ONLINE QUALITY CONTROL FILTERATION SYSTEM USED IN HYDRAULIC OIL PROCESS

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Abstract

Machinery is a chain of parts working and moving against one another to accomplish a manufacturing job; as a result, friction is inevitable leading to excessive heat and damaging machine components. Therefore, lubrication must be applied to lengthen the life of the machine and reduce the breakdowns; as well as, it prevents corrosion by protecting the surface from water and other corrosive substances, it transports contaminants to filters to be cleaned, and it controls temperature by absorbing heat from surfaces and transferring it to a point of lower temperature where it can be dissipated.

An intelligent efficient online testing and filtering system has been built and developed. In this system examines the cleanliness of the hydraulic oil and digitally displays its contamination level. The oil will circulate in the system and at every cycle, the system will automatically filter the oil toward the desired cleanliness level. The key advantage of this work is its ability to achieve a remarkable improvement in oil cleanliness, and to extend oil lifelength. The experiment is carried out online without stopping the hydraulic system which saves time and reduces cost.

Keywords: Hydraulic oil, filteration system, oil cleanliness, oil contamination

Introduction

The hydraulic oil used as lubricants for a hydraulic system face many problems like: oil heating, slow operation, oil leakage, corrosion, rod sticking and tube exploding. However, there are three easily detectable alarming indications that give early warning of root cause conditions. These symptoms are abnormal noise, caused by aeration or cavitations, high fluid temperature damaging seals and accelerating fluid degradation and slow operation manifested in reduction in the flow. (Casey Brandan)

Furthermore, lack of experience in dealing with hydraulic systems, has resulted in some commong mistakes that could be summarized as follows:

Changing the oil, two conditions necessitate an oil change are as follows: degradation of the base oil and depletion of the additive package.

Running too hot leads to destroying hydraulic components, seals, hoses and the oil itself. It depends on the viscosity - and viscosity index. As the oil's temperature increases its viscosity decreases.

Using the Wrong Oil, if oil with a viscosity that's too high for the climate, the machine has to operate in is used, the oil won't flow properly or lubricate adequately during cold start.

Wrong Filter Locations to-be-avoided are the pump inlet, piston pump and motor case

Running System to Failure, When hydraulic component fails, large amounts of metallic particles are generated. These particles circulate in the hydraulic fluid, often causing damage to other components before the system`s filters can remove them.

Changing the filters, change filters when all their dirt-holding capacity is used up - but before the bypass valve opens. This requires a mechanism to monitor the restriction to flow (pressure drop) across the filter element and give alert when this point is reached.

Oil analysis is an indicator of oil contamination; inspection can be both visually (color, emulsion, free water) and troubleshooting as in oil analysis. Some of tests used to assess lubricants physical properties and to detect contaminants are as follows: viscosity measurements, oil oxidation or oil acidity, water content, particle counts and Machine wear analysis (Ardison Oils)

Contamination in lubricating oils is the root cause of premature oil degradation and accelerated wear of machine components. Dirt, debris, and water often enter equipment lubrication through vents, lubricators, and seals during normal equipment usage and maintenance. Prevention and control of contamination is often the most reliable means of preventing equipment failures and prolonging equipments life. There are four types of filtration systems considered as a necessity to reduce contamination and expenses. They are as follows: centrifugal filtration, pressure filtration, magnetic filtration, and depth filtration (Finex 2009)

Various studies were carried out in using filtration systems to improve the quality of hydraulic oil. Wang, (Wang 2012) has conducted a case study of condition based maintenance modelling based upon the oil analysis of diesel engines using stochastic filtering. While Finex, (Finex 2009) discussed the installation of self-cleaning filters to help cleaning debris from mixers before liquid fuel was pumped into tankers, resulting in increased productivity and a safter working environment for operators. The filters have alos significantly improved the final quality of the liquid fuel product.

Parker Arton (Parker 2003) has introduced another new system designed to prevent breakdowns in hydraulic systems, the MGSB filter. The company claims that approximatly 80% of hydraulic system breakdowns are caused by oil contamination and that efficient filtering processes will help to cut the cost of maintenance and ownership for end users. Others, such as Madulkar, (Mahulkar 2011) worked on the application of derivative free filtering in hydraulic systems for the purpose of real-time fault identificaiton. The paper dealt with internal leakage faults. Also, Krause, (Krause 1979) has assessed microfilter of engine oils applying a filtering test rig. The economic aspects of microfilternig are discussed in the light of results obtained from the test rig and from service applications.

Exerpimental System Setup

In this study, a new filtration system has been introduced. This system is made with an oil cleanliness testing machine according to ISO 4406 that tests the cleanliness of the oil and then filters it until the desired cleanliness is achieved. This can be done in two ways: online or offline. The system is composed of:

Filter: A depth-filtration type filter provides efficient contamination removal down to 1 micron particles size which makes it able to decrease sudden breakdowns caused by oil contamination that usually ends up with hydraulic system stoppage, refere to figure 1.

Figure 1 - Gulf Coast 01 oil filter

This filter removes moisture down to 40 ppm preventing the corrosion of the steel parts of the hydraulic system and the fuel viscosity will be maintained at the desired level. Furthermore, the ability of this filter to remove oil bubbles decreases the chance of oil over-heating caused by improper lubrication due interaction between oil and air also it decreases the chance of oil leakage caused by diesel effect of air bubbles compressed under pressures.

The power of filter in removing solid, water, air bubbles from oil reduces the chance of sludge and varnish formation which usually lead to slow operation and decrease in hydraulic system efficiency. The maximum working pressure held by the filter is 6 bar which is not of that importance with respect fluid flow since the filter will be installed as a “by pass” filter connected to the oil reservoir and will not interfere with the normal fluid flow. It has a maximum flow rate of 1.89 liters/minute which makes it fast in filtering the hydraulic system oil reservoir .It is light weighted, which makes it easy to be fit on the portable filtration system. The filter has standard Inlet/outlet connections that makes it easily connected. This filter is able to clean the oil of a 1000L oil reservoir. The filter is located 40 cm above the pump connected with a straight hosepipe to allow easy oil flow and prevent bubble formation that usually results from non -straight hoses. the filter inlet/outlet are 0.4 inches while pump inlet/outlet are 1 inch, for that reason a size-converting connection and tap have been added to control the fluid flow and make sure the filter is not receiving more than its capacity “1.89” liters/min.

Reservoir: A 10 liters reservoir (refer to figure 2) is added to the system as an extra container to facilitate the online oil filtering without stopping the operation of the hydraulic system. This reservoir is used to keep the flow rate of the hydraulic oil constant during operation, avoiding the possibility that oil level flow might be reduced to slow down due to filtration. The reservoir is located 50 cm directly above the pump to speed up the fluid flow.

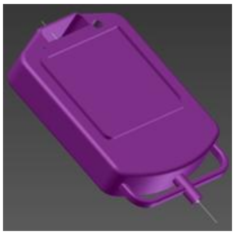

Figure 2 - 10 liter oil reservoir, where oil will be poured to be pumped to the filter and the cleanliness test machine, and then back to the reservoir.

Pump: A ½ horse power pedrollo pump, as shown in Figure 3, is used to circulate the oil throughout the system. It has the following specifications, as displayed in table 1.

Model	HP	Discharge Pressure (Bar)	Suction Lift In Cm 13	40	65
			Liters/minute (LPM)		
JSWX05F16P 115/230 Volts	1/2	2	45	40	30
		3	30	25	20
		4	20	14	10
		5	8	**4**	0

Table 1 - pump specifications

The maximum pressure of the pump is “5 bar”, which is; for safety reason, less than the maximum pressure held by the filter, which is “6 bar”. Following the pump specifications, the filter was placed 40cm above the pump. Thus, resulting in a flow rate of 4 liters/min which is considered more than the flow required by the filter.

Figure 3 – Pedrollo Pump

Particle Counter: Particle Counter ROC-61 is located above the filter, (refer to figure 4), and is used to test and to monitor oil cleanliness level online and count the oil contaminants through laser technology. It works when the oil enters its hose-pipe with a specific flow rates. It gives the new cleanliness level of the oil every 3 minutes. Also it gives warning signs for: rise in contamination, component wear, filter and seal failure, water ingress, oil oxidation, cavitations through codes that appear on the screen and defined in its catalogue. The benefits of this machine is: low cost, compact, highly accurate, ideal for fluid cleanliness trending, online partial oil analysis, up to 500 bar working pressure, flow rate 0.5l/min and it can be linked to a terminal and display the oil cleanliness level every 3 minutes.

Figure 4 – Roc-61 particle counter

Testing Procedure

Figure 5 shows the assembled hydraulic oil filtration system. The testing procedure was carried out as follows:

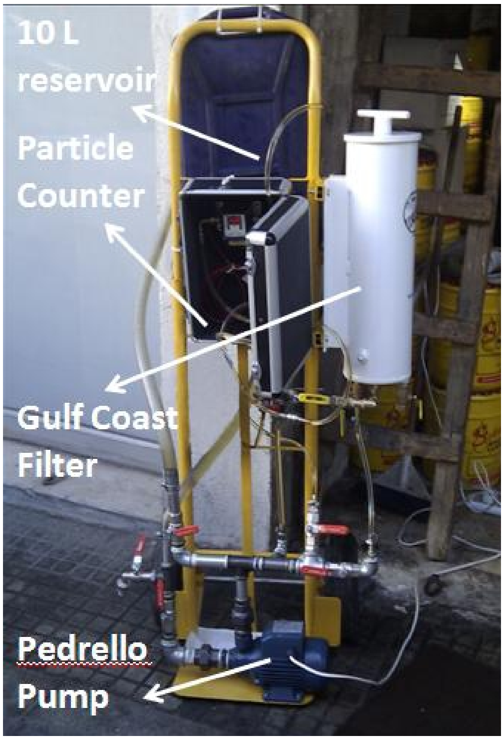

Figure 5 – Online Filration System

1. Connect the outlet tap of the hydraulic system reservoir to the filtration system reservoir through hose pipe
2. Open the tap to give a flow rate of 1.89 L/min “flow rate of the filter”
3. Adjust the taps to make sure the oil is going to enter the testing machine without being filter, and return it back to the reservoir

4. After testing the oil cleanliness, open the tap of the filter, and let the oil pass from the pump to the filter then to the testing machine
5. Monitor the oil cleanliness level in every circulation
6. After the oil cleanliness level is reached, pump the oil to the hydraulic system reservoir

Results and Discussion

ISO cleanliness codes ranges from 18/16/13 "the minimum cleanliness level" to 14/12/10 "the maximum cleanliness level required by hydraulic system`s components". Where the value 18 means that the number of particles of size less than 4 microns must be between 18^3 and 18^4, and the value 16 means that the number of particles of size less than 4 microns must be between 16^3 and 16^4, and the value 13 means that the number of particles of size less than 4 microns must be between 13^3 and 13^4

In this study, ten liters of contaminated hydraulic oil was used in the hydraulic system. The first obtained reading as per ISO code was as follows: 23/21/18 and showed the presence of water and solid contamination and very small level of air contamination. The pump transferred dirty oil from the reservoir to the filter to the testing machine then back to the reservoir. New cleanliness level reading was given by the cleanliness machine every 3 minutes. The oil reached the desired cleanliness level, and returned back to the reservoir.

Time	4µm	6µm	14µm
8:58	23.2	21.1	18.3
9:01	23.2	19.8	16.8
9:04	23	16	16.8
9:07	22.9	16.8	16
9:10	22.9	15.9	15.9
9:13	22.8	15.2	15.2
9:16	22.1	15	15
9:19	21.8	15	14.8
9:22	21.5	14.8	14.5
9:25	21.3	14.1	14.1
9:28	19	13.3	13.3
9:30	18.3	12.4	11.4

Table 2 – Oil cleanliness Result

Table 2 presents the resulting data from the filtration system used in this study. The presented data show clearly how the cleanliness level of the oil improved drastically from 23/21/18 after passing through the filter for 10 circulations to reach 18/12/12. And hence, the desired cleanliness of the oil is achieved.

Table 3 shows the relationship between oil cleanliness ISO code and the hydraulic component lifetime. Following the data presented in table 2, it is clearly that, after half an hour of filtration, the life of the oil has been increased by 3 to 4 times.

Hydraulic Component			
Current ISO Code	**Target ISO Code 2 × Life**	**Target ISO Code 4 × Life**	**Target ISO Code 5 × Life**
23/21/18	19/17/15	18/16/13	17/15/12
22/20/17	19/17/14	17/18/12	16/14/11
21/19/16	18/16/13	16/14/11	15/13/10
20/18/15	17/15/12	15/13/10	14/12/9
19/17/14	16/14/11	14/12/9	14/12/8
18/16/13	15/13/10	13/11/8	-

Table 3 - ISO codes for hydraulic components

Conclusion

As a conclusion applying the filtration method resulted in: improved oil cleanliness level, increased machine performance, increased component life, increased fluid life, reduced downtime and fewer repairs.

The main feature of the system is its robustness and availability to carry out oil analysis on the set to guarantee good results. This system helped in solving one of the most crucial problems that the owners of hydraulic oil systems suffer from. Where it measures the amount of contamination in oil and furthermore it filtrates the oil to the desired cleanliness. One of the most important benefits of this system other than cleaning the oil and extending its life time, the test is done locally and online without stopping the machines which saves time and money.

Furthermore, this system can be used for larger hydraulic system by applying some modifications such as bigger reservoir and a higher pressure pump, if these two modifications were applied, the distance between the reservoir and the pump must be increased in order to ensure the required flow rate. Also modifications can be done according to the desire of the hydraulic system owner, if he wants it to be temporary or permanent, and in both cases satisfactory results are obtained.

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