

Filtration vs. Separation

What is the Difference?

Removing Solid Contaminants from Machine Tool Coolants

By Polytech-Filtration

Overview

Solid contaminants are removed from metal working fluids and coolants by filtration or separation. Separation uses the physical characteristics of the solids to remove them from the liquid. Filtration involves passing the liquid through some material to remove the contaminants. While the terms are often used interchangeably, there are important differences which must be understood and considered when selecting equipment for a particular application.

Separation

Removing solids from liquid by separation involves using the physical characteristics of the solids to move them through the liquid so that they can be removed. The two principal means of solids separation in coolants and metal working fluids are gravity separation and magnetic separation. The appeal of separation is its simplicity, but, as with most things, the devil is in the details.

The key to effective separation is that the separating force must overcome the resistance of the liquid to the movement of the contaminant within the time available. In a tank or pond heavier solids settle out of suspension. If the pond is still, even very fine particles settle out eventually. Most people can't afford to have their fluids sitting around, so the model is more like a flowing stream and the rate of settling becomes paramount. Just as a stream runs clear at low flows and carries off rocks during flood, the dwell time or turnover rate in a coolant tank is an important measure of separation as a viable option. In general, if the bulk of the solids will settle out of suspension in 10 to 20 minutes, gravity separation and settling may be a good option.

Of course success comes at a price. Good separation systems soon fill with solids so a means of removal is necessary. Labor on all but the smallest, simplest systems generally precludes manual clean out so a drag conveyor may be needed to remove solids.

Depending on the space available for settling tanks and the coolant flow rates required, it may be necessary to accelerate the process. Hydrocyclone separators concentrate solids in a small "underflow" stream and discharge the remaining liquid at a greatly reduced solid contaminant concentration level. The small (5% of total flow) concentrated flow can be given enough dwell time that a significant percent of the solids can settle out.

Unfortunately, solids are not usually of the uniform size and shape that hydrocyclones handle best. Large solids may settle out so fast that a first stage drag-out conveyor is justified. Small floating particles float right through the hydrocyclone. Soft stringy chips as seen in many grinding applications can clog the hydrocyclone underflow, directing the full contaminant load to the clean tank or back to the machine tool. Fine particles have a low separation force relative to their surface area so are far more sensitive to turbulence and tend to stay in suspension.

Centrifuge separators are often used on very fine particles because they spin the contaminated liquid at high speeds to create high separation forces due to the centrifugal force. Nevertheless, centrifuge separation efficiency on fine particle is sensitive to flow rates and the dwell time in the centrifuge.

Magnetic separation has many similarities to gravity separation in that the magnetic attraction creates the force to move the particle through the liquid and the force available and the distance and resistance to movement through the liquid determines the effectiveness of the separation. The level of magnetic attraction (both due to material and distance from the magnet), the flow rate and turbulence and the viscosity of the liquid have a profound impact on separation efficiency.

Yet another challenge in separation is that the materials to be removed are heterogeneous or may change with manufacturing demand. Steel grinding swarf may be pulled out with a magnetic separator but the aluminum oxide abrasive grit whistles through. If the part is changed to stainless steel or the fluid changes from water to oil all bets are off. Since separation techniques are so dependent on material characteristics separation systems lack flexibility.

Filtration

Filtration has two essential elements. A barrier material the liquid can pass through (filter media) and a difference in pressure between the two sides of the filter material to move the liquid. The type and format of filter media and the means of applying the differential pressure define the basic filter system. The filter media, the characteristics of the solid contaminants, the required coolant flow rates and the available differential pressure all influence filter sizing.

In coolant filtration the differential pressure is usually applied by gravity, atmospheric pressure (vacuum filters) or pump pressurized systems. Gravity filter systems utilize the head pressure of a pool of liquid to create the higher pressure with differential pressures of 0.2 – 1 PSI. Vacuum filters create a lower pressure beneath the filter media so that the atmosphere, at 14.7 PSI, forces liquid through the media . Air blower vacuum systems can provide 2 PSI differential pressure. Centrifugal pump suction based vacuum filters can provide up to 5-6 PSI differential pressure. Kinetic fluid pump based vacuum filters can provide up to 13 PSI differential pressure. Pressure filters start at 15 – 20 PSI differential and in special cases go up to as much as 250 PSI differential pressure.

Filter media include granular or powdered materials such as sand, cellulose fiber and diatomaceous earth and more “structured” materials ranging from sintered metals, wedge wire screens and perforated plate to fabric, paper, microglass and porous membrane materials. All filter media imposes some restriction to the flow of liquid and as might be expected filter media that can retain small particle generally have a higher resistance to flow. Since the resistance to flow through filter media varies with the square of the velocity which in turn is directly related to the filter area, sizing of filters is critical to

both filter media life and the required differential pressure. The selection of filter media is a function of the flow rate required, the sizes of the particles to be filtered, the required clarity of the filtrate and the volume of contaminants.

When filters become fully loaded with contaminants the contaminants must be removed. Filters are generally back flushed to remove contaminants or the filter media is replaced. Backflushing is a reverse flow of liquid to clear the filter; backflushed contaminants must still be isolated and removed. Filter media can be difficult to backflush effectively because particles become lodged in the media and the backflush fluid tends to follow the easiest flow paths. Replacing filter media adds media replacement and disposal costs. Manual filter renewal or replacement is frequent for small filters with low solids loading but becomes difficult in heavily loaded applications and automatic means are employed.

Another factor that can significantly impact coolant filtration performance is the distribution of the particle sizes. Some machining operations produce a range of particle sizes, others produce particles that are fairly uniform in size. During filtration, the process with varied size particles can often build a "cake" where the larger particles are deposited on the media surface and start to capture smaller particles as the cake thickens. In this case, a relatively open, unrestrictive filter media may give very good filtration results with fairly long filter cycles. Other operations such as ceramic and glass grinding produce fine uniformly sized particles. A filter medium tight enough to capture these particles has little chance of building any significant depth of contaminants. The filter media captures a thin layer on the surface and "blinds off" preventing adequate flow through the media. Applications with very fine, uniformly sized particles are much harder to filter, require significantly more filter area for a given flow rate and will consume far more filter media than applications that produce varied particle sizes.