



Quaker Knowledge Network

Filtration

Skill Builder

Overview

Most, but not all, metalworking systems have some form of filtration. Whether it is a system for coolants, cleaners, stamping fluids or corrosion preventives, the intent is generally the same. The purpose of filtration is to remove contaminants in order to:

1. Help maintain the current fluid in a status of "fit for continued use."
2. Prolong the life of the fluid by keeping it clean.
3. Protect fluid pumps from damage.

While there is both gravity and positive filtration, the vast majority of end users utilize positive filtration. Because of this aspect, this Skill Builder will focus on positive filtration.

Definition

A filter is a porous, physical membrane/device with a function of separating contaminants (chips, fines, shop towels, cigarettes, dirt, etc.) from the main fluid. The key to understanding the filtration is, "Just how clean does the fluid have to be?" The answer to this question will dictate filtration type and configuration needed to achieve that level of cleanliness.

The effect of dirt and fines on the surface finish requirements of the final part will generally dictate the filter system requirements. For example, if the operation is striving for a 10-micron finish, but the filter unit is permitting particles larger than that level, the finish requirements may not be met. Generally plant engineering and the filter manufacturer will decide on the overall design and set up of the filtration system. The designed system may have many elements.

Elements of Filtration

All filter systems have essentially the same elements in design. You need the following:

1. A process where the fluid is used and becomes contaminated.
2. A holding tank or reservoir that holds the bulk of the dirty fluid.
3. A cleaning device where the filtration takes place; this could be part of the main holding tank or a separate tank.
4. A "clean" tank that holds filtered fluid; this could be a section/part of the main holding tank.

Filter systems tend to differ in their approach to handling the flow of the fluid. There is:

1. Full flow - permits continuous cleaning of all the dirty fluid.
2. By-pass - only filters a small percentage of the dirty fluid.
3. Batch filtration - similar to the by-pass but handles a large volume as part of the flow.

Most operations with stringent finish requirements typically have that type of application set up on a by-pass filter. The by-pass filter would use finer filtration than the bulk operation. Setting up a series of successfully finer filters may be necessary to avoid blinding of the final filter in the by-pass system. Usually it is the engineering staff that will dictate how much the fines will impact the finish.

When references are made to the dirty side or clean side of the filter you have to understand where the fluid is considered dirty (i.e. prior to filtration) or clean (i.e. after filtration). This understanding is important when using additives. Sometimes it is better to add to the dirty side versus the clean side depending upon the purpose of the additive. For systems where there is a clean side next to a dirty side, the clean side typically overflows back into the dirty side as a way to maintain flow.



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Methods of Filtration

Filtration can be conducted under gravity, vacuum or pressure. Gravity filtration is dependent upon the flow of the fluid or the lack thereof. As the fluid slows down, solids have a chance to settle to the bottom while lighter fluids will rise to the surface. Many settling tanks have baffles or weirs that help to slow the speed of the fluid. These same tanks also tend to have some form of drag bar/drag chain that sweeps across the bottom of the tank at scheduled intervals. The tank usually has an angled ramp at one end to permit the solids to be dragged up and out of the tank.

Vacuum filters utilize a vacuum to pull fluid through a membrane and leave the debris on the surface. Over time, a filter "cake" will build up providing finer and finer filtration. Usually, a vacuum filter is set to "index" when the vacuum reaches a specific level. Indexing is the process whereby the filter paper advances to yield more clean surface area for filtration or the drag chain moves across the surface of the filter to remove debris and yield more surface area for improved filtration. The level setting for the indexing is set by the manufacturer. This setting can be altered by the end user in order to use less media or improve the filtration. There are times when a certain contaminant might "blind" the media and cause the filter to index too often. A typical setting is 8-10 inches of mercury (in. Hg).

A pressure filter is just the opposite of a vacuum filter. Pressure filtration tends to be more efficient because more volume can be forced through the media versus a vacuum set up. Because of this, pressure filters can have a smaller footprint but can also cost more money.

Some systems can use a pre-coating to obtain finer filtration. The pre-coating can be something like diatomaceous earth (DE) or some form of fine cellulose. No matter what the pre-coat, the concept is to help build a thicker filter cake faster. A thicker cake means finer filtration.

Filtration Capacity

Filter media is rated as either nominal or absolute. These terms are used to describe the cut-off point at which filter membrane operates. Of course, these terms are applied under controlled laboratory conditions with low-pressure differentials. For example, a membrane rated at 10 microns nominal means that a high level percentage (~90%) of particles will not pass through at 10 microns. However, there can be a level of inconsistency in the filter media that permits larger particles to pass through.

This also impacts absolute ratings. The term means this is the largest particle size that can pass through the membrane, under controlled conditions. There is a higher degree of consistency in a membrane with an absolute rating. Like the example above, a 10-micron absolute media means that a higher percentage (>90%) of particles greater than 10 microns will not pass through. More media is being rated under absolute ratings instead of nominal ratings.

Filter Paper (Types and Weights)

There are many manufacturers of filter paper but there is similarity in the materials themselves. Typical types of media are:

1. Polyester - generally good for coolants
2. Polyolefins - both propylene and polyethylene are good for oil removal
3. Rayon
4. Nylon

Other considerations for the type of media are high wet strength, lightweight, chemical resistance and cost. These are the details that the media supplier should provide. Certainly, their knowledge of their product will be critical in choosing the proper media.

Beyond the parameters listed above, media performance is also chosen based on its weight (oz./yd²), air permeability (ft.³/min.) and burst strength (PSI). There is not always a



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direct relationship between the weight and the porosity. It certainly makes sense that the more material per square yard that you have, should remove/retain more contaminants. See the table below for approximate comparisons. Again, the filter media supplier should be able to choose their best product for a given application.

Approximate Weight vs. Porosity	
Ounces/Square Yard	Micron
2.25 - 3.0	10
0.90 - 1.00	50
0.60 - 0.80	100
0.50 - 0.70	150
0.40 - 0.60	200
0.40 - 0.50	300

Stripping of Fluids

The main concern, from a fluid perspective, is to make sure that the filtration is not finer than the average particle size for the fluid. The difference between an emulsion and a solution is important to understand. An emulsion is a mixture of "oil particles" (or whatever the primary lubricant is) evenly dispersed in water. The oil particle is not a hard particle, like a grain of sand, but is more like a porous water balloon. The "skin" of the balloon is the emulsifier. If the skin gets broken, the particle falls apart. Remember, too, that particle sizes vary based on the level of emulsifier. Soluble oils can range from 2-10 microns. Semi-synthetics are micro-emulsions and have an average particle size less than 1.0 microns. On the other hand, a solution does not have visible particles but still contains particles less than 0.1 microns. A solution will pass through filters that would strip a soluble oil or semi-synthetic.

For example, if a product being used in an application has an average particle size of 5 microns, then the porosity of the filter media should be larger than 5 microns. The purpose of the filter is to remove the chips and other debris while

allowing the emulsion to pass through unharmed or unaltered. The use of a 5-micron absolute filter would probably have a negative impact on the fluid in this example! The "stripping" of an emulsion could result in poor performance and eventual emulsion stability. Key components can be stripped out of the fluid.

Ultrafiltration (UF) is sometimes used but it must be recognized that UF is extremely fine. UF uses a semi-permeable membrane, under pressure, to achieve a nominal cut-off of 95% or higher based on molecular weight. UF is unsuitable for soluble oils and semi-synthetics and can even strip out certain components of true solutions and cleaners. UF can filter as low as 0.05 microns! Many UF filters have pre-filtration, as low as 5 microns, to protect the UF membranes. Clogged UF membranes can be expensive to replace. Often times UF is used to process the final waste stream from a waste treatment process. The UF will strip just about everything out of this process stage.

Types of Filters

There are some standards used in the industry at this time. One manufacturer introduced the "wedge wire" concept for positive filtration years ago. Closely-knit wires run across the floor of the filter unit spaced about one ten thousandth of an inch apart. The wires are wedged-shaped so that the larger part of the wedge is at the surface and the narrower part faces toward the "clean side" of the filter. As the debris builds up on the surface of the wedge, the vacuum increases because it is more difficult to pull the fluid through the debris. When the vacuum reaches its set point, the drag chain will move perpendicularly across the wires to remove the debris in order to create a renewed filtration surface.

Another version of the wedge wire is called the suction indexing drum (SID). Imagine the wedge wire filter described above rolled into a large tube with both ends sealed. This tube is suspended in the dirty side. Suction is applied to one end of the tube so that fluid and debris is pulled into the tube on all surfaces. Instead of having a drag chain that scrapes off the built up debris, the drum rotates against a fixed blade that



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knocks the debris to the bottom of the tank. There, the drag chain scrapes the bottom of the tank and removes the debris.

Also similar to the wedge wire is a porous metal plate, called a platen, covered with filter paper and supported by a vacuum chamber. The platen allows the filter paper to fit tightly but not be pulled into the vacuum chamber. The method is employed with most paper filters.

Bags, cartridges and canisters are replacements for paper. The concept remains the same except these media offer the option of serial filtration by altering the number and porosity of the filtering media. For example, there could be several filters in line with the first filter at 25 microns, the second at 10 microns, and the last filter at 5 microns. This level of filtering actually works better than a single pass through a single porosity. The devices that contain these media are typically smaller and easier to work with versus a large pressure or vacuum filter. Much of this media is rated for specific applications based on flow rate and permeability.

Another option to filter paper is a permabelt. A permabelt is used just like filter paper but is contained in a closed loop process. When the indexing process occurs, the permabelt moves ahead but passes through an area that back flushes the belt to remove the debris. Eventually the entire belt gets used over and over in filtering the fluid. Permabelts are typically made of polypropylene.

Adjunct Processes

It is possible to have other process equipment as part of keeping fluid clean. These other processes are typically associated with removing additional fines or floating contamination, like tramp oil.

Removing additional fines can be achieved via centrifugation, a hydrocyclone or magnetic separator. Commercial centrifuges have been used for years to remove fines as well as tramp oil and other floating contaminants. If properly maintained, a centrifuge will perform well in keeping the fluid clean. It

is possible, however, that some of the oil-soluble components can be extracted along with the tramp oil. The hydrocyclone uses a similar process as a centrifuge but has no moving parts. It tends to be less efficient and also relies on about 5-10% bypass of the fluid to assist with removal of debris. Another method is a magnetic separator. The concept is the use of a magnetic conveyor that pulls metallic fines out of the fluid and dumps them into a hopper. Of course, this only works for iron and steel alloys.

Tramp oil removal can be achieved with an assortment of skimmers that pull the floating oil off of the surface. As mentioned above, a centrifuge will remove tramp oil. Also, coalescers are typically set up as part of a by-pass process. As the fluid moves through the coalescer the flow rate decreases and provides the residual time to permit the coalescing to occur.

Troubleshooting

It would be expected that the supplier of the filtration system would provide the service to solve problems. However, there are many times that the response is too slow or the fluid gets blamed without investigation. Below are some suggestions based on Quaker's experiences.

If the question arises as to whether the filter is working or not, the first action to take is to obtain samples from the clean side and dirty side. You can also compare the clean side to a sample coming out of the nozzle at the machine that is using the fluid. Sometimes fairly simple tests can be conducted to compare the fluid samples. In some cases, it might be necessary to run a particle size analysis.

If the question above indicates that filtration is not occurring, then the supplier must get involved. It is possible that one of the following is part of the problem:

1. The SID is not rotating properly. There could be something physical blocking the gear mechanism that impacts the drum rotation or something is jammed against the scraper blade.



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2. The scraper blade that cleans the SID is bent or is somehow not contacting the surface. The scraper blade should be changed every 12 months.
3. The filter paper is torn or continues to tear because of some blockage as the paper is loaded into the filtration area.
4. For systems that utilize bag or cartridge filters confirm that the bag/cartridge is the correct model and is properly fitted in place.
5. Make sure that the vacuum setting was set properly and is currently at that setting. Sometimes adjustments are made to overcome a temporary problem and the original setting is not re-established. The same can happen with timed settings.
6. Many systems are set up with some type of by-pass mechanism that guarantees that the clean side can never starve the demand. This mechanism permits the dirty side to flow into the clean side. Make sure that this mechanism is functioning properly.
7. Make sure nozzles are not clogged and they are properly aimed at the work area to provide maximum coverage with the fluid.

A SID can be lifted out of the system for inspection. Unfortunately, systems with filtration at the bottom of the tank can only be inspected by draining the entire system. This applies to standard wedge wire systems as well as vacuum filters that utilize paper filtration. This obviously can have a large impact on getting any work performed on the system if there is nowhere to store the current fluid.

Summary

Understanding how the fluid system functions can be critical to successful operations. You can provide input to your customer to help them solve their problems. This makes you more valuable to them as a supplier.

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