dell'uomo sono più che raddoppiate



Questo soprattutto grazie ai progressi svolti dalla medicina nel campo della

PREVENZIONE



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In the past the **most invasive surgeries** received the greatest attention (and greatest success in economic terms) from the public; the ability to prolong the procedures, making them increasingly "radical" and imagining a time when we could substitute worn parts *ad libitum* was the true frontier of research.

In reality, the most substantial improvements in human living conditions have been achieved through less showy paths. Personal hygiene (a direct consequence of the availability of drinking water) and especially the simple act of brushing your teeth, have led to resounding successes in eradicating chronic forms of infection. Daily dental care prevents the formation of bacterial deposits, precursors of hard precipitates (tartar) that facilitate gingivitis and cavities. The consequence of losing teeth (as a result of more severe cases of pyorrhea) leads to incomplete mastication, with subsequent serious consequences on the gastrointestinal tract.

LA CHIRURGIA

In antico era proprio la **CHIRURGIA** invasiva che riceveva le maggiori **aspettative** da parte del pubblico



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Lezione di anatomia - REMBRANDT. F.1632

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The eventual anaerobic infection can cause an abscess (only an annoying pain in this phase) that if long neglected can trigger a wider inflammation called Reuma, which can have serious cardiac repercussions.

This chain of events can in some cases go unnoticed, and "palliative remedies" can make people erroneously think that the phenomenon has been contained or resolved, without going to the root cause of the problem.

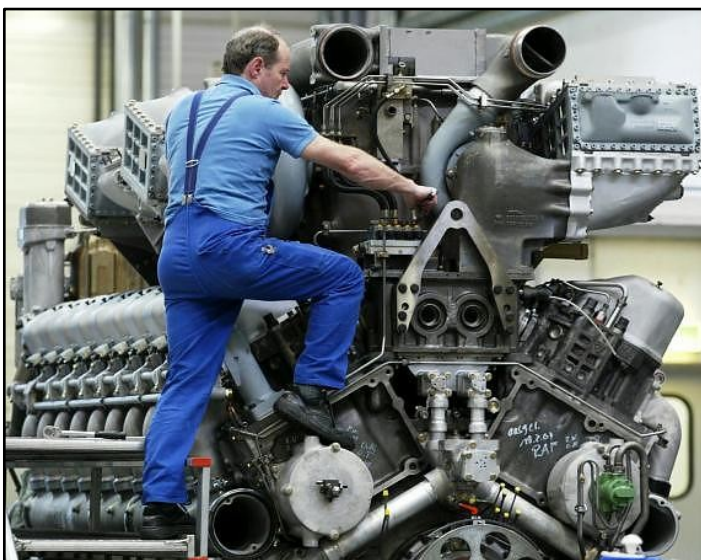
In support of traditional medicine, in the 1950s clinical Diagnostics started to become widespread, which, through minimally invasive blood tests, manage to present a true picture of an individual's health condition.

In the mentioned case of an acute dental abscess, the examination of the ESR (the time of sedimentation of the corpuscular part of the blood) would certainly indicate some altered values. A general examination (which would simply indicate an inflammation) is very inexpensive, but paired with the patient's feeling of discomfort it can guide the doctor toward the most appropriate therapy to delimit the affected area.

If it becomes necessary to resort to more detailed investigations, we can proceed with Ultrasound (where applicable) or X-ray scans of the areas to be checked.

A parallel with the industrial world

In the case of the machines whose integrity we must guarantee, both for their value as assets and as essential production elements for a continuous cycle, we will try to apply diagnostic systems that have a strong association with the topics we previously addressed.



Source: Daimler-Crysler

Here, too, we have gone from the concept that "disassembling is good" because it was required by the user manual or by other people who have experience with similar tasks, to the concept of "predicting" the harmful event.

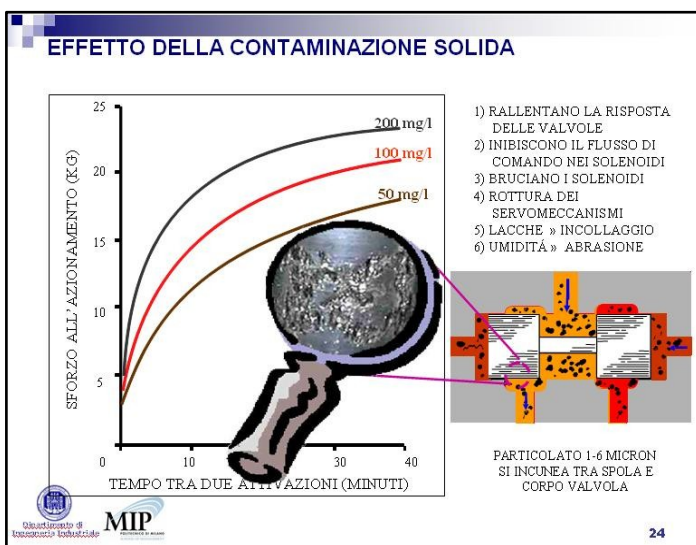
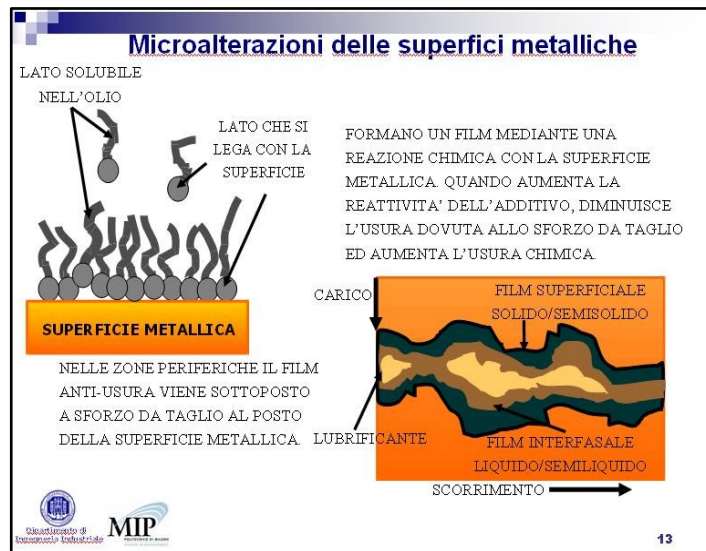
After all, in mechanical systems (unlike organic ones) the concept of conservation of operational integrity through self-maintenance is not yet a practical reality, except with some particular software.

In the case of lubricated (or oleodynamic) equipment, by examining a drop of used oil in comparison with a drop of new oil, it is possible to obtain substantial information on the reliability of the system.

All this is possible thanks to the incredible developments of technology, which managed to specialize generic instrumentation originally created to monitor chemical and physical parameters of new fluids.

It has thus been discovered that the precursors of damage in power transmissions are found in **microalterations of the metal surfaces**, due to the breakdown of the film of anti-wear additives. Cementation alone cannot withstand the heavy loads of the most stressed mechanisms.

Soot or "lampblack" is also a common by-product of diesel combustion; it is filtered by imperfect seals (*blow-by*) at the bottom of the engine.



Originally, these are carbon particles (similar to graphite) smaller than a micron, and as such they're not harmful, but can actually contribute to lubrication. However, if **present in excessive quantities**, they tend to bind with the degraded parts of the lubricant and when the operating temperatures are too high, along with traces of humidity, they tend to agglomerate, forming large abrasive precipitates responsible for wear.

This results in obstructions of passages, stiffening of the segments and blockages in the piston seats (with subsequent further blow-by increase), while the hottest metal parts tend to get covered with an amber film (*varnishes*) compromising axial play and holding.

Part of these soot particles escape into the external environment through the exhaust and become a big part of the harmful "PM10".

The parallel with medicine and clinical diagnostics is very obvious; particles that by themselves are harmless can get out of control and aggregate to form actual



“blockages” to the correct circulation of oil, **damaging pistons and bearings**.

Something similar also happens in turbine oils, by themselves very advanced products, made from excellent quality bases and equipped with additives that make them suitable for prolonged operation in conditions of medium stress.

When the use of steam turbines (large machines,

with huge volumes of oil in circulation, which operating T°C has always been very low, and whose main purpose was to lubricate and give hydrodynamic support to the bearings) was supplanted by the increasingly frequent use of Turbogas turbines, it became clear that not all products can perform the same.

Here, too, the argument goes that many energy producers had to wait for the completion of a certain timed cycle, then proceed to the disassembly of hot parts, to find some micro- or macroscopic damage that resulted from the precipitation (in the **form of varnishes**) of certain denatured fractions of the lubricant.

Hydrodynamic lubrication is essential in such conditions of temperature and speed exchange between components; even a minimal disturbance of this equilibrium (not to mention the partial or total obstruction of nozzles) can compromise the machine’s entire operation.

Here the "normal" tests that were valid for the past Turbosteam turbines, in which the main issue was the presence of large volumes of water (through condensation of the steam itself, due to imperfect seals), which you could avoid by controlling the demulsivity of the oil, are outdated in the predictive management of Turbogas turbines.



Today, instead of waiting for them to settle on the bottom of the tank, causing inevitable oxidative phenomena and several cm of water, we can determine their amount up to a few ppm present in the circulating oil (Karl-Fischer method) and stem the leakages, checking the ΔP of the seals.

In determining Foaming (ASTM-D892) we are confronted with a “photograph” of the current state of a fluid, rather than with the perception of the evolution of its degradation. Moreover, the intrinsic volatility of the method makes it hard to replicate. One might as well observe the real foam flap that forms in certain passages and take note of it, intervening with the appropriate corrective actions.

Unfortunately, the color of the oil (sometimes a very stimulating but subjective perception) cannot be considered a meaningful examination, unless we are operating under controlled conditions (see ASTM-D1500).

SPETTROMETRIA ALL'INFRAROSSO

Con lo spettrometro FT-IR viene determinato lo spettro di assorbimento della luce infrarossa caratteristico dell'olio in esame.



Lo spettro viene analizzato con metodi matematici (messi a punto dall'ente militare statunitense JOAP), ricavando informazioni sulla condizione chimica dell'olio usato, e sulla sua vita utile.

AFFIDABILE, RAPIDA ED ECONOMICA

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More reliable (quick and cheap) is the **Fourier Transform Infrared Spectroscopy (FTIR)**, which performs a multi-parametric scan of the new oil's specific molecular bonds and periodically compares them to the used product.

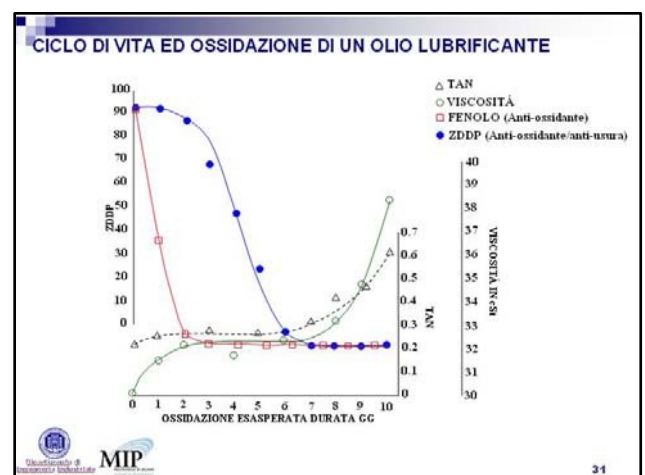
The result is a trend that, particularly with regards to oxidation, is able to extrapolate the real life expectancy of that particular lubricant charge.

In the case that something begins to change, it is possible to observe the correlated **T.A.N.** behavior and maybe

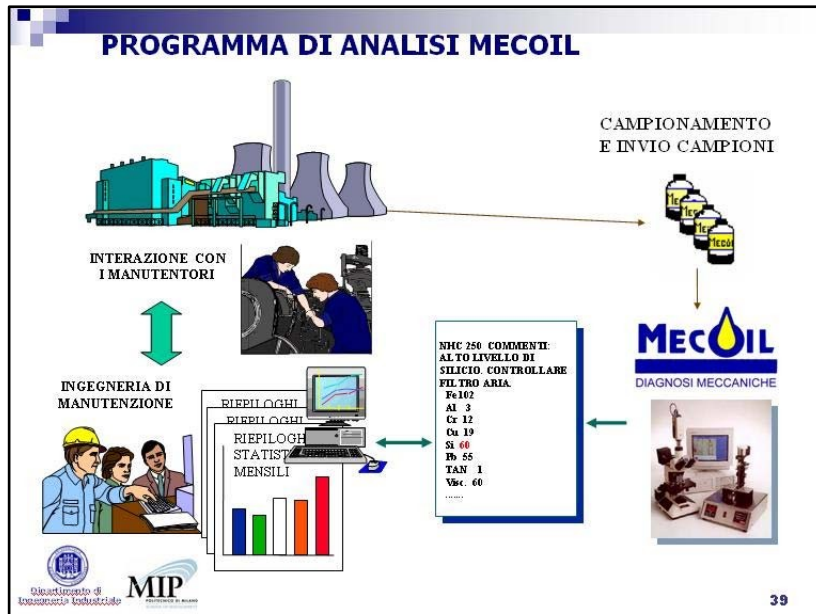
carry out a membrane micro-filtration in order to measure the presence of varnish precursors.

Here, too, the analyses have become “easy”, meaning they allow you to get quick, cheap and thorough answers without having to manipulate large volumes of sample for long periods.

A substantial contribution to prolonging the life expectancy of the machines, through longer operating hours of the charges thanks to the removal of contaminants, was made by the introduction of push filtration systems (commonly referred to as “dialysis”, borrowing terminology from medicine again) with offline oil circulation. The achieved goals, in terms of system cleaning and operational safety, are proportional to the investments in products suitable to operate for long periods, with small continuous volumes, in order to “flush” the lubricant, restoring it to its most suitable conditions.



Conclusions



In the Energy and Manufacturing sectors, **Predictive Oil Analysis** programs are increasingly being used (almost integrated with preexisting insurance policies), to safeguard the integrity of the machines without forgetting that the correct management of oil charges can lead to incredible economic and environmental benefits.

This was a simple discussion about stimulating topics, but we don't claim to have exhausted the topic. We are available for any further explanations on the subject and invite you to visit our website: www.mecoil.net.

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CEO of Mecoil D. Meccaniche Srl

For every “**key word**” highlighted in blue, there is a corresponding panel.

For: MeTim-Dalmine, March 16th, 2007