Bag filtration

Considerations in bag filtration

When selecting a filter bag and the assorted options various aspects need to be taken into consideration to make sure the best possible performance level will be achieved. This article looks at some of the most relevant criteria.

Bag filtration is used in many industrial processes to remove unwanted particles from a liquid. Traditionally, this filtration method was a basic option for nominal non-critical applications. Today, filter bags are used to filter many different liquids, from water to glue, for wider and more stringent applications and conditions. Some of the most relevant criteria are:

- Characteristics and size of particles or solids to be removed (absolute versus nominal)
- Process conditions (flow rate, pressure, temperature)
- Filter media types
- Ways to improve filtration processes
- Considerations for filter housing choice

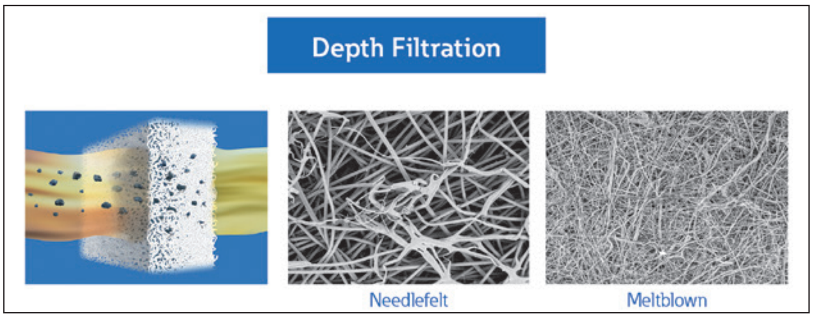

Figure 1. Typical filter media of depth filtration.

Characteristics

When cleaning a liquid, only certain contaminants may need to be removed but others, which are not critical or which are valuable, can or have to stay in the filtrate. When practically all particles of a specific size and larger need to be removed an 'absolute' filter is needed. The 'absolute' pore size rating specifies the pore size at which a particle of a particular size or larger will reliably be retained by the filter with defined efficiency (e.g. >99%) under strictly defined test conditions. Example: 15 µm absolute means that all particles with pore size of 15 µm or larger will be retained to 99% during one filtration process.

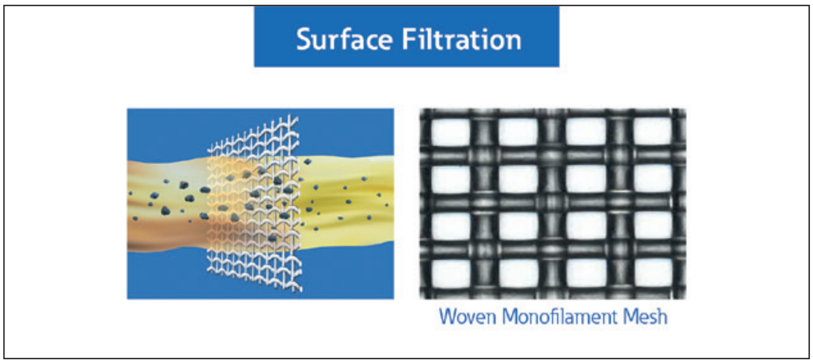

Figure 2. Typical filter media of surface filtration.

A 'nominal' pore size rating refers to a filter capable of preventing passage of an undefined percentage of solid particles of greater than the stated pore size, which is normally expressed in micrometers (or microns). Conditions during filtration, such as operating pressure, shape and concentration of particles, have a significant effect on the retention capability of the filters.

The discussion on 'nominal' versus 'absolute' is one of the most important criteria to look at. 'Nominal' is not worse than 'absolute'. The key is to find the filters that work best in the specific application without exceeding or putting in finer filters than needed. This is typically done by on-site testing.

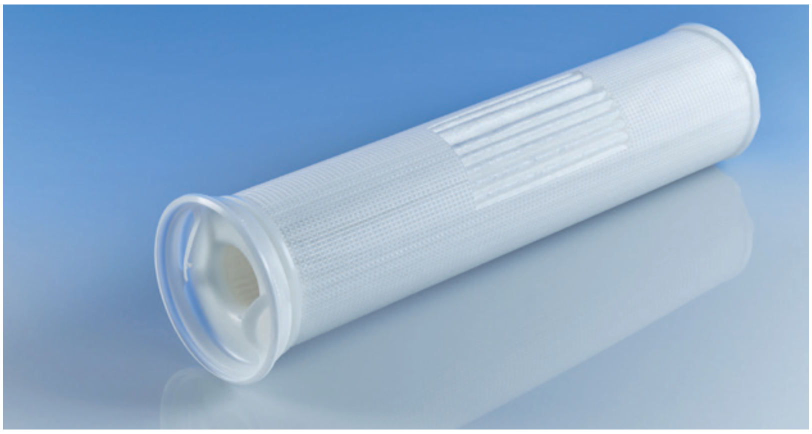

Figure 3. Structure of a pleated filter bag.

The cost-value ratio needs careful consideration: the finer the filter, the more expensive it will be. In addition, finer filters typically clog faster, too, which relates to downtime and again increasing costs. To avoid clogging, the industry often relies on two or more filtration steps. With every step, the filters become finer in order to remove smaller particles than in the previous step. This prefiltration process reduces the risk of too early filter clogging until final filtered liquids are ready for usage.

Process conditions

The process conditions are highly relevant to choosing the right filtration solution. Depending on the application there might be a need for a specific temperature resistance or the ability to deal with higher pressures. Next to choosing the right type of filter, process parameters also play a role in the specific sizing of the system.

Once the filter type is selected, the required flow rate defines the number of filter bags required. Depending on the process conditions, the quantity of filter bags can be increased. In a batch process, for example, more filter bags might need to be considered to avoid interruptions for changing out filter bags. Following a scheduled change-out interval it may be more appropriate for better maintenance planning.

Other factors can be ergonomic in nature, or footprint or height restrictions. Often smaller, more compact filters are preferred for height accessibility or ease of exchange. When filtering viscous liquids, such as glues, paints or resins, it may be more practical to have a shorter type filter where the housing has a lower access point and the bag itself is shorter. The capacity will only be half of the more popular size, but the ergonomic advantage makes it the preferred option.

Filter media types

Filter bags are popular in many processes and industries, going from basic water over food products, paints and coatings to various chemicals and solvents and all in variable ambient temperatures for these applications. Typical filter materials are polypropylene, polyester and polyamide (nylon). Each of these has specific characteristics, making them compatible in specific conditions. There are three basic filter media types: needlefelts, woven monofilament meshes and meltblown media.

Needlefelts are the most popular and are formed by mixing assorted sizes of fibers and condensing them together through a needling process. They carry a 'nominal' rating between 1 µm and 200 µm. Here, polypropylene and polyester are commonly used and available in either a sewn or welded configuration. Where a sewn filter bag with a metal ring used to be the standard choice, this has evolved to a fully welded version with a bypass free plastic seal ring.

The mixed fiber structure makes needlefelts a depth filter. This means particles can be trapped within the matrix of the filter. While large particles will stay on top, smaller ones migrate in the media structure and depending on their size will be trapped or can go through. Needlefelt filters enable high flow rates, while performing at low clean initial differential pressure. To limit fiber release into the filtrate the polypropylene and polyester, different versions feature either a singed or glazed surface finish. Specific versions are available for use in the food and beverage industry.

These versions follow regulations for plastics in contact with foodstuff. Typical applications in the food industry include vegetable oils, fats and sugar solutions. Needlefelt bags are usually a single layer product and are available in standard and extended life variants.

Woven monofilament meshes form a 2D grid surface filter. They typically vary between a 5 µm and 1,200 µm particle size range. When looking at round and crystalline particles, these filters can be considered to be 'absolute' rated and as such, they will provide a much sharper cut off, where it is critical to remove all particles of a certain size or bigger. A typical application here can be the protection of nozzles to prevent blocking of the opening. The most common material used is nylon or polyamide (Figures 1 & 2).

The last media group are the meltblown filter media for which polypropylene or polyester are also the most common materials used. These types of filters are manufactured directly from a polymer without the need to use surfactants or specific additives, as needed for the processing of fibers or in the needling process. The filter media, therefore, has a purer, finer fiber structure, enabling a much tighter retention rate.

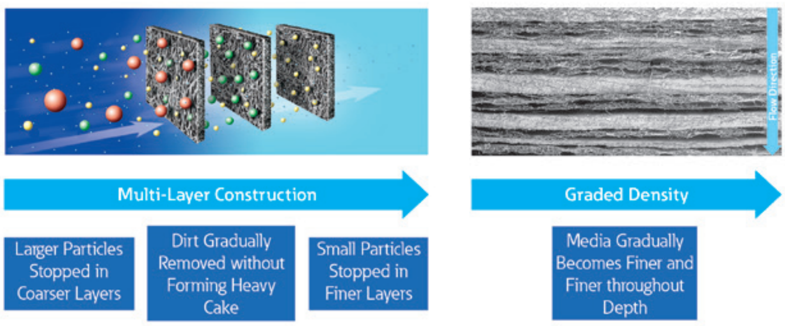

Figure 4. Flow through a multi-layer construction.

Graded multilayer constructions provide a staged filtration process and optimal filtration capacity. These filter bags are typically used where particles need to be removed down to 1 µm on a high efficiency basis and typically have an 'absolute' efficiency rating.

Improvements

One of the key challenges in sizing and selecting the filter media is to find the type of filter that comes closest to the optimal maintenance interval. In the industry many types of filter bags are available that will give the same particle retention efficiency capability but have different capacity levels. All of these filter bags can also be used in the same filter housing, though some may need additional tools or support baskets.

The optimal capacity of the filter bag can be chosen when the filter system is sized up or the capacity can also easily be upgraded in applications already running. Increasing the capacity and life of a filter bag reduces maintenance intervals, saves on product losses and disposal cost. Even when the filter bag is more expensive, optimal selection can offset this additional outlay by bringing savings in process cost.

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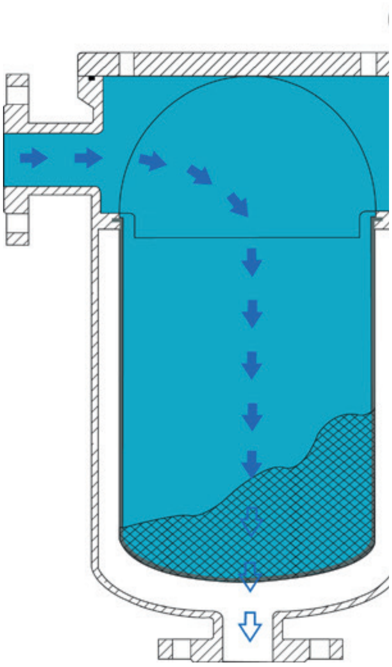

Figure 5. Bag filter housing with side inlet.

There are four different approaches to increase capacity:

1. Add more or larger filter bags (traditional way)

2. Switch to higher capacity filter media

3. Increase the filter area in the existing filter

4. Multi-step filtration (prefilter/final filter) with different pore sizes

The traditional way

The most traditional approach to increase capacity is to increase the number or size of the filters. This can be achieved by installing an extra filter or exchanging the bag filter housing for a larger one. It is, however, a costly option requiring investment, process downtime and extra available floorspace.

There are, however, more astute ways of tackling this problem. Based on the solution there are ways to boost the capacity by a factor 2, 5 or even up to 10 compared to basic standard needle-felt media. There are two criteria that will play a role here. One is the capacity of the media used and the second is the surface area packed into one single filter.

Higher capacity media

Instead of adding additional filters there is the option to switch to higher capacity media. As we learned above, a standard needlefelt is a depth media. Here, the contaminant is trapped in between the fibers of the media and filling the void volume inside that media. Standard needlefelt media (polypropylene or polyester) typically have thicknesses of 2 to 3 mm. There are high-capacity, or often called extended lifetime, media available.

These feature the same removal efficiencies, taking out the same size particles, but are at least twice as thick and have more than double void volume. Hence, when loaded optimally, capacity increases of up to 2 to 3 times can be expected. An added benefit of using thicker filters is the increased retention capability for gelatinous or deformable matter. The filter bag itself is visually similar, apart from the thickness of the media.

Increase filter area

Another way to increase the capacity is to increase the filter surface inside the same filter bag. Various designs can be found and each, however, comes with its specific benefits and limitations. Increasing the filter surface lowers the velocity of the liquid through the filter media. There is also a direct correlation between the velocity through a filter and the capability to optimally load the void volume in the depth of the media.

There is a theory that says when you double the filter surface, you can increase the capacity by a factor 2 to 4. The higher gains relate more to applications where there is a constant cake build-up of crystalline particles of the same size. This is not always the case and the capacity gain will be somewhere in the middle. What is true,

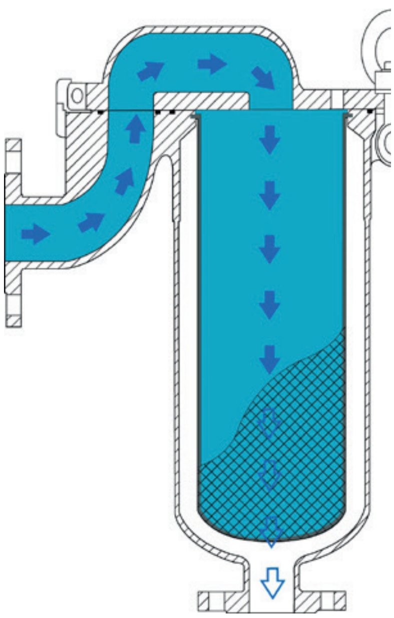

Figure 6. Bag filter housing with top inlet.

however, is that there always will be an extra gain above the sheer increase of surface.

There are two common ways to increase the surface inside the filter bag. One design has a normal outer shape, but also features an additional inner cylinder of a smaller diameter, which is inverted inside the outer cylinder. Both are joined at the bottom by a simple flange. The filtration surface can be increased by as much as 65%. An additional and very important advantage is that the inner volume of the filter bag is reduced by 75%. This is volume that is not used and can be taken up by unfiltered liquid, which is lost when the filter is hard to drain.

A second and most typical way to increase the surface inside a filter is the pleating process (Figure 3). However, the right balance needs to be found between the surface area and media depth. When used in bag filtration one further factor plays a crucial role, this is the direction of the flow. A cartridge filter operates with a flow from 'out' to 'in'. In a circular pleated construction, however, the unfiltered liquid arrives where the pleats are nicely open.

The filtrate leaves the pleats where they are dense and compressed; here there is no particle build-up. In a filter bag concept, however, this goes the other way. It is critical, therefore, to design the filter so that liquid and particles can pass through the pleat structure at the inside and can be trapped inside the filter media. A proper use of separation and drainage layers can help here.

Figure 7. Eaton's TOP LINE single bag filter housing with top inlet.

Multi-step filtration

Last but not least, multi-step filtration is always worth considering when increasing the capacity of a filter. This concept combines two or more filter levels with different pore sizes: pre- and final filtration. Certainly, when having contaminant with a very wide spread of particles sizes, it makes sense to remove contaminants in different stages. It can even be so with different filter systems (Figure 4).

In traditional filter bags, the basic way again is to install multiple filter housings, this time connected in series. Filter bags of a lower to a higher retention are then passed through in sequence. As an alternative multilayer filter bags can be selected; the benefit being that, as they are all together in one bag, only one housing is needed and footprint is reduced. This type of installation is used for higher efficiency filter bags, where particles of descending size are held back through the graded depth of the filter.

Housing considerations

There are two basic flow patterns: top inlet or side inlet (Figures 5 & 6). Top inlet versions have the filter bag sealing ring compressed directly by the bolted lid - this improves sealing and eliminates potential bypass. The filter bag also sits level at the top of the filter and is, as such, easier to change out. This version is recommended for all higher efficiency filters. The housings also have a reduced height and better accessibility compared to the side entry models.

Finally, there are two extra accessories used to help facilitate filter bag operations. The Bag Lock, also known as Bag Positioner, tool is used to install the filter bag in an easy and correct way. As its intrinsic strength is limited, it needs to be supported by a metal basket which will take all the differential pressure. Unsupported bags can be prone to damage and bursting problems, certainly at the bottom seam area.

The accessory can stay in the housing during filtration and prevents the filter from collapsing during backflushes. It can also be reused during the next maintenance phase. These accessories can also be equipped with magnetic rods, serving as an extra trap, catching ferritic particles prior to coming to the filter media. This enhances filter life or prevents damage from the sharp metallic particles.

Standard size 02 filter bags measure 180 mm (7 in) diameter with a length of 730 mm (29 in), which provides a filter surface of about 0.47 m^2. However, inside the bag is a volume of close to 16 liters (4.2 gallons), which remains mainly unused. When the filter is clogged-up and requires replacement, it can be sometimes difficult to drain this liquid, which leads to product loss and makes removing the bag significantly more difficult.

A displacement balloon is a metal, stainless steel construction, that takes up that unused volume inside the filter bag. It is placed inside the bag and stays there during filtration, before removing the filter for maintenance, the bag positioner is taken out and the volume of the product inside the filter bag drops from 16 to 7 liters. This accessory is very commonly used for all viscous and expensive products, e.g., paints and resins.

Bag filtration

With more than 50 years in use, bag filtration is a standard process used around the world. Its ease-of-use and high capacities have always been the major benefits of filter bags. With the new developments in materials and technology, filter bags are becoming more and more popular.

Being capable of 'nominal' to 'absolute' filter levels, filter bags can be valid alternatives in many stringent applications. As the article explains, thoughtful planning and appropriate scaling are key to success when choosing the right filter bags. Therefore, Eaton Filtration is offering in-depth consultancy on choosing the right filter technology and filter bag to its partners and clients and guarantees the same high level of product quality worldwide. ●

About the author

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