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Liquid Particle Counting Considerations

This paper covers several basics of liquid particle counting. It starts by providing examples from industries currently using particle counters and suggests how this can be used in other areas. Also discussed here are the advantages of using an optical particle counter (OPC) and the considerations of sample volume and sensitivity.

Benefits of Monitoring

The obvious reason for monitoring the fluids used during the manufacture of products is to somehow reduce cost and improve yields. In many cases, the methods of accomplishing this are straightforward, yet some industries opt for predominately labor intensive methods, or wait until the product has been completely packaged before performing a final QC analysis on the cleanliness.

Learning from Industry

Much could be learned in many industries by performing a survey of best practices used in other industries that rely on clean manufacturing. For instance, semiconductor manufacturers learned many years ago that a significant savings could be realized in the factory by using particle counters to determine the frequency of filter replacement. Inevitably the pressure drop specification was set significantly towards the conservative side due to the extreme risk of being wrong. However, by using an appropriate combination of particle counters and other electronic monitors to provide a clear picture of fluid quality they discovered that filters did not require replacement until 2 – 3 times their original frequency. Given the cost of filters, the ROI on monitoring equipment can be as short as one year. Currently, the pharmaceutical industry continues to use the filter drop method of filter replacement and prefers to inspect quality into the system just prior to product shipment.

Data storage companies have been driven to compete on single digit margins, while producing some of the most dramatic increases in memory capacity. In the process they have forced the development of relatively inexpensive re-circulating, continuously filtered cleaning systems that insure the components that go into a disk drive have only a few particles per square centimeter larger than 0.2 microns. In many cases the cleanliness is automated and industry continues to use stagnant cleaning baths in many cases. Some have reported that cleaning is futile because the parts are more contaminated after leaving the cleaning bath than they were when they went in. Quality assurance is established by visual inspection, or gravimetric analysis of the residue removed from a part by means of spray extraction and collection on a filter patch.

Figure 1. Parts cleaned in various industries

When considering the benefits of switching to automated particle monitoring, you should look beyond the initial cost of equipment and evaluate all the ways the instrument can be used to save money. Several years ago, a larger semiconductor fab purchased several compression batch samplers. They were given to two different cleanroom areas run by different managers. One manager used the sampler almost exclusively to optimize filter selection for each process. The other manager integrated the sampler into the process equipment and monitored for any process upsets. Both reported that the equipment paid for itself within six months. The information learned was shared throughout the company allowing them to save a large amount of previously wasted money.

Figure 2. Compression Sampler

Measurement Basics

A question that frequently arises is, “How do optical particle counters compare to other methods?” The answer is, “it depends.” Consider, for example, the many different ways to measure a particle visually. Most naturally occurring particles are irregular in shape, so how do you classify the size?

Referring to **Figure 3**, is it the longest dimension? The longest dimension in one axis? Perhaps it should be the equivalent area? When examining most particles, each of these different methods will yield a slightly different answer.

Optical particle counters (commonly referred to as OPCs) work on one of two principals; they either measure the amount of light that is obstructed by the particle as it passes through a directional light source of known energy density (light obscuration), or they measure the amount of light that is scattered away from the directional light source (light scattering). The result is compared to the amount of light (obscured, or scattered respectively) by a calibration particle of known size and shape, typically polystyrene latex spheres (PSLs). In other words, an optical particle counter will report natural particles as the optical equivalent diameter of a PSL suspended in water.

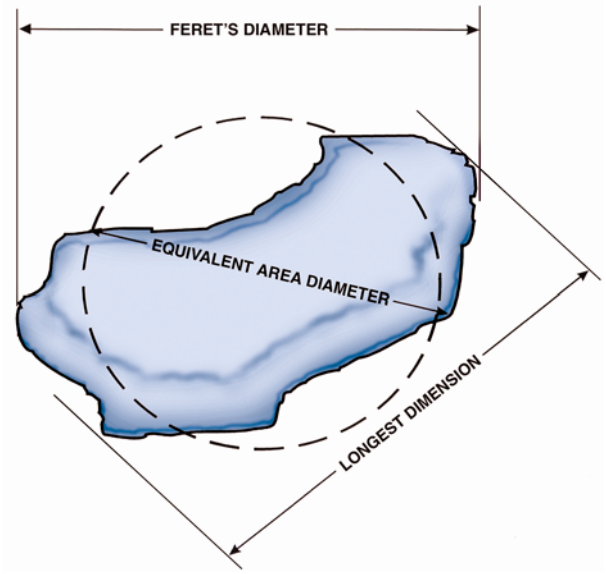

Figure 3. Measuring Particle Size

While this may again result in a slight difference in the measurement obtained by other methods, the repeatability of this measurement is highly reliable. Couple this with the relative ease of use, and reduced labor intensity and the benefits are generally believed to be significant.

There are a few considerations that should be given to implementing a monitoring program using OPCs. When monitoring on-line, care should be taken to eliminate any source of particle shedding upstream of the particle counter. Valves that are used to isolate the OPC when not in use at a given location should be opened 100% during monitoring. Flow control should be accomplished downstream from the OPC.

Partially open valves contribute to particle counts in two ways:

- First, they trap and release particles continuously over time, resulting in the appearance of elevated particle counts. Most valves present more surface area to the flow stream when only partially open. Pressure surges caused by operating other valves in the system will cause more particles to be released from the increased surface area.
- Second, depending on the extent to which the valve has been opened, it can produce a pressure drop that causes bubbles to form in the sample stream. OPCs cannot typically distinguish a bubble from a particle, so the data will appear to contain more particles than are truly present.

When performing batch sampling operations, it is important to allow sufficient time for the sampling apparatus to clean-up. Proper operation of the equipment is essential.

Following the manufacturer’s recommendations will usually insure quick and simple testing with this type of equipment.

Sample Volume vs. Sensitivity

When selecting a particle counter, the value of total particles counted per unit time cannot be emphasized enough. Particle Measuring Systems has written several papers that discuss the reasons statistical significance is important, so this paper will not repeat them here. In general, it should be known that as particle counters approach the limits of technology, the volume of liquid assessed by the instrument will be less than 100% of the flow rate. Some manufacturers of particle counters do not publish this difference in their specifications, so it is important to ask, “What is the sample volume?”

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Figure 4. Particle Counter with High Sensitivity and High Flow Rate

If the application of interest requires high sensitivity (ability to detect very small particles) in a very clean fluid, you must evaluate the time required to count a minimum number of particles. In many ultra pure applications this time may be several hours. Unfortunately, a sample interval of this length will not allow the operator to detect temporary upsets of short duration. If the ability to detect these upsets is important, consideration should be given to sacrificing sensitivity for a particle counter with greater sample volume. It should be easy to understand that process upsets will not generate only one size particle, but rather an increase in particles at all sizes proportionately. Therefore, a less sensitive particle counter will be able to detect the upset and report it as it happens because it can be set with a sample interval of only a few minutes.

Conclusion

Optical particle counters are used in many industries. However, they are not used to their most effective benefit everywhere. Industry benchmarking could help many manufacturing companies that are just entering the ultra clean manufacturing environment to make significant strides forward.

While there are differences between OPCs and visual measurement techniques, they are not of significance and the highly repeatable nature of OPCs makes them an operator's tool of preference.

Finally, consideration must be given to the number of particles counted in the sample interval desired. If this number is not enough for statistical significance, the better choice is often a less sensitive particle counter with greater sample volume.

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