POLLUTION HYDRAULIC FLUIDS ANALYSIS BY THE DIFFERENTIAL PRESSURE FILTERS EVOLUTION

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This work aims at characterizing the behavior of the hydraulic filters used to reduce the polluting particles contained in the hydraulic systems working to high pressure, live with aim at the pollution of the fluid employed. By analyzing the cause of the hydraulic installations breakdowns, one notes that they are caused in most of the cases by the hydraulic fluid which exceeds a threshold of pollution following or not a suitable insufficient filtration.

An analysis of pollution was carried out on the level of two filters on a hydraulic system (one on the discharge pipe whose pressure is about 250 bar with an element filtering of mesh x=15 µm and a second on the return line towards the tank subjected to a pressure P = 10 bar, having dimension meshes x = 25 µm).

This study is based on the analysis of the effectiveness, the rate of separation as well as the degree of retention of these two hydraulic filters (pressure filter and that of return) of a hydraulic system on the level of the hot rolling mill to iron and steel complex ARCELOR MITTAL in Algeria .

In addition, our study is based on the method of the oils analysis by the electronic counting of the particles according to the standards (NAS 1638), and detect the relation which exists between the number of the selected particles and the differential pressure, as well as the frequency of each filter filling.

Keywords:maintenance – oils analysis - hydraulic filters - pollution

1. Introduction

The principle of the conditional preventive maintenance consists in defining parameters characteristic of the equipment health, and supervising their evolution periodically in order to program the preventive interventions at the optimum time.

Oil analysis is a new tool of progress at the disposal of the persons in charge for service maintenance in the companies, the results of oils analysis make it possible to detect the anomalies characteristics of dangerous breakdowns (the case of the hydraulic systems) also making it possible to establish a strategy of

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predictive maintenance to anticipate the breakdown and management "at best" the oils renewal.

An effective filtration protects the hydraulic systems against the breakdowns, and increases simultaneously the life of the expensive and strategic components. Therefore a bad filtration has as consequences:

- An increase in escapes;
- Seizing of the drawers of the valves;
- The valves opening and switching delay;
- Destruction and modification of valves characteristics.

Thus the purpose of the hydraulic filters is to reduce the level of the fluid pollution and to preserve a value of the more or less acceptable degree of purity in order to protect the components from the hydraulic system [1]. Therefore, it is preferable to install a filter of pressure which is generally assembled, in the flow of the fluid on the discharge pipe of the hydraulic pump. It is installed, generally before the piloting or the regulation apparatus. It has advantages such as [2,3]: the pressure loss being indifferent, the filter meshes can be very fine (15µm in our case). All the circuit will thus be protected except for the pump. The installation of another filter on the return line of the hydraulic system is essential in order to eliminate the polluting particles turned over to the tank and which will be aspired by the pump; one can regard this filter as a protection of the pump.

The classification of the hydraulic oils pollution degree [4-5-6] is based on the particles number of different sizes contained in this oil, knowing that new oil always contains polluting particles in suspension, with a more or less significant quantity.

Generally the hydraulic system contains also particles coming from the bad sealing. To maintain the correct operation of a hydraulic installation, it is necessary that the used oil preserves its initial characteristics which must be constant or stable, such as; the level of cleanliness and the normal temperature.

Three plans which will be thereafter the subject of a thorough study: filtration, cooling and reheating of the hydraulic fluids) play a very significant role in oils maintenance.

2. Experimental study in hydraulics of pollution oils:

2-1. Material used:

2-1-a- Electronic System of particles counting

It gives the particles number (Fig. 1) of size: (5:15) µm, (15:25) µm, (25:50) µm, as well as the evaluation of the purity classes in accordance with the standard: ISO 4406:99, ISO 4406:87 and NAS 1638.

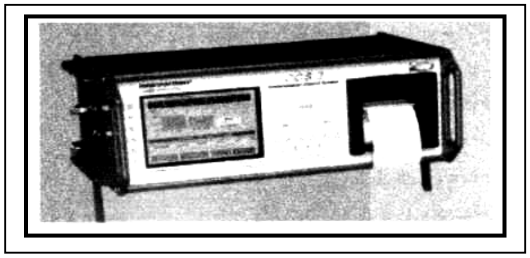

Fig. 1: Radiation counter on line with laser detector CCS2

2-1-b- Hydraulic filters of different size

A filter installed between the pump and the hydraulic motor (jack) is used in this study, and another after the jack (on the return line towards the hydraulic tank) of the same circuit, whose mesh size for each one is 15 µm and 25 µm respectively. (a control of by-pass equipped with a non-return valve is installed in parallel with each filter to protect the filters in the event of filling).

2-1-c- A differential pressure gauge

To allow the measurement of the differential pressure or the pressure loss generated by the particles polluting the level of each filter (the pressure difference in oil hydraulic before and after each filter).

-2. Principle of measurements

The principle of the tests according to Fig. 2 is based on the measurement using a CCS system, of the particles number before and after each filter, and one takes each time the value of the differential pressure (Δ P) indicated on the differential pressure gauge.

According to the cards of analysis delivered by system CCS one calculates the number of retained particles *Nr* on the level of each filter [7] in the following way:

$$Nr = Ne - Ns \quad (1)$$

With: *Ne*: The number of the particle contained in oil before the filter.
Ns: The number of the particles contained in oil after the filter.

In addition, one calculates the holding capacity of each filter in the following way:

$$\beta x = Ne / Ns \quad (2)$$

where *Ne* and *Ns* represent the number of particles before and after each filter whose dimensions are higher or equal to the average meshes diameter *x* of the filtering element of the filter. One can deduct the degree from filter retention by the following expression:

$$D = ((\beta x - 1) / \beta x).100 \quad (3)$$

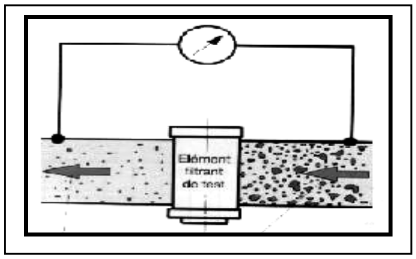

Fig. 2. Measure pressure loss on the level of the filter

2-3. Obtained results:

The tests were carried out under normal operation conditions, the results obtained are given in Table1 and Table 2 for each filter.

2-3-a. For the pressure filter (210 bar, 15 µm):

Table 1

Counting of the particles on the pressure filter: 210 bar, 15µm

N°	(h)	N^{bre} of particles by 100 ml						Particles selected	Δ P (bar)
		Entry filter			Exit filter				
		5 : 15 µm	15:25 µm	25:50 µm	5 : 15 µm	15:25 µm	25:50 µm		
1	0	28420	2750	920	13470	1160	300	2210	1.15
2	75	13270	1300	330	5510	380	80	3380	1.40
3	125	21890	2470	2830	13930	1650	620	4410	1.70
4	170	13320	6820	10980	33570	3870	1570	16770	2.20
5	325	11940	5220	6750	22070	2220	830	25690	2.20

2-3-b. For the return filter (10 bar, 25 µm):

Table 2

Counting of the particles on the return filter: 10 bar, 25ìm.

N°	(h)	N^{bre} of particles by 100 ml						Particles selected	Δ P (bar)
		Entry filter			Exit filter				
		5 :15 µm	15:25 µm	25:50 µm	5:15 µm	15:25 µm	25:50 µm		
1	0	42940	7190	6670	43780	5680	3810	2860	0.50
2	75	74880	8580	7600	48000	6810	5540	4920	0.78
3	125	148930	11950	6070	77690	6010	3390	7600	1.20
4	170	115340	7850	4530	83630	6130	4160	7970	1.80
5	325	23460	3370	2760	26460	2900	2190	8540	0.30

3. Analysis of the results:

3.1. The differential pressure parameter (**ΔP**)

This parameter is very significant and characterizes the pressure loss in the filter. This is due to the fact that its increase causes the filter obstruction by the increase of the maintained number of particles. It is a good conditional maintenance indicator.

The obtained results are in good agreement with the theory [1], the differential pressure parameter **(ΔP)** increases with the increase of the maintained (stopped) number of particles in the filter. Furthermore, this number increases with the increase of the operating time as shown in Fig.3 and Fig.4. For that reason, we worked with the number of cumulated particles which gives an idea on the filling degree evolution which is necessary to determine a cleaning program or to carry out a filter change if necessary.

In addition, it can be seen clearly that the differential pressure parameter increases abruptly for a filter of small meshes (pressure filter with 15 μm). When the filter on the return line (with 25 μm) manages to separate a number of particle from the order 7970 (see Fig. 4) the differential pressure becomes significant and remains capable to actuate the safety non-return valve, which in its turn lets the fluid without filtering pass (it is a safety condition).

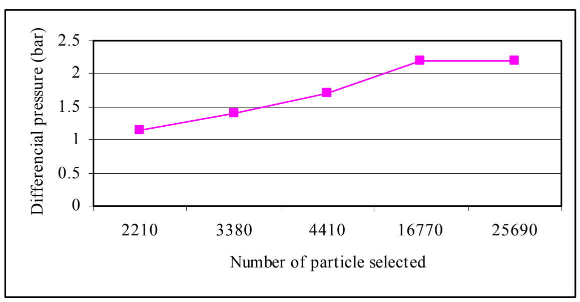

Fig.3. Differential pressure of the pressure filter 15 μm .

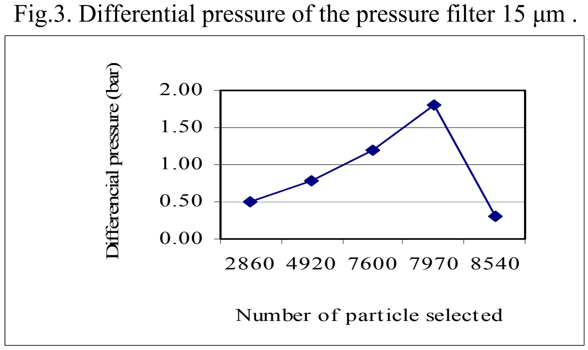

Fig.4. Differential pressure of the return filter 25 μm.

3-2. The filter separation (retention) rate

The filter effectiveness measurement consists in comparing the number of particles of a given size before and after the filter [3]. The maintained number does not really characterize the filter effectiveness, because if the number at the entry is significant, the number maintained becomes also significant.

For calculating the retention rate **D** for each filter, it is necessary that one determines the separation capacity of the polluting particles β_x. According to our results, one can affirm that β_x increases with the increase of the polluting particles size in the fluid (see table 3). This may be explained by the obtained results which confirm that the separation capacity of the particles becomes better if the filter meshes elements are very small (Fig. 5).

According to standards, the separation filter is considered to be acceptable if the separation capacity β_x becomes higher or equal to two ($\beta_x \geq 2$). For that, the operation of the filter on the discharge pipe in our hydraulic system is normal (β_{15} in all the phases of the tests is higher than **2**). Thus D is higher than 50%, and then the pressure filter is well adapted.

Table.3

Holding capacity β_x

N°	t; (h)	βx =Ne/Ns	
		Pressure filter	**Return filter**
		x ≥15 µm	**x ≥25 µm**
1	0	3.07	1.46
2	75	4.13	1.31
3	125	4.56	1.92
4	170	6.99	1.20
5	325	8.13	1.20

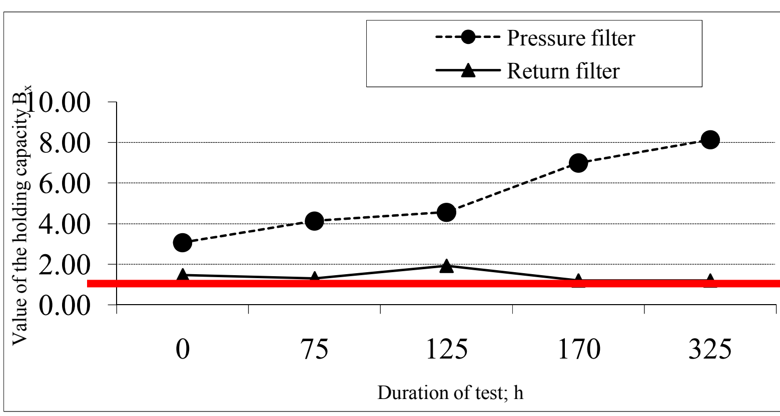

Fig.5. Evolution of the holding capacity.

A value of $\boldsymbol{\beta_x}$ lower than two means that the separation of the particles is insufficient (Fig.5), or the existence of an obstruction (stopping) in the filter, the flow of the fluid is ensured through the safety tube installed in derivation of the filter and which is equipped with a non-return valve causing a reduced pressure loss ΔP.

3-3. Relation between the capacity β_x and the retention rate D

The analysis of the previous results is carried out while following the evolution of the holding capacity β_x (*Table.4*), as it can be also carried out based on the analysis of the retention rate evolution D. The same results are obtained without any change (see figure 6), because these two parameters are generally linked by an appreciably linear relation (**D** increases with the increase in $\boldsymbol{\beta_x}$).

Table. 4

Degree of retention according to $\boldsymbol{\beta_x}$

N° of test	Pressure filter (15 μm)		Return filter (25 μm)	
	β_{15}	D (%)	β_{25}	D (%)
1	3.07	67.43	1.46	31.51
2	4.13	75.79	1.31	23.66
3	4.56	78.07	1.92	47.92
4	6.99	85.69	1.20	16.67
5	8.13	87.70	1.20	16.67

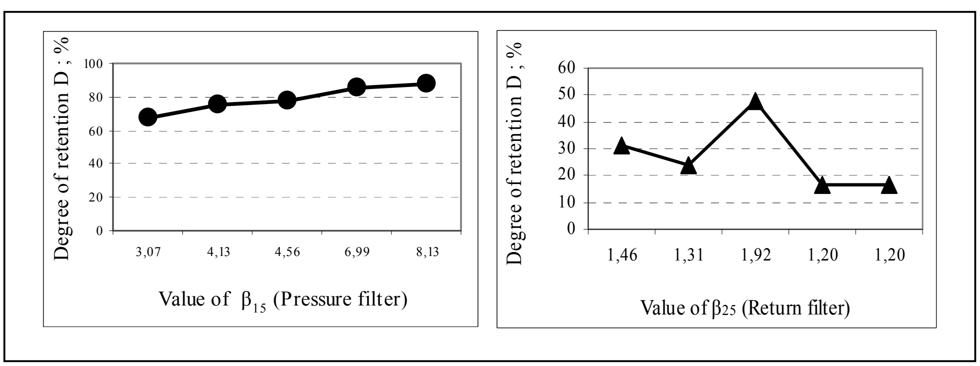

Fig. 6. Relation between the degree and the capacity holding.

4. Conclusion

Oils analysis constitutes a powerful tool in order to know the state of the machine components, even the lubricant state. Good information leads to a good decision.

Therefore, the so-called oils analysis tool is intended to be used by the people in charge for maintenance and for production, as well as by the engineers who wish to know the bases of the oils analysis, and those who want to make this tool profitable.

Up to now, we managed to get answers for several expected questions such as: for which and what oils analysis will be used? It should also be noted that we are indirectly involved in the periodicity or the frequency analysis of oil, bearing in mind that while the installation is operating, the fluid conveys a significant quantity of particles which the filter collects. Thus, it becomes necessary that this filter should be controlled at the installation starting time and cleaned or replaced if necessary in order to avoid the sudden increase in the pressure los. For that reason this thorough study of the filter differential pressure as well as the fluid separation rate has been done.

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