Monitoil® - Online sensors for efficient and cost saving oil conditions' monitoring

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Abstract
World-class maintenance strategies require an integration between onsite monitoring and online information sharing. This can be applied to all PdM techniques and general performance testing.

When it comes to oil's condition monitoring, the standard approach is to take samples of in-service fluids and send them to an off-site laboratory. Monitoil® is designed to collect parameters from various sensors and mirror these data from the field to a web-connected Datacenter, allowing the revamping of existing assets with non-invasive technologies. Monitoil® can be customized to monitor in-service lubricants in several applications, to collect information about fluid degradation and contamination from the beginning.

Keywords:
Lean Organization, Predictive maintenance, Safety, Efficiency, On-line Monitoring, Sensors.

1 INTRODUCTION

When it comes to oil conditions' assessment and we want to make sure that everything is running under safe circumstances, several "subtle" parameters are involved. Many of these are only perceivable in a dedicated environment (tribological laboratory specialized in used oil analysis) with sophisticated instruments and dedicated technicians. But there are quite a few parameters that can be pinpointed with a certain accuracy and used as "pass or not" early warning test to avoid worsening of the situation. We are referring to "intrusion" of alien liquids not belonging to lubricants' family, like water or coolants in general that are very detrimental to machines' health. At the same time, a premature oxidation, leading to viscosity increment or an excessive amount of sludge can be detected with new generation sensors. Accuracy is reasonable for our purposes; we are not interested in high precision, but we aim to monitor the behaviour of certain trends and we look after that particular 50% (or even more) increase of such data to decide when is the proper time for drawing a sample to be tested off-line in the dedicated laboratory.

Many machines are running constantly (24/7) and they rely upon cooling systems that through dedicated interfaces are responsible to maintain the lubricating properties of circulating oil. If this chain is somehow interrupted or minor leaks are occurring, oil integrity is severely affected and we should be able to pick such (very subtle) phenomena, right before they become "loud signals". There are currently two approaches to determine "what" and "how much" is going on inside an equipment, in terms of online (rugged & compact, though inexpensive) oil sensors.

Dielectric measures and FTIR technologies are both available to give a "hint" of the basic structural (chemistry and physical properties) situation of the running lubricant. Probably a combination of such parameters, with extra input of Viscosity measure (one of the key elements in dynamics of lubrication) can be suitable to fulfil the requirements of a serious manager, during routine maintenance procedures.

On our formerly OMT unit (by now the project name turned to Monitoil®) we initially started with very few parameters to be controlled: Temperature, Particle counting, Pressure and few others to check the quality of lubricants in critical equipments, in industrial facilities. But these items are very seldom affected by serious "wounds" given the extra care provided by dedicated personnel and only the much stressed hydraulic systems are undergoing a certain amount of problems. Usually a modern factory is well ventilated and equipments are installed in proper areas, their tanks & reservoir with important amount of oil well monitored.

1.1 The co-gen world

On the other hand the situation with diesel engines involved in co-generation facilities is totally opposite; these are engines running 24/7 at very high ambient T°C, with different (often the poorest available) quality of fuels, depending on quotations in the energy market.

In these cases the amount of running oil is not large; at the most we can say a total of 100 l and filtration mostly neglected. These units are supposed to work constantly with the same batch of oil, unless off-site analysis carried in external dedicated labs are considering the levels of some parameters too high for safe procedures and ask for "immediate oil/filter change" to remove any risks. All this process may take quite a few days and in our opinion can be helpful and productive, if carried together with a constant monitoring of (at least) the few basic oil properties.

Usually a 24/7 gas engine works for more or less 500 h with the same lubricant (about 20 days). A mid-sized gas engine changes 150 l of lubricant almost every three weeks! Preventive maintenance approach is scheduled by the engine builder, based on operating hours, and it is not tuned on the real oil conditions. By monitoring the actual viscosity value, when there are evident stress processes, technicians could extend the oil life by some days (e.g. 3/4 days). This could resolve in 15 full oil changes/year instead of 18 changes/year. Considering 5€/l (basic cost for product, without labour), we save more than 2250€ per year!

2 WHAT IS THE MONITOIL®

Mecoil Diagnosi Meccaniche s.r.l., with the partnership of several companies, University of Florence, and under the sponsorship of Regione Toscana, has developed a remotely monitored machine, to be constantly "tutored" with numerous sensors or an on-line data collection system. Data are transferred to a web based platform, where decisions are automatically made on how and when is needed a corrective intervention either by human personnel or trough remotely assisted devices.

Monitoil® (Formerly Online Machine Tutor) has been designed as a practical response to increasing demand of assistance and corrective maintenance (only when necessary, based on actual conditions' of the unit) in critical environments where these actions are difficult or expensive.

The outputs from the operating machines are captured by several sensors (i.e. pressures, T°C, Vibrations…) and analyzed through an expert system (Figure 1), that is capable to "remember" previous failures, in order to take proper actions to correct them.

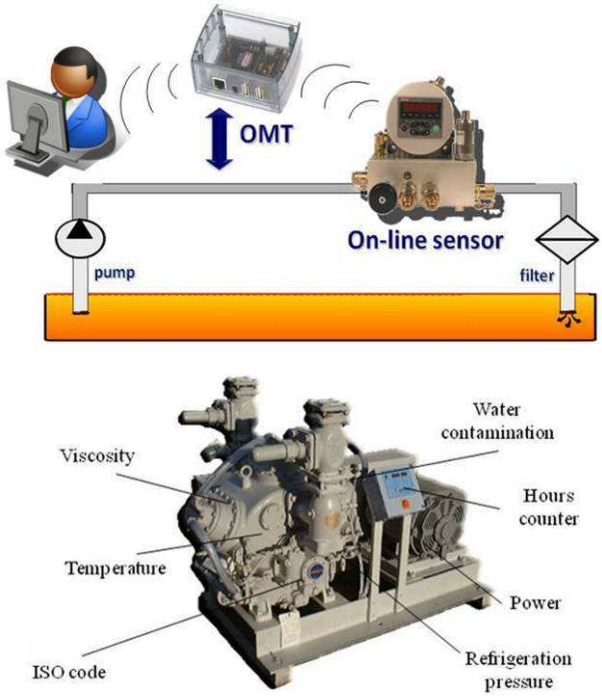

Figure 1: Monitoil® Operating diagram.

One of the clues of this approach is considering that around the world several manufacturers already developed specific sensors (custom made) for their own products. This approach requires custom-tailored assemblies for each single system, with the need to adopt as many sensors/interfaces as the existing equipments installed at a certain plant.

Mecoil has been trying since long to develop such process, by assembling through one single interface, as many items as usually existing in a certain plant. We are looking after a more universal, dedicated revamping of apparently obsolete machines, to give them a new (and more productive) life, with a minimal investment.

3 SYSTEM STRUCTURE AND TECHNICAL SPECIFICATIONS

Monitoil® is contained in an IP67-protected box, enabled for use in dangerous or contaminated environments. The basic system can be connected with up to 8 sensors (input: 0/20 mA or 0/5 V; output) and is equipped with an Ethernet port, for web connection.

Figure 2: Monitoil® Box.

The basic system can be supplied (upon request) with UMTS connection (Figure 2) to safely run in environments where local LAN is not available or with IT security restrictions. Finally, the system can be configured to locally archive data on a micro-SD memory card.

The Monitoil® system (Figure 3) has been developed on a G20 board (by ACME System) and a custom-made Monitoil-Sensor board, fully developed by Mecoil.

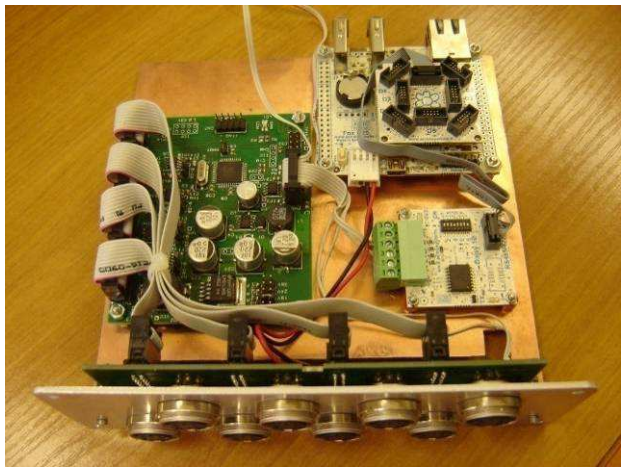

Figure 3: Monitoil® – Internal view.

The G20 board works on a Debian OS, on which the Mecoil-developed Monitoil-Software manages and analyzes data coming from the connected sensors. The Monitoil-Sensor board manages the I/O ports and performs A/D conversion.

The Monitoil® system can be directly connected with up to 8 external sensors, with special connectors. If necessary, the system can be linked to an undefined number of items, by cascading Monitoil-Sensor boards.

The G20 board is then web-connected using the TCP/IP protocol, and works as a full-web mini-server, with a resident local database and worldwide-available internet pages showing the historical data of the monitored machinery.

Via the web interface (Figure 4), the user can set alarm thresholds for the single monitored parameters, or for multi-parametric monitoring (e.g. an alarm is released when two or more limits are simultaneously exceeded). When a defined alarm situation is recorded, Monitoil® is able to send email or SMS text messages to the configured personnel, in order to trigger a survey, a service intervention or other simple tasks (oil sampling,

thermography, etc.). The set limits can be used also to remotely alter the machine's operation (by shutting down the machine, reducing or increasing speed, etc.). The same web interface is used to set single sensors timeout (ms) and update the *Monitoil-Software*.

Figure 4: *Monitoil-Software* – Web page. The increase of yellow line indicate the induced contamination of a different fluid in the system (ester in a mineral oil).

An Artificial Intelligence system is under development, to allow Monitoil® to self-instruct and automatically generate alarm limits, based on the historical data.

4 A MANAGER VIEW

We explained in the previous charter that each Monitoil® has a custom dedicated web page, to show all the trends. The Permantenere software can manage all data transfer, taking care of many different units, under a relatively easy "root" architecture, with proper authorization protocols.

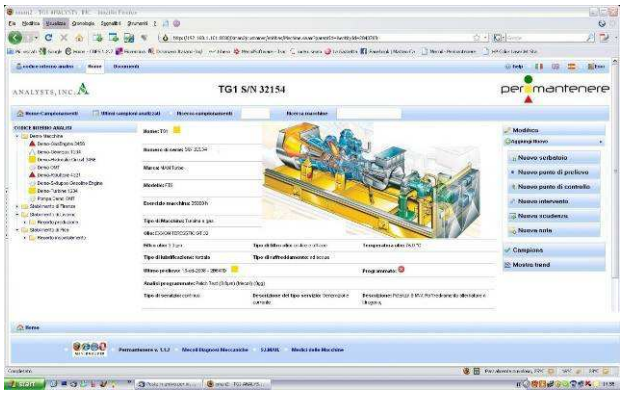

Figure 5: Machine information page in Permantenere software.

Permantenere is an multi-language unsurpassed software system, that allows to share and manage all the diagnostic information on critical assets condition (figure 5). Permantenere enables to manage and organize information coming from different diagnostic monitoring techniques: on-line (Monitoil®) and off-line (Vibration monitoring, Thermography, Ultrasound, Oil analysis). All the results are available in real time through the web, with no need for expensive installation or other actions on the existing customer's assets. By using Permantenere, each customer could manage, develop and archive many different kinds of reports regarding maintenance actions (routine and on-condition).

5 USE CASES

We have installed few systems with different architectures, covering the needs of customized off-line filtration units (Figure 6), hydraulic components in heavily polluted environments and results are very intriguing.

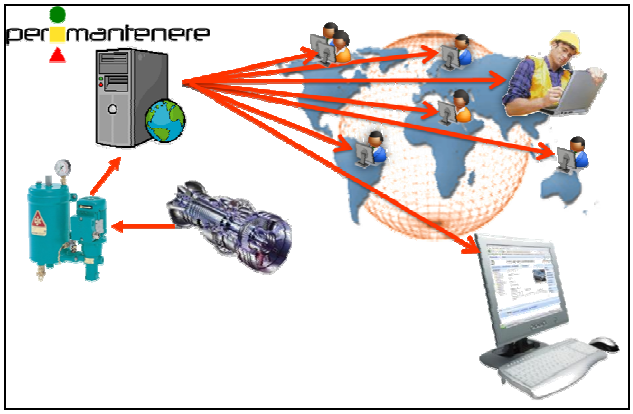

Figure 6: Remote filtration monitoring diagram.

5.1 Monitoil installation on an offline oil filtration cart (OFT: On-line Filter Tutor)

A standard CJC filtration cart was upgraded with the Monitoil® device and sensors, in order to record running hours, ISO and NAS contamination codes upstream and downstream to the filter, water content and differential pressure across the filter, to monitor filter efficiency, together with equipment running temperature. With this system, in the case of high differential pressure across the filter, the filtration cart could automatically be turned off (pump switch on/off) to avoid unnecessary oil pumping through the filter bypass. An alarm message was triggered via web, to warn for the need of filter replacement.

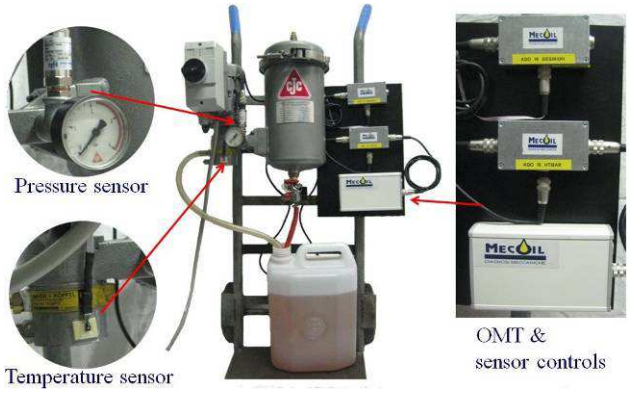

Figure 7: Monitoil® – On-line Filter Tutor

Main OFT capabilities:

- Real time monitoring of particles and moisture allows immediate validation of filtration systems.
- Retrofitting of old filtration units (e.g. remotely controlled coalescing filters for transformer oils).
- Filter condition data (service hours, differential pressure, etc) are easily available on the web, for filtration companies' evaluation and customers' satisfaction.
- The competent personnel can be automatically informed when the filter elements need to be replaced.
- Low cost and flexible, easy to install package.

Figure 8: OFT web page.

6 CONCLUSION

The original OMT project was born a long time ago, as an internal necessity to monitor few of our critical instruments, installed at different customers' sites. From such initiative (maintaining control over a certain machine from far away) we spotted some other potential issues that may eventually become interesting for global industrial surveillance of strategic assets. By now, with increased potentiality to manage several sensors/parameters with very compact box and dedicated web based software we targeted trough Monitoil® system the ability to monitor online co-gen diesel engines that are responsible of a great consumption of lubricants and service efforts to run always at their best.

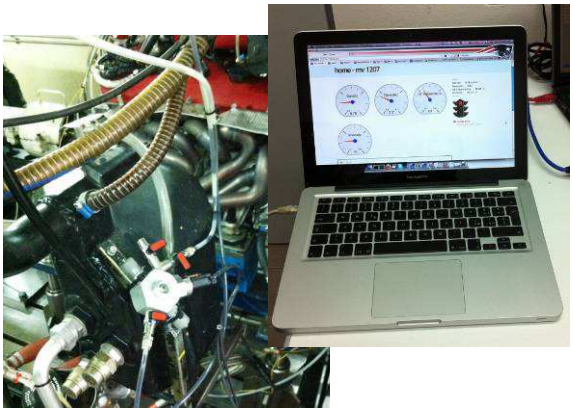

Figure 9: Monitoil® Block plug to the engine.

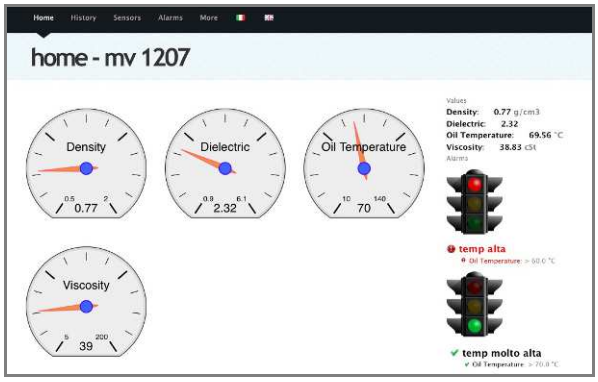

Figure 10: Virtual cockpit with alarm warnings

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