Honing Filtration Fundamentals

by

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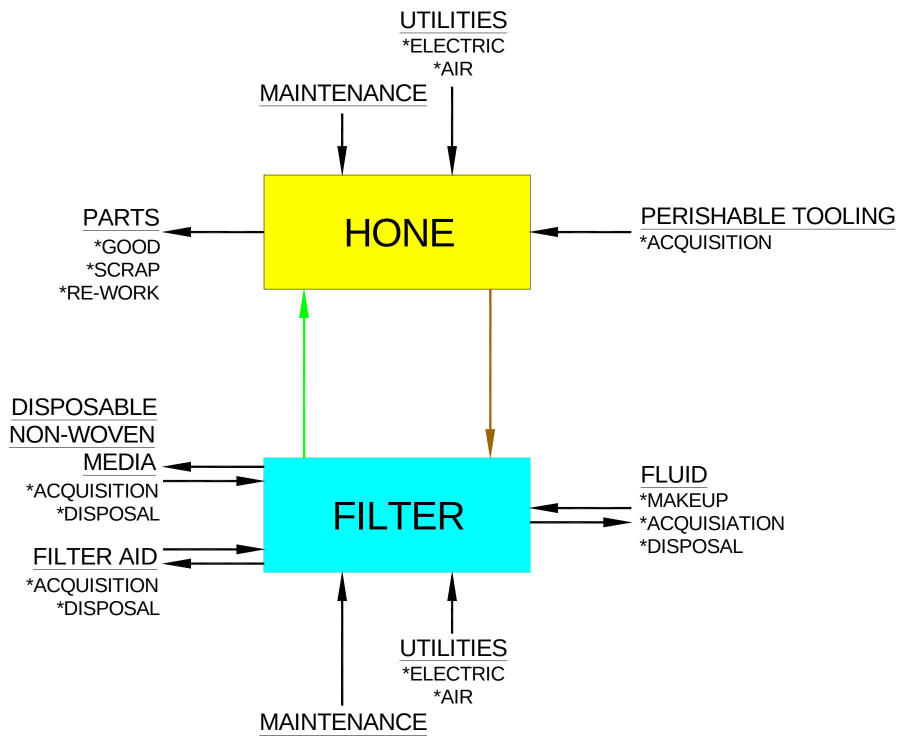
The Goal

In today's manufacturing environment it is essential that every manufacturing process be as efficient and cost effective as possible. Operating costs must be minimized to compete. Parts must be produced at a faster rate with more consistent quality. Productivity must be maximized. The honing process is no exception to the rule.

The goal therefore is to minimize the operating costs associated with the honing process. Certainly there are many ways to do this. We can select a better honing stone and tooling. We can select a better metalworking fluid. All of these are viable options, however many times these variables are changed to treat the symptom of the problem and not the problem itself.

For example, if a manufacturing engineer is faced with the problem of short honing stone life the usual result is to select a harder stone material (at a higher cost per tool). The tool life goes up, however the real problem may not have been addressed. Dirty fluid may have been the reason for the reduced stone life. A better, more cost effective solution in the long run may have been to optimize the filter media selection and/or replace the filter system with a more efficient one. With clean fluid the less expensive tooling could be used - thereby reducing operating costs. Coupled with the other benefits of a better filter, such as reduced disposal costs, reduced makeup fluid costs, and reduced labor to clean sumps the overall operating costs may have been substantially reduced by addressing the problem - a poor filter system, instead of treating the symptom.

The Honing System



The honing system consists of, as a minimum the following items:

- Hone
- Honing stone/tooling
- Metalworking Fluid
- Product
- Filter System

It is our job to minimize the operating costs associated with this system.

What are the operating costs?
The operating costs include, but are not limited to the following:

Hone • Maintenance • Utilities	**Product** • Reject • Rework
Honing Stone • Acquisition Cost • Life • Effectiveness **Metalworking Fluid** • Acquisition Cost to fill the system • Makeup costs to maintain the fluid level in the system • Disposal costs	**Filter System** • Maintenance • Utilities • Filter Media Costs • Dump and Recharge Costs • Fluid Disposal Costs • Solids Disposal Costs • Media Costs

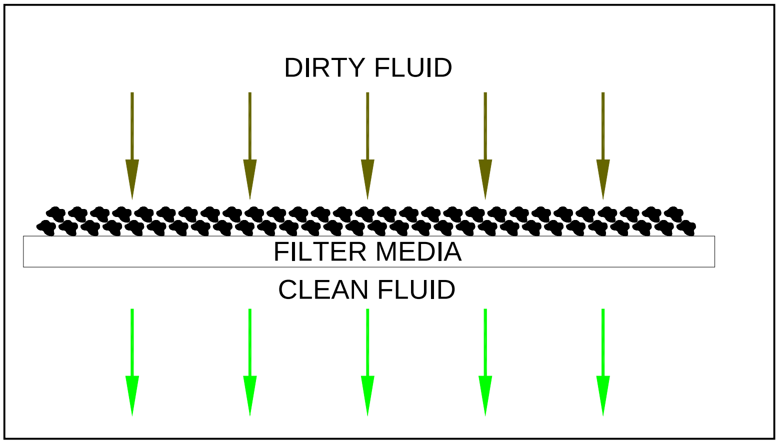
How do we minimize the operating costs through better filtration?
There is no perfect filter or filter media. There is however, an optimal combination for every application. With a proper understanding of the filtering process, available filters, and available filter media it is possible to select the best system for any application. The information contained herein is designed to assist in making the proper choices.

Principals of Filtration:

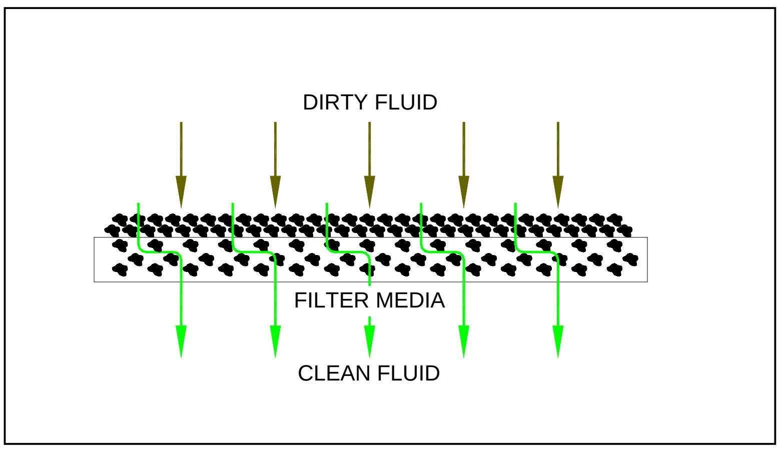
All filters utilize a force to drive fluid through a barrier (filter media) where the solids are collected. **Higher differential pressure across the media translates to more and finer particles being removed - a better, more efficient filter.**

In some cases the barrier merely prevents the solids from entering the clean side of the system (screening). In this case the solids are not removed from the system but are prevented from entering the clean side.

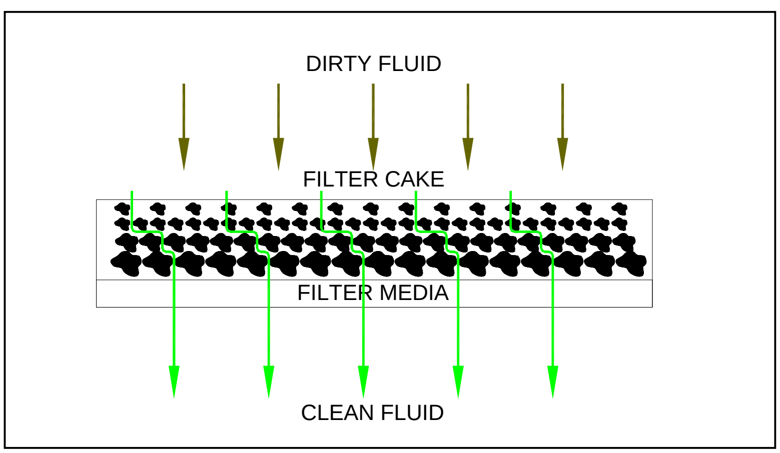
In other cases the solids are trapped and removed from the system (filtering). The filtration process can take 3 forms; 1) surface filtration, 2) depth filtration, and 3) cake filtration. All 3 forms of the filtering process are utilized to remove honing solids from metalworking fluid. NOTE: For this discussion the filter barrier is usually non-woven disposable media, or filter paper.



Surface Filtration:
In surface filtration the media is the sole barrier to trap and remove solids. In this form of filtration the solids are trapped on the surface of the media and once the entire surface is plugged the media will be indexed to expose another fresh section. The media is generally very tight and relatively expensive.



Depth Filtration:
In depth filtration the media is the sole barrier to trap and remove solids. In this form of filtration the solids are trapped in the depth of the media and once the depth and surface are plugged the media will be indexed to expose another fresh section. The media is generally very tight, and is lofted (has depth), and is relatively expensive.



Cake Filtration:
In applications where there is a good mixture of larger solids and small particles we can use the larger particles to bridge over the filter media and establish a filter cake to trap finer particles. In this form of filtration the larger dirt becomes the filter media and traps smaller particles for removal.
Dirt filters dirt.

The grinding process produces a good mixture of large and small solids. The honing process generally does not. In this case we have two choices; 1) select a larger filter, or 2) add the larger particles in the form of a filter aid. The filter aid establishes the cake and traps the smaller particulate. It also extends the filtering cycle. Many different types and grades of filter aids are available and some of these are described later in this document.

In cake filtration the filtration media need only be tight enough to catch the solids to establish the cake. The filter media for this application can be a cleanable belt.

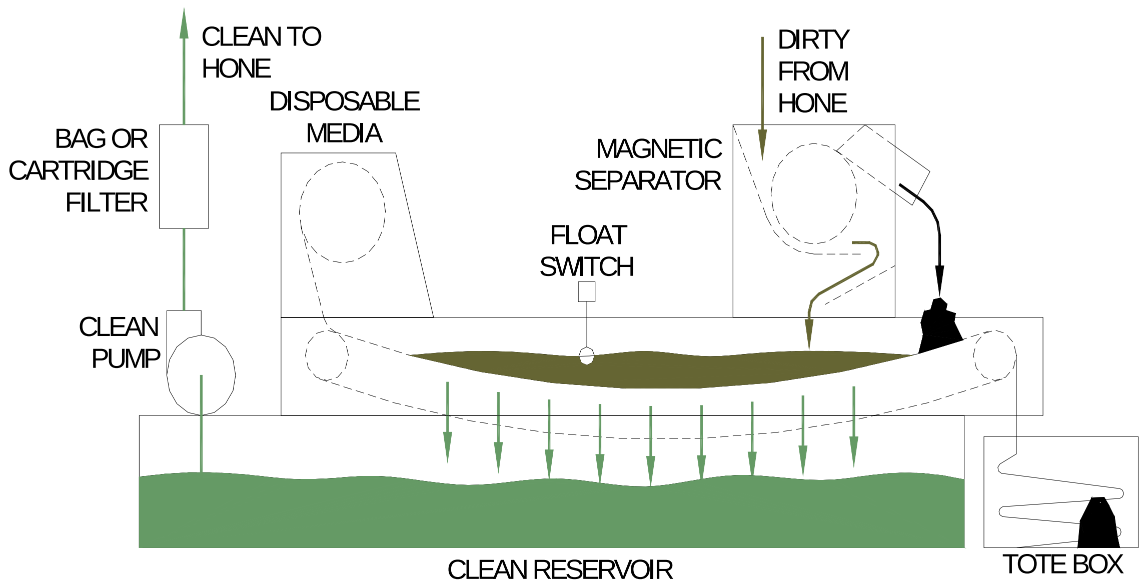
Common Liquid/Solid Separators:

There are many devices that can be utilized to remove solids from liquids. Some of these are as follows:

- Centrifuge
- Separators
    - Hydrocyclone
    - **Magnetic**
- Dragout
- **Gravity**
- **Vacuum**
    - **Hydro-Vac**
    - Air Vac
- **Pressure**
    - Manual Clean
    - Bag
    - Cartridge
    - **Automatic Clean**
        - **Tubular Backwashing**
        - **Flat Bed**
- Combinations
    - Tubular Backwashing with Flat Bed Pressure Filter
    - Tubular Backwashing with Dragout
    - Others

All of these are used in metalworking applications, however many are not efficient enough for honing. This paper will detail only the most commonly used devices for honing **(Bold)**.

Gravity Filter (Surface Filtration Mode):

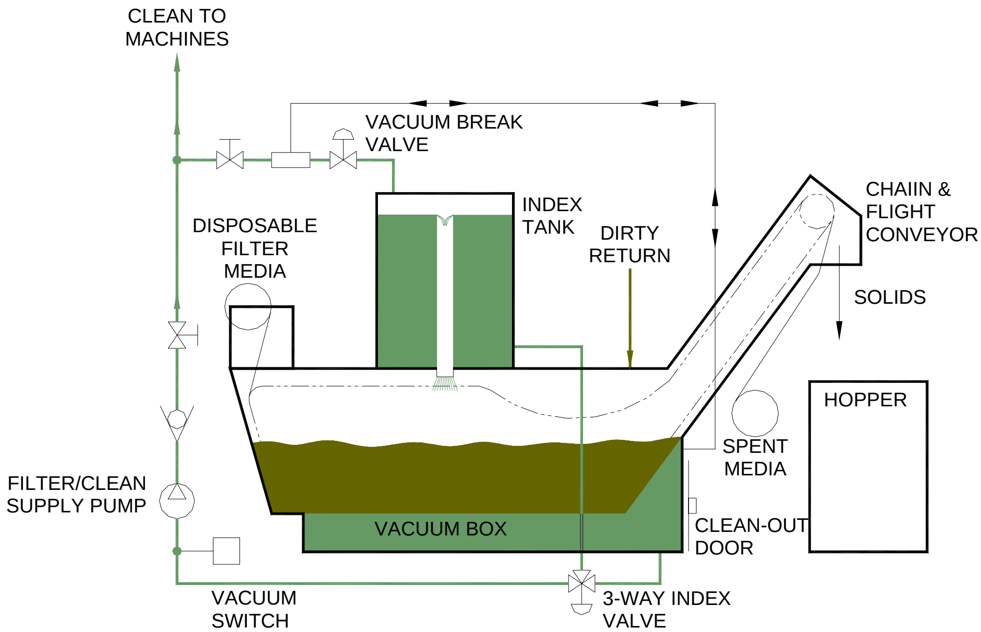


The gravity filter is a simple filter where the force driving the fluid through the filter media is gravity. As the media plugs and the fluid level rises a float switch is tripped and the media is indexed. The gravity filter usually must be combined with a magnetic separator and in some instances a bag or cartridge filter to increase efficiency when used for honing. The magnetic separator will remove ferrous particles. The bag or cartridge filter is usually placed in the clean supply line to protect the hone from any particulate that has passed through the separator and filter media.

Gravity Filter	
Features	**Limitations**
Inexpensive	Low Efficiency Secondary Filter Required Frequent Dump & Recharge of Fluid
Simple	Higher Media Cost per Gallon Processed
	Limited Media Selection

Gravity Filter	
Features	**Limitations**
	Manual Attention to Change Bag/Cartridge
	Wet Cake Discharge High Fluid Makeup Costs High Disposal Costs

Hydro-Vac Vacuum Filter (Surface, Depth, or Cake Filtration Modes):



HYDRO-VAC VACUUM FILTER

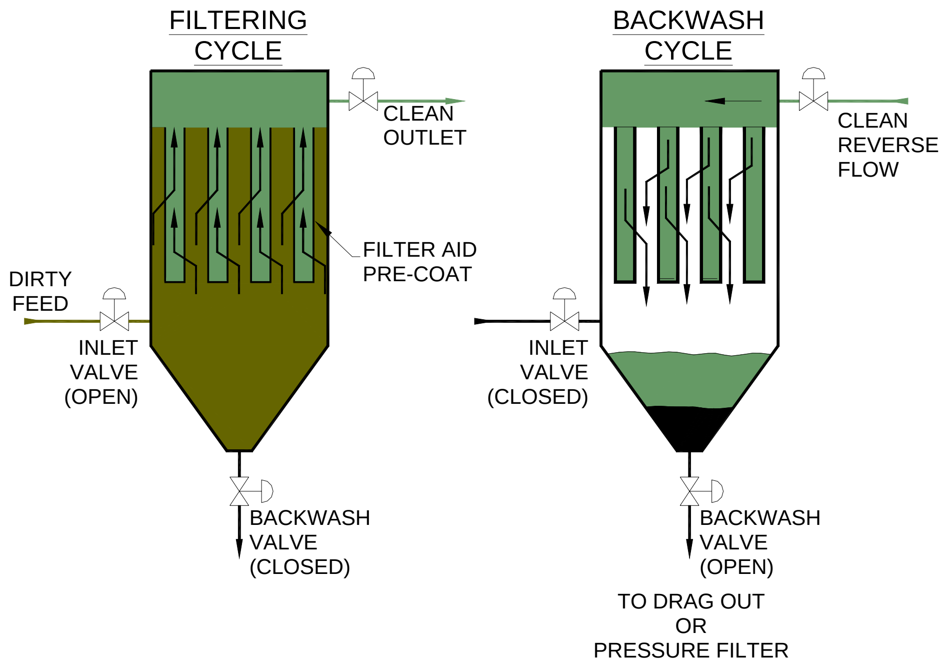
The hydro-vac is essentially a drag tank that utilizes filter media. The media lay below the fluid level in the dirty tank. It is held in place by the weight of the chains and flights. The filter pump draws a suction under the media to pull the fluid through it. The solids are contained on the top. When the media becomes plugged with solids the pump suction is redirected to a clean reservoir and the vacuum on the filter media is released. The conveyor motor is energized and the media is indexed 12"-24". The spent media may be re-rolled for easier disposal. After the index cycle the pump suction is returned to the vacuum box and fluid is once again drawn through the filter media. The clean reservoir is re-filled for the next index cycle.

Some vacuum filters can utilize cleanable belts as well as disposable non-woven filter media. In the honing application the cleanable belt must usually be utilized with filter aid. The filter aid protects the belt from plugging.

Hydro-Vac Vacuum Filter	
Features	**Limitations**
Less Media Usage than Gravity	Limited Media Selection Limited Efficiency

Hydro-Vac Vacuum Filter	
Features	**Limitations**
Greater Media Selection than Gravity	No Positive Seal Fluid Bypass from Dirty-Clean Limited Efficiency
Better Efficiency than Gravity	Maintenance Moving Conveyor in Dirty Fluid Must Drain Tank to Service Filter
Filter Aid Capability	Wet Cake Discharge High Fluid Makeup Costs High Disposal Costs

Tubular Backwashing Pressure Filter (Cake Filtration Mode):



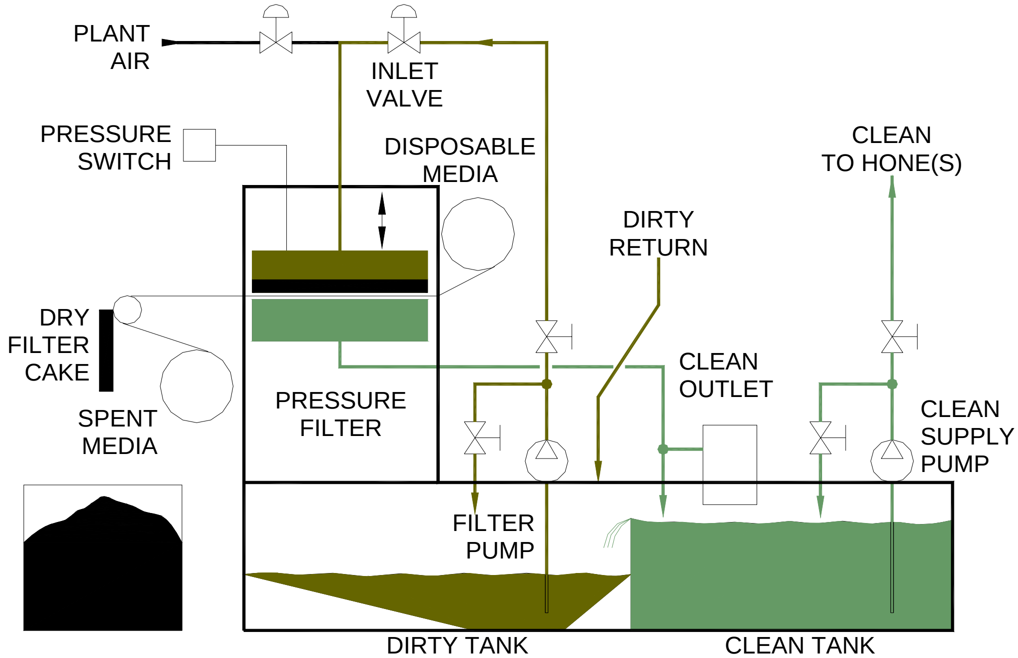
BACKWASHING TUBULAR PRESSURE FILTER

Tubular filters require the use of filter aid (diatomaceous earth, Perlite, cellulose, etc.) to function properly. Tubes are pre-coated with the filter aid material by pumping a slurry of the filter aid and process liquid into the vessel. This provides a filtration barrier down to sub-micron levels. Dirty liquid combined with filter-aid slurry (body feed) is pumped into the filter during the filtration cycle to further enhance the filters efficiency and filtration cycle length. When the filter reaches it's terminating pressure (usually 20-30 psi) the filtration cycle is ended and the tubes are automatically back washed with clean liquid. The dirty backwash slurry is drained into a collection tank for dragout or de-watering/de-oiling with a flatbed pressure filter.

Virtually any number of tubes can be provided within single or multiple housings. Common sizes include 248 tube (186ft^2 of filtering area) and 376 tube (282 ft^2 of filtering area) housings.

Tubular Backwashing Pressure Filter	
Features	**Limitations**
Highest Level of Filtration	Must use Filter Aid Can Strip Components of Some Fluids
Low Operating Costs Filter Aid Cost per Gallon Processed Fluid* Disposal*	Can be Difficult to Pre-coat Vertical Tubes Limited Efficiency w/bad pre-coat Tube Plugging w/bad Pre-coat
	Wet Cake Discharge High Fluid Makeup Costs** High Disposal Costs**
**When used with flat bed pressure filter for de-watering or de-oiling solids*	***Unless used with flat bed pressure filter*

Flat Bed Pressure Filter (Surface, Depth, or Cake Filtration Modes):



PRESSURE FILTER

The filter can be described as a single, horizontal chamber pressure filter that is fully automatic and operates at up to 50 psi differential pressure. The filter chambers are closed with the filter media (filter paper or cleanable belt) between them. Dirty liquid is pumped into the filter and solids begin to accumulate on the filter media thereby increasing the filter pressure. When the pressure reaches the terminating set point the dirty liquid flow is stopped and compressed air is brought into the upper chamber to dry out the collected solids. When the solids are dry the chambers are separated and the filter media is advanced until a fresh section of media is in position between the chambers. The process is repeated. The dry solids are separated from the filter media for disposal.

Flat Bed Pressure Filter	
Features	**Limitations**
Highest Level of Filtration Positive Seal - No Bypass of Dirty to Clean Filter Aid Capability Largest Media Selection	Limited Range of Sizes

Flat Bed Pressure Filter	
Features	**Limitations**
Reliable No Submersed Conveyor or moving Parts in Dirty Fluid Essentially Static Device	Highest Cost per Unit of Filtering Area
Small Footprint Less Filtering Area Required to do the same job Easier to Fit into Tight Spaces - Modular Design	
System Design Ensures that Machines will be Supplied with Fluid at all Times - Will Not Starve Machines	
Dry Cake Discharge Less Fluid Makeup Less Solids Disposal Minimal operating costs	

Filter Media:

Filter media includes non-woven, disposable media (filter paper) and cleanable belts. Both of these play an important role in the filtering process. The role of the filter media differs with the mode of filtering; surface filtration, depth filtration, or cake filtration.

Role of the Filter Media:

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Surface Filtration:
In surface filtration the media is the only barrier to trap solids and prevent migration. A tight, consistent media with random distribution of fibers must be selected. These media are usually relatively inexpensive. Examples would be spunbond polypropylene or polyester/cellulose blends.

Depth Filtration:
In depth filtration the media is again the only barrier to trap solids and prevent migration, however in this mode the media is designed with some loft (depth) to trap the solids in it. These media are some of the most expensive, but can be very efficient at removing solids and extending filter cycles to acceptable limits. Examples would be PowerLoft, CrystaLoft, and HolliFlo.

Cake Filtration:
In cake filtration the role of the filter media is to catch the large particles to establish the filter cake. After the large solids are trapped they become the filter media. Dirt filters dirt. In this mode the media needs to be just tight enough to establish the cake. Relatively inexpensive disposable, non-woven media can be selected. Cleanable belt material can be utilized on the flat bed pressure filter and to a lesser degree also on the vacuum filter. Examples would be Rayon, spunbond polypropylene, and spunbond polyester.

Types of Filter Media:

There are many product families available to choose from. Each family has a number of different grades or basis weights. Each product therefore has a basic set of measured properties that indicate overall performance. These include material, weight (oz/yd^2 in US), grab strength (in machine and cross directions), burst strength (psi in US), and air permeability (CFM/ft^2 in US). Heavier basis weights within the same family will be stronger and tighter. However, this is not true when comparing different families of products. A 1 oz/yd^2 rayon is not equivalent to a 1 oz/yd^2 spunbond polypropylene.

Some manufacturers will provide a nominal micron rating for each product. These ratings should only be used as a guide. Non-woven media do not have a woven, consistent opening size. The tighter media have smaller diameter fibers that are more randomly distributed which provide a tighter nominal micron rating.

Some non-woven, disposable media product families are:

Rayon (Surface Media):

Common Weights:	0.5 OSY - 1.25 OSY
Notes:	Lowest cost/yd^2
	Unidirectional fibers - low efficiency
	No wet strength – can't be used on vacuum filter
	Absorbs some tramp oils

Spunbond Polypropylene (Surface Media):

Common Weights:	0.5 OSY - 2.50 OSY
Notes:	Good general purpose media
	Good strength
	Oleophilic (attracts oil)
	Low cost/yd^2
	Layered versions available for limited depth filtration

Spunbond polyester (Surface Media):

Common Weights:	0.50 OSY - 3.0 OSY
Notes:	Very strong
	Chemical and temperature resistant
	Moderate/high cost/yd^2

Polyester/Cellulose (Surface/Depth Media):

common Weights:	1.0 OSY - 3.5 OSY
Notes:	Good strength
	High cost/yd^2
	High efficiency
	Absorbs some tramp oil

Meltblown Polypropylene (Surface/Depth Media):

Common Weights:	1.0 OSY - 2.7 OSY
Notes:	Very high efficiency
	Very little wet strength – can't use on vacuum filters w/o support media
	Moderate/high cost/yd^2

Lofted (Depth) Media:
Most of these media are proprietary in material and construction. These are usually heavy products starting a 2.0 OSY . Some are as heavy as 9.0 OSY. Some examples are PowerLoft®, CrystaLoft®, HolliFlo®, and MasterFlo®.

How to select the proper filter media?
Proper media selection is dependent upon many factors, including, but not limited to: type of filter, filter condition, fluid, material being honed, mode of filtration, maximum particle size allowable, ... I recommend consulting with a filter media supplier to obtain the optimal selection.

In general, select the media that delivers the best performance/operating cost ratio. A tighter, more efficient media may be more costly per roll but may deliver lower operating costs, i.e. longer life, better part quality - less scrap, less fluid usage, etc.

Filter Aid:

Filter aids are solid, intricately shaped, porous particles that are utilized as the large particles to remove smaller particles in the cake filtration process. There are numerous filter aids available, however most will fall into three categories; cellulose, perlite, or diatomaceous earth (DE). Each has properties that make them attractive.

Role of filter aid:

Filter aids extend filtering cycles and increase filter efficiency. The smaller solids are trapped by the larger, porous filter aid solids in the depth of the filter cake. This provides a flow path for the fluid and prevents the filter media from plugging prematurely.

Type of filter aids:

Cellulose:
There are a number of different grades of cellulose fiber filter aids. They are generally classified by the average fiber length. The longer the fiber, the more easily it will bridge the filter medium. The shorter the fiber, the more efficient it will be at removing smaller particles.

Notes: Not as efficient as perlite or DE
Ash less. Can be incinerated.
Inert
Organic

Perlite:
Perlite consists of naturally occurring siliceous rock (volcanic glass). When perlite rock is heated quickly the water trapped in it is released and it expands from 4-20 times its original size. Several grades are available. They are generally classified by relative porosity.

Notes: More efficient than cellulose
Inert

Diatomaceous Earth (DE):
DE is an industrial mineral composed of the skeletal remains of microscopic aquatic plants. These are called diatoms, hence the name diatomaceous earth. DE is available in numerous grades and are usually classified by median pore size.

Notes: Most efficient filter aid
Composed mainly of silica
10-200 micron in diameter
Human carcinogen, however with proper handling not dangerous.

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Proper filter aid selection is dependent upon many factors, including, but not limited to: type of filter, filter condition, fluid, material being honed, mode of filtration, maximum particle size allowable, ... I recommend consulting with a filter aid supplier to obtain the optimal selection.

In general, select a filter aid that has about the same size particles and an equal amount as those to be removed. As always, select the filter aid that provides the best performance/operating cost ratio.

What are The Benefits of Good Filtration?

We've analyzed the process, selected the best filter media or filter aid or have selected a different type of filter. What do we stand to gain? What are the benefits of good filtration? Minimally they are:

- Proper Honing Tool Action
    - Expansion
    - Contraction
- Extended Stone Life
- Extended Fluid Life
- Reduced Disposal Costs
    - Fluids
    - Solids
- Increased Productivity
- Better Quality Parts

These translate to **maximum productivity and minimal operating costs!**