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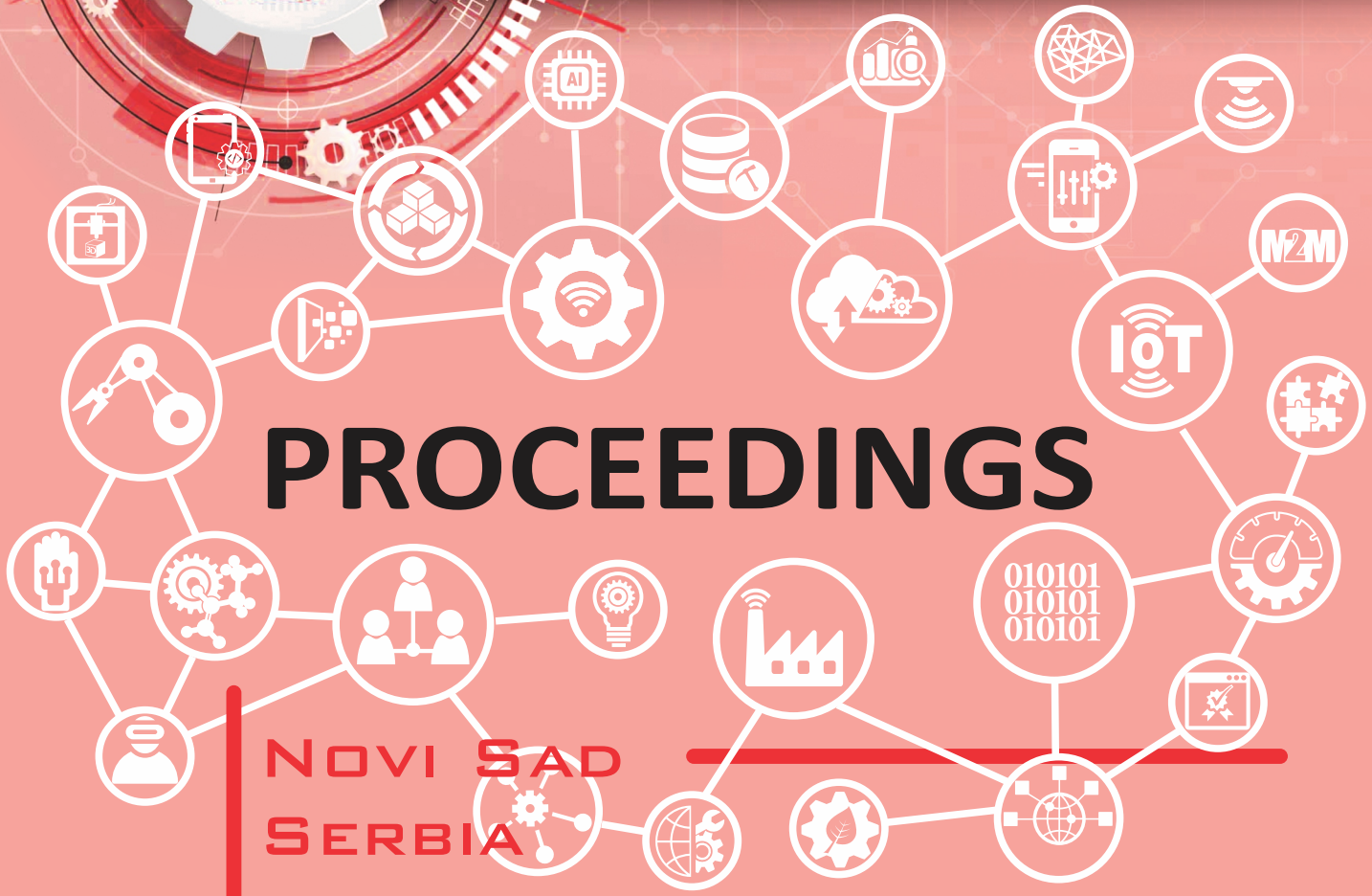
Faculty of Technical Sciences

Department of Production Engineering

13th International Scientific Conference

MMA 2018

Flexible Technologies



PROCEEDINGS

Novi Sad

Serbia

September 28-29, 2018

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FACULTY OF TECHNICAL SCIENCES
DEPARTMENT OF PRODUCTION ENGINEERING
NOVI SAD, SERBIA

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IMPORTANCE OF OFFLINE FILTRATION SYSTEM USE

Abstract: *Any machine which uses mineral oil for power transfer or lubrication is dependent on the condition of the oil. Maintaining oil performance and machine components at their best is therefore vital. System filters are primarily the last line of defence, but are not conducive to achieving optimum oil cleanliness, as pressure shocks will result in the release of a large amount of the particles already retained by the filter insert. However, originally installed (suction, pressure, return) filters are still important as last chance inline filters. Secondary oil filtration is ideal for ensuring the lowest possible degree of contamination in the system, e.g. to achieve a specific level of oil cleanliness. Because an secondary filter circuit works independently of the hydraulic or any other oil lubrication system, its level of efficiency remains constant –in any situation of system operation. This paper will present reasons that justify use of an secondary filtration system.*
Key words: *Contamination control, secondary filtration systems, lubricating oil, maintenance*

1. INTRODUCTION

Condition and proper treatment of the hydraulic, engine, gear, turbine or any other type of oil, have a great influence on machine working performances, its service life but also the lifetime of the oil itself [1].

Important oil conditioning techniques are: condition monitoring, solid particles filtration, dewatering, degassing, varnish removal and system temperature control. What kind of conditioning techniques will be applied depends on the conditions of exploitation, environment conditions, machine complexity, etc. It has been proven that significant number of machine failures is related to wear caused oil contamination with solid particles [2-4], which puts particles filtration on the first place as an oil conditioning technique.

Irrespective of where it is applied, filtration could be as primary (screening) and secondary (cleaning). Primary filtration is intended to protect the equipment and it is usually installed by the Original Equipment Manufacturers (OEM). This type of filtration needs to assure full fluid flow with minimal flow resistance and to retain rough solid particles. Therefore, this kind of filtering is called screening. Its purpose is not to maintain the oil clean, but to extract large solid particles or other foreign bodies which can cause great damage to the equipment and instantaneous loss of operating function (movement blockage or breakage of moving elements, blockage of flow channels, increase of friction or energy consumption). In order to fulfill these requirements and to provide pressure drop as small as possible, screening filters have short flowing paths, and filter media is very porous.

On the other hand, secondary filtration systems are designed to extend the equipment service life, by separating finer particles, to the level determined by the most critical component which have clearances from 1 to 10 $\mu m_{(c)}$ (hydraulic servo and proportional valves, pumps, bearings, etc.). Except causing wear of components, friction and energy consumption increase, this particles acting as catalysts of lubricant physical and chemical degradation processes [5]. This strongly influences overall machine performances and service life of the machine and components. Original Equipment Manufacturers (OEM) rarely include, secondary filtration systems, which is why they are mainly sold as an accessory.

Controlling the lubricant level of contaminants by filtration, allows significant prolongation of its service life [6,7], which can significantly affect the amount of waste oil produced, the costs of its storage, transport and disposal on an annual basis [7].

2. OFFLINE FILTERING SYSTEM COMPOSITION AND CONSTRUCTION

According to the principle of operation, secondary filtration systems can be compared with the work of kidneys and dialysis devices. The secondary filtration system has its own pump and a separate circulation circuit, so it operates independently of the system whose oil is filtered (Figure 1), which is why it is also called the offline filtration system. This means that it can be stopped at any time for a filter element change without interrupting operations.

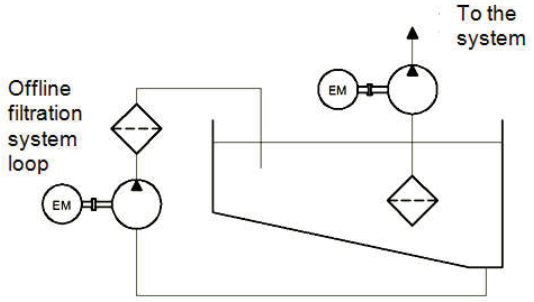

Figure 1. Offline filtering system scheme

Offline filtering systems can be divided into mobile and stationary. Systems are mobile if their task is to

serve multiple machines, regardless of which volume or oil type is filtered, while stationary filtration systems are specifically designed to serve only one machine.

The complexity of the offline filtration system varies depending on the needs, but essentially all consist of basic elements such as: supporting structure (metal frame), electric motor, pump, filter (low-pressure housing and filter insert), saturation indicator and hoses for connection (Figure 2).

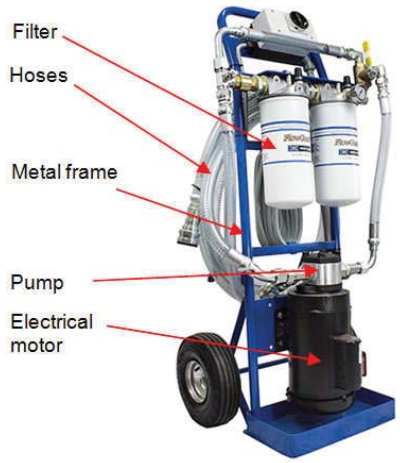

Figure 2. Typical mobile offline filtering system (Des-Case)

In addition to the above mentioned basic elements, the filtering system can be upgraded with filters specifically designed for water extraction, filters for the varnish removal, vacuum system for air extraction or heating and cooling system. Its expansion also includes the installation of systems and sensors for monitoring the level of contamination during filtering.

As filter inserts in offline system, high-capacity filters are used, with small porosity and long flow path with absolute degree of separation of particles smaller than 10 $\mu m_{(c)}$. Secondary filtration beta factor, which stands for particulate removal efficiency (according to multi-pass test procedure - ISO 16889:1999), should not be lower than 200. However, performance of installed filters can variate, and depend on condition of system and the environment.

Pumps used in offline filtration systems are vane or gear pumps, and the choice depends on the operating viscosity of the oil to be filtered. The vane pumps can be used for fluids whose working viscosity is within the range of values from 15 to ~ 490 mm^2/s, while gear pumps are used for fluids with viscosity up to 1000 mm^2/s. Offline filtration system pumps are working with low pressures (up to p = 10 bar). This eliminates or at least minimize the risk of hydraulic shocks appearance that could damage the filters and reduce its efficiency in retaining impurities. As far as the pump capacity is concerned, it varies depending on the application of the filtration system and moves within the range of values from 5 to 100 l/min for mobile offline systems, and over 100 l/min for stationary filtering systems.

System design varies depending on the needs of the end user. An example of the simplest structure of the offline filtration system is shown in Figure 3.

The complexity of the filtration system construction increases as the higher demands are set, such as the requirement for the existence of a sensor that monitors the level of contamination during the filtration process (Figure 4).

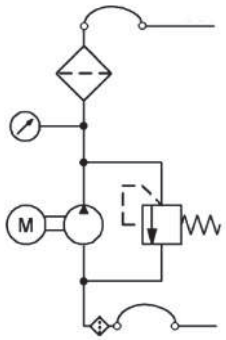

Figure 3. Usual offline filtering system hydraulic circuit

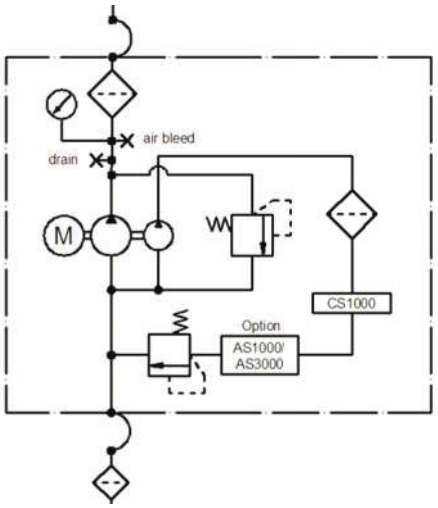

Figure 4. Example of an offline filtration system with APC sensor [8]

Presence of the Automatic Particle Counter (APC) make filtration system efficiency monitoring easier and increases reliability in the offline filtration system results. There are recommendations for specific applications where exist the risk of water contamination and mixing of water and lubricant (marine and offshore applications, turbine machines, etc.) to use offline filtration systems which have dewatering filters. Water separation can be done with coalescence filters, absorbent filters, centrifugal process or vacuum chambers. Figure 5. shows the system which have coalescent filter for water retention.

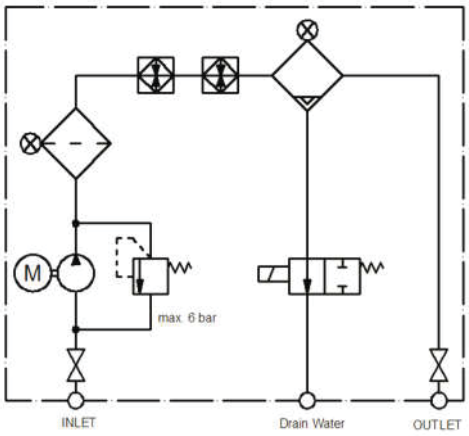

Figure 5. Example of an offline filtration system with coalescing filter for water removal [8]

3. REASONS FOR USE

First of all, offline filtration system should not be purchased before the level of fluid contamination is established. In order to calculate cost-effectiveness of the investment in offline filtration system implementation, one should know parameters such as: contamination level, machine downtime costs, costs of changing the oil and filters with new one, costs of old lubricant and filters disposal, labor costs, etc. Without this, implementation of the offline filtration system, will not do any harm to the machine, but it could be just an unnecessary waste of money (especially when applying filtration treatment on oil which is chemically and physically depleted). Trough the practice, there is a lot of cases where was noted misusing of the offline filtration systems in Serbia. In most cases offline filtration program, where it should be, is not used at all.

One of the reasons for the offline filtration systems utilization, as it was mentioned before, is that filtering systems installed by machine manufacturer (suction and return-line filters), are usualy designed to detain rough dirty particles thereby preventing damage to the pumps, or other components that are sensitive to the presence of the same. Those system filters are always a compromise between flow rates, linear velocity, viscosity, contamination, system pressure, pressure drop, dirt-holding capacity, physical size, accessibility and cost [9]. Offline filters are not governed by system requirements as they operate independently from the system. Therefore, operators have many options for filters, their capacity, media and micron ratings.

As for in-line pressure filters, they can be designed to extract particles $\leq 10\ \mu m_{(c)}$, but it affects flow restriction to a level that would deny the equipment proper lubrication. In addition, they have low capacity, and as pressure shocks caused by stop/start of the main pump will result in the release of a large amount of the particles already retained by the filter insert.

The biggest reason to filter oil by offline filtration is to maximize the return on the investment in the oil and to extend equipment life.

Filter system selection must follow a thorough analysis of the system constraints and a clear definition of the task objectives. Following questions could be very helpful when determining elements of the offline filtration system:

- What is the tank volume?
- What will the fluid viscosity be during filtration?
- What is the initial and what is the targeted cleanliness level?

It is highly recommended to use offline filtering systems where the consequences of contaminated oil are high (wind turbines, steam and gas turbines, rolling mills, paper machines, et cetera). Utilization of the offline filtering provides:

- Removal of oil aging products, solid particles and water,
- Continuous maintenance of desired lubrication oil cleanliness level,
- High contamination retention capacity,
- Optimal protection of oil system components,
- Avoiding expenses on flushing and manual cleaning of oil tank and other components,
- Reducing the load on in-line pressure filters,
- Reduce the number of equipment downtimes,
- Increase equipment availability and operational reliability,
- Lowering costs for service and maintenance, etc.

4. OFFLINE FILTERING SYSTEM APPLICATIONS

There are various applications of the offline filtration system usage (Figure 6). Except filtration, offline systems could be used as following: flushing (flushing of the system, pipes, tanks or any other system component), reservoir draining, oil transferring, stored oil cleaning, etc. Power flush involves reducing the oil level in a tank or sump and flowing the oil at a high velocity across the bottom to push out low-lying sediment. Wand flush implies that wand which is attached to one of the cart hoses, is used first to discharge at high pressure (kicking up adherent debris). Then the flow is reversed and the wand vacuums the sediments. Transfer cart is application where oil is transferred from a storage container to the machine's lube compartment or reverse. Another application is the cleaning stored lubricants. The cart multipasses fluid out of and back into the drum to drawdown contamination. Sump and reservoir drains will wash out debris better if the waste oil is pumped out as opposed to simply flowing out by gravity. Line or hose flush is another application where filter cart is used for cleaning.

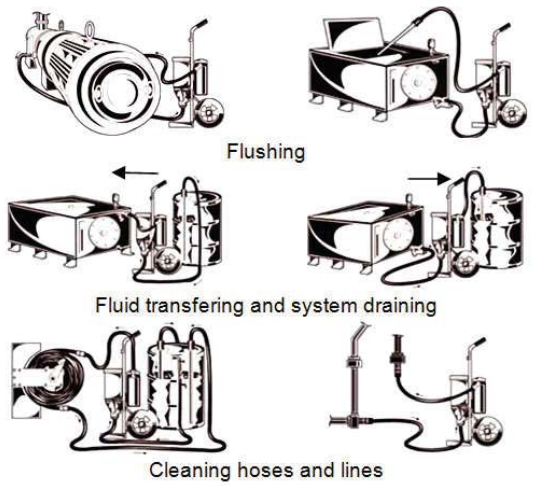

Figure 6. Applications for filter carts [10]

5. CONCLUSION

Primary filtration will help protect the equipment investment whereas secondary filtration helps to maximize the return on the equipment and oil investment. Because it extends useful life of oil and the machinery, filtration helps the environmental protection. With the continued rise in equipment costs, machine downtime costs and oil replacement costs, adding offline filtration to equipment can be very smart decision for the equipment owner.

Offline filtration systems utilizes low-pressure filters that are easily accessible and serviceable. This type of filtration significantly reduces risk of releasing previously retained impurities due to low pressure oscillations in offline filtering circuit. Using of secondary filtration systems guarantees optimum protection of machine components, and provides higher level of reliability.

In order to be economical and rational, before utilization of the offline filtration, oil analysis must be performed. Only then, the technicians will know the right moment when the application of the offline filtration is appropriate, otherwise it could be a waste of money.

6. REFERENCES

[1] Botly, J.: *Engine filtration: Effective maintenance is the key to optimal performance*, Filtration+Separation, November/December, pp. 22-24, 2010.
[2] Battat, B., Babcock, W.: *Understanding and reducing the effects of contamination on hydraulic fluids and systems*, The AMPTIAC Quaterly, Vol. 7, No. 1, pp. 11-15, 2003.
[3] Kumar, M., Mukherjee, P.S., Misra, N.M.: *Advancement and current status of wear debris analysis for machine condition monitoring: a review*, Industrial lubrication and tribology, Vol. 65, No. 1, pp. 3-11, 2013.
[4] Nash, T.: *Filtration: It's the little things that get you*, Hydraulics and Pneumatics, No. 5, pp. 29-31, 2006.
[5] Karanović, V., Jocanović, M., Orošnjak, M.: *Condition Monitoring of Hydraulic Machinery by Oil Analysis*, Proceedings of PSU-UNS International Conference on Engineering and Technology - ICET, pp. 1-4, Novi Sad, Serbia, Faculty of Technical Sciences, June, 2017.
[6] Hydraulic fluids: Controlling contamination in hydraulic fluids, Filtration & Separation, Volume 47, Issue 3, May–June 2010, pp. 28-30
[7] Sutherland, K.: *Filters and Filtration Handbook - Sections 5 D, E*, Elsevier, Oxford, 2008.
[8] Hydac International, *Filter Systems – Product Catalogue*, Sulzbach/Saar Germany, 2016.
[9] Khonsari, M., Booser, E.R.: *How to Match Oil Filtration to Machine Requirements*, Machinery lubrication, No. 11, 2006.
[10] Cooper, D., Perez, R.: *Onsite Portable Filtration Case Study*, Practicing Oil Analysis, No. 5, 2002.

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