Monitoring Cleanliness Levels in Hydraulic Systems with the Mesh Blockage Method

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Monitoring hydraulic system cleanliness levels through particulate contaminant measurement is fundamental to achieving system reliability. However, automatic particle counting using light extinction technology is sensitive to optical interference caused by conditions such as non-homogenous fluids, free water and air bubbles in the system. These conditions can yield erroneous data and result in incorrect conclusions and excessive maintenance costs. A Mesh Blockage instrument can provide significant advantages over the light extinction method. This session will explain the differences between automatic particle counting using light extinction technology and Mesh Blockage technology for evaluating fluid cleanliness levels in hydraulic systems.

Reasons For Fluid Sampling

Monitoring system cleanliness levels in hydraulic systems is fundamental to achieving system reliability. The reasons for monitoring system cleanliness include:

- To measure the operational cleanliness level of the system or process
- To measure the contamination generated by a component or a process
- To measure the level of contamination going into a component or process and monitor the progress of 'clean-up'
- To identify sources of contamination as part of a proactive approach to maintenance

Fluid Sampling Requirements

Obtaining a representative sample is critical to cleanliness analysis of a hydraulic system. Field data has shown that bottle samples are less accurate than automatic in-line counters especially in monitoring the cleanliness of critical systems. Systems requiring an ISO 4406 Cleanliness Level of 17/15/13 or better should be monitored using an in-line counter.

Factors influencing the accuracy of off-line analysis or bottle samples include:

- Introduction of environmental dirt into sample bottle
- Incorrect cleaning of sample bottle
- Inadequate flushing of sampling valve
- Effectiveness of sampling process

General Requirements for Fluid Cleanliness Monitor

The general requirements for a fluid cleanliness monitor include the ability to detect small particles in order to provide a warning of increased wear rates. The monitor should be able to measure a wide range of particle sizes and concentrations and have a proven accuracy and repeatability. Factors that can influence the fluid cleanliness monitor's performance and provide false data should be eliminated.

The amount of time required to obtain results from a fluid cleanliness monitor should be such that corrective actions can be taken with minimum delay. The results of the fluid cleanliness monitor should be presented in an industry acceptable form A widely accepted and understood method of expressing a fluid contamination level is ISO 4406-1999 Cleanliness Coding System. A fluid cleanliness monitor should have the ability to monitor a wide range of industrial fluids including hydraulic, wash and solvent fluids.

Fluid Cleanliness Measurement Technology

There are two major technologies for measuring fluid cleanliness levels on-line. These are automatic particle counter using light extinction technology and Mesh Blockage technology instrument.

Automatic particle counters using light extinction technology operate by passing the fluid sample though a very narrow passage in the instrument's sensor. The senor is illuminated by a light source, usually a laser diode, aimed perpendicular to the flow and is the light is captured by a photo-detector. The passage of particle through the sensor generates a pulse and each pulse is analyzed for its magnitude and is recoded. The relationship between voltage reduction and particle size is obtained through sensor calibration.

Automatic particle counters using light extinction technology are sensitive to optical interference caused by such conditions as dark fluids, fluid mixtures and emulsions. The results can be influenced by the presence of free water and air bubbles which interfere with the laser light and consequently registering the presence of a particle. These interference conditions give erroneous data which can result in drawing incorrect conclusions, wasting maintenance time and ultimately reducing confidence in cleanliness monitoring.

Mesh Blockage instruments operate by the principle of the particles blocking a mesh with regular sized pores. The mesh blockage is a function of the number of particles in the fluid whose size is greater than the mesh pore size. The capture of particles on the mesh creates an increase the differential pressure across the mesh. The increase in mesh differential pressure is proportional to the number of particles in the fluid.

Mesh Blockage instruments are not influenced by conditions such as dark fluids, fluid mixtures and emulsions. Other fluids conditions such as the presence of free water and air bubbles have slight influence on the Mesh Blockage Instrument results.

Fluid Condition Effects on Cleanliness Monitors

Figure 1 below illustrates the influence of water on particle counts. The automatic particle counter using light extinction technology results, represented by the red, green and blue lines, increased significantly with the addition of water to the system. Once the level of water, represented by the black dots, started to decrease, the particle counts obtained from automatic particle counters using a light extinction technology decreased. The results obtained from a Mesh Blockage instrument, represented by the solid black lines, vary slightly due to the presence of water.

Figure 1

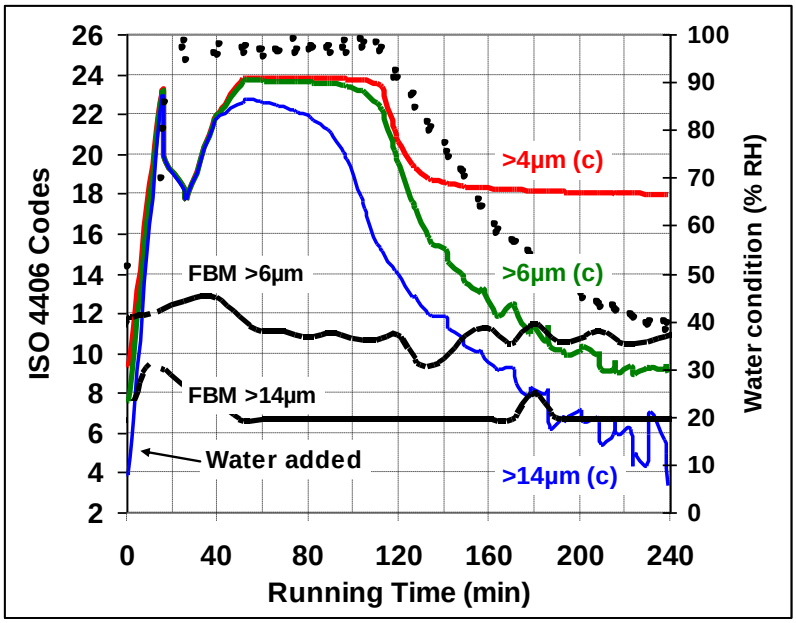

Table 1 below shows the effects of air on particle counts. The automatic particle counter using light extinction technology results increase significantly with the addition of air to the system. The results obtained from a Mesh Blockage instrument vary slightly due to the presence of air.

Table 1

Test Description	Automatic Particle Counter Location #1			Automatic Particle Counter Location #2			Mesh Blockage Monitor	
	4 µm	6 µm	14 µm	4 µm	6 µm	14 µm	6 µm	14 µm
Air Off	13.8	11.5	6.5	13.7	11.1	<1	10.6	7.7
Air On	18.8	17.8	14.2	18.6	17.4	12.7	11.3	8.1

Case Study - Transmission Test Stand

An automotive manufacturer established an ISO 4406 Cleanliness Level of 16/14 for their transmission test stands. Monitoring the transmission fluid's cleanliness level with an automatic particle counter using light extinction technology yielded results ranging from ISO 20/18 to 18/16. Monitoring the level using a Mesh Blockage instrument showed the transmission fluid's cleanliness level was ISO 14/12. The ISO 14/12 Cleanliness Level was confirmed through optical microscope examination of the fluid.

Conclusion

In order to monitor fluid cleanliness levels, the measurement instrument has to have proven accuracy and repeatability. The measurement method needs to be fast and without the chance of false alarms. Automatic particle counters using light extinction technology are susceptible to non-homogenous fluids, air, and water that can cause measurement errors. Mesh Blockage systems are not severally affected by these conditions.