

The Attraction of Magnetic Filtration

New option for cleaning industrial coolant or oil systems is efficient, economical, and environmentally sound

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Efficient performance of coolants and lubricants is a challenge to engineers and machine tool operators — in terms of process efficiency, operating cost, and environmental compliance. Magnetic filtration is a relatively new concept that offers a number of advantages over traditional media-based filtration. Basically, the concept involves placing a high-intensity, permanent magnetic rod in the fluid path, positioned so that all fluid must pass around the rod. This provides sufficient contact to extract ferrous contamination from the fluids. The rods are periodically removed cleaned and put back into position. Current-model magnetic systems, like the [Eclipse Magnetics](#) Micromag, Filtramag and Automag systems, are designed to be easy to clean and to ensure no blockages or loss of pressure occurs.

The major advantages of magnetic filtration are that there are no operating costs, reduced expense for other consumable items, lower fluid usage, and increased finish accuracy. In addition magnetic filters fit well within environmental polices for manufacturers. But, in order to understand how magnetic filtration can add to manufacturing efficiency it is important to consider other types of fluid filtration media.

Methods of barrier filtration

Barrier filtration is the most common mode of industrial coolant or oil filtration, and usually it takes the form of a cartridge, bag or sheet. All of these use lengths of media (typically cast, woven or spun polypropylene, polyester or cellulose materials) that may be pleated and formed into cartridges (to achieve a high surface area); sprayed or wound over a mandrel (for depth filters; formed in to bags (for convenience or for higher 'dirt' loadings); or simply used as a roll of flat material over a frame. The basic principle is that the barrier is interspersed with pores — e.g., 40-micron size — so that any contamination greater than the size of the pore passing through the fluid will be extracted.

Barrier filtration creates a pressure drop, which for media-based filtration gives both an advantage and a disadvantage.



Figure 1A Micromag filter installed. It's the basic model magnetic filtration system available in three sizes (5, 10, and 20 inches) from Eclipse Magnetics, for filtering ferrous particles from machine coolants and lubricants at flow rates up to 150 liters/minute

Taking a cartridge as our example (although bags and sheets operate in much the same manner), a cartridge system will, if sized correctly, start with a very low differential pressure — the difference is between the pressure upstream of or before the filter and the pressure downstream of or after it.

As contamination is removed from the system this contamination will start to block up parts of the cartridge medium, causing this differential pressure to increase. This will continue until the differential pressure is too high for the upstream pressure to overcome, at which point the cartridge is effectively blocked. In practice the pressure downstream may have fallen below a usable level, or flow starvation may have occurred, long before this point so a maximum differential pressure will normally be set, at which point the cartridge is either cleaned or, more often, taken out and disposed, and a new one is installed.

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Figure 2 Micromag has a debris capacity of up to 3.8 kg between cleanings. Cleaning the filter core takes only a few minutes. Some alternative designs have self-purging capability.

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Advantages of barrier-based filtration

Ease of control — The advantage of differential pressure is that it gives the operator, or the machine manufacturer, a clear indication of filter life and a clear indication of when a cartridge should be taken out and changed, and a simple system reading the drop in downstream pressure can be used to trigger an automatic machining center to bypass the filter (or switch to another installed parallel in a duplex system) or shut down the machine.

Capital cost — Another advantage of media-based filtration is that it is relatively cheap to buy (although not necessarily cheap to own.) Capital costs of the housings is often subsidized by the filtration supplier, on the basis that a new installation will generate sufficient revenue from disposable media sales for many years to come.

Disadvantages of media-based filtration

Replacement and disposal costs — Of course, the disadvantage of increased differential pressure is that the cartridge must be replaced with a new one (which must be purchased and stocked), and the old one will need to be disposed of (complete, in most cases, with a certain amount of coolant or oil and the contamination removed, which may have a recyclable value.) This cost of disposal is a growing concern: it's no longer acceptable simply to drop it in a bin. Also concerning is the cost to the environment (or to a company's ISO 14001 accreditation) of producing this type of mixed waste. In particularly high contamination applications, barrier filters may have to be changed every few days.

Limited efficiency — Another disadvantage of this pressure loss is that it restricts the level of filtration achievable in practical terms. Consequently, the media-based filtration installed will always be a compromise between the level of filtration desired and the level of filtration that is economically practical to maintain flow. Typically, the filtration capability may be set at 40 micron in order to avoid restricting flow. Unfortunately this means that particles below this size continue to be circulated, which causes wear, lowers the quality of the parts' surface finish, reduces oil/coolant life, etc.

There are, of course, many other types of media-based filtration systems available (powder, cross-flow, etc.) but these are somewhat less common than cartridges, bags, and sheets, and exhibit many of the disadvantages discussed above. Powder systems also will add the disadvantage of powder handling and the health and safety implications associated with that. Cross-flow systems (which would be expected to give several years life between cartridge media changes) offer a good way to reduce dependence on consumables and have many of the benefits of reusable filtration, but they have a very high capital cost and a higher reliance on energy.

Advantages of magnetic filtration

Economy — Magnetic filtration uses a permanent magnetic core or rod that does not need replacement or disposal, saving on the cost of replacement filters and the cost of disposal of the

used contaminated filters. Also, because magnetic filtration will clean up the oil/coolant more efficiently, the oil will require changing less frequently, thus also saving on both the cost of replacing the oil and the cost of disposing of the 'old' contaminated oil.

Ecology — As above, because magnetic filtration is re-usable and more efficient it will not create the waste associated with media-based filtration. In addition the oil/coolant will last longer, nor will valuable and diminishing resources be wasted creating the new cartridges and oil.

Efficiency — High-intensity magnetic filters extract the smallest particles right down to sub-micron size. This improves the quality of the oil/coolant in the system, which will have a positive effect on parts quality, surface finish, and ultimately will reduce product rejects.

Types of magnetic filtration

There are a number of magnetic filtration and separation devices available, ranging from methods that simply suspending a commercially available magnet in a machine's fluid sump to well-engineered automatic self-cleaning systems that can operate 24 hours a day, every day, without any operator input.

Many grinding or milling manufacturing operations already employ drum magnets, often operating in conjunction with a media roll system, and some will have magnet rods suspended in bag filters, but the efficiency of such systems will often be limited by the strength of the magnets employed, the contact time enabled (the time the fluid spends flowing in an area where ferrous particles can be attracted from it) or by the quantity of the fluid that is actually exposed to the magnet.

To achieve the most efficient submicron filtration it is necessary to use a system engineered to ensure all of the contaminated fluid is exposed to the magnet for a sufficient period of time, and that that magnet is sufficiently powerful to draw the contamination out of the fluid. It is also essential that this system is easy to clean (if it is a manual system) or reliably self-cleaning.

To achieve the magnetic strength required, and thus the filtration efficiency desired, the preferred magnetic material would be Neodymium Iron Boron (commonly called 'rare earth'.) As this is an unstable material, which will very rapidly corrode in any fluid, it is generally nickel-plated and then, for ease of cleaning and to isolate it from contact with the fluid being filtered, encased and sealed in a stainless steel tube. Rare earth can be as strong as 12,000 Gauss (measured on the outside of the stainless steel casing – a measurement taken directly from the plated magnet would be meaningless as this is not how the magnet would be used in service.) This is around six to seven times stronger than the more common ceramic magnets seen in speakers, latches, switches, etc.

In all systems it is important to know the flow rate and pressure, expected level of contamination, and the type of contamination order to specify and size the system correctly. Magnetic filtration can be used wherever ferrous particles are likely to be present in a fluid. This can be cast iron or steel, which are by far the most common applications for this, but it may also be used on more difficult and less magnetically attractive materials, such as stainless steel and carbide. 300 Series stainless steel, which is the most common grade of stainless steel encountered in the industry,

and which does not normally have magnetic properties, will become paramagnetic, and thus can be removed from a fluid, when hardened. Hardening will occur due to wear or any cutting (grinding, milling, etc.) process, and so any loose particles in a fluid are likely to be paramagnetic and can be filtered out with a sufficiently strong magnetic force. These less attractive materials will need to be filtered at a lower flow rate to allow sufficient contact time for them to be removed efficiently.

Eclipse Tools North America is one of world's most recognized names for magnetic products, including magnetic filtration. Its product line consists of three main products that cover almost all applications:

Micromag, for flow rates up to 150 liters/minute, is the simplest and lowest-cost option for many applications. Its particular flow geometry and high-intensity rare earth magnets ensure extremely efficient removal of all particles down to submicron levels, while the patented magnetic circuit design ensures that a flow path is always available and that no significant pressure drop is introduced, even when the element is fully loaded.

Micromag is available in three sizes (5, 10, and 20 inches) and will handle a flow rate of up to 150 liters/minute (20-in. version) with a debris capacity of up to 3.8 kg between cleanings. Cleaning is very easy, taking only two to three minutes. A high-pressure version, which can operate at up to 80 bar, is also available.

Filtramag is a model for flow rates from over 150 liters/minute to up to 500 liters/minute, and for removing less magnetic material (such as stainless steel and carbide.) Filtramag uses six high-intensity rare earth magnetic rods. In the standard version these rods are extracted with the housing lid, as a complete assembly, and readily wiped clean using the supplied 'C' scraper. In the Easy-Clean version the magnetic rods are pulled out of the rod assembly, again as a complete assembly, causing all of the trapped magnetic material to fall away immediately to the supplied collection tray below (thus, no wiping is required.)

Automag/Automag Skid is a self-purging system, with fully automated cleaning for flow rates from 450 liters/minute to 900 liters/minute. In filtration mode, the high-intensity rare earth magnetic rods attract and retain contamination, as in the manual assemblies described above. But, at user-definable periods the magnetic rods are automatically shuttled away from the retained contamination, causing this contamination to fall away. At the same time a divert valve is operated, enabling this deposited contamination to be purged away to a separate tank. Then, the magnetic rods will shuttle back to their filtration mode position and filtration will continue. This cycle takes just a few seconds.

Automag is available in two standard sizes (6 rod and 12 rod) with flow-rate capacities up to 900 liters/minute (or many times higher with coupled systems.) Contamination capacity is virtually unlimited, as the purge frequency can be readily adjusted to cater for this.

In an industry that strives both to reduce operating costs and improve quality to remain competitive in an ever more competitive global marketplace, and also needing to comply with environmental standards, magnetic filtration offers an excellent alternative to buying, handling,

and disposing of conventional media-based filtration. It's also an opportunity to improve finished product quality and reduce coolant and oil usage and disposal.

Neil Fowler is the marketing manager for [Eclipse Magnetics](#), a developer of industrial fluid filtration products and systems. Contact him at nfowler@eclipsemagnetics.com.