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DISPOSABLE FILTERS - A REVIEW

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Abstract: Filtration is removal of particles from fluid by passing it through a permeable media. The device used to achieve this is known as a filter. The range of fluids used in chemical processing covers a vast spectrum from paint to food, to fine chemicals. Each filter has its own merits and demerits and is applicable for a certain filtration range; some can be used as pre-filters while some have very good dirt holding capacity. Any single type of filter may not be suitable for the removal of different types of contaminants and that too of wide particle size range. Large variety of disposable filters are available like melt blown filters, cartridge filters, pleated filters, spun bonded filters etc. Hence filters produced with different techniques are available from which to choose as per requirement of the process and different types of filtration procedures for testing them. This paper gives a review of the popular category of disposable filters available in the market with their application range.

Keywords: contaminants, filtration, trapping mechanism, melt blown filters, string wound cartridges, pleated filters

I. INTRODUCTION

The type and nature of contaminants in the slurry to which a filter may be subjected when used in field is unknown. If the particle size of known elements is taken in to account like human hair is of 75µm, or the smallest pencil dot a human eye can see is of 40 µm. In the micro organism's category, a yeast cell is of 3 µm or a common bacterium is of 0.2 µm. These dimensions given here have been given to make it clear that the fluids which need to be filtered may contain contaminants of variable sizes, including those which may or may not be - visible by eye, flexible or living.

Depending upon the targeted particle size to be removed, the entire filtration process can be classified as micro filtration, ultra filtration and reverse osmosis in the increasing capacity of trapping power of smaller particle sizes. Figure 2 shows the micron (µm) range for the three different types of filtration which are very common in this field.

0.0001µm - 0.001µm 0.2µm 0µm-100µm

$1A^0$ <----------> $10A^0$ <--------> $200A^0$ < ---------> $100{,}000A^0$

Reverse Osmosis Ultra filtration Micro filtration

Figure 2 shows particle size removal ranges of various types of filtration **[1]**

II. NATURE OF CONTAMINANT AND FILTRATION CHARACTERISTICS

Contaminants within these fluids fall into three categories:

1 Solids such as sand grit and pipe scale.
2 Gelatinous particles formed in the mixing process.
3 Fibres from hairs and packing materials.

Solids are relatively easy to remove from a fluid. Flexible contaminants including fibres are not always easily removed because they sometimes can squeeze and make their way through the filter structure. The most difficult to remove are deformable gels. These have the ability to blind a filter by smearing over its surface. At high pressure drop, gels also can be extruded through the filter structure. They are best removed if filter media with gradual decreasing pore size is used. String wound cartridges are suitable to remove all of the three mentioned contaminants.

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The industry as shown in [2] may follow any method/procedure of filtration & separation to remove unwanted particles or contaminants like centrifuge, continuous vacuum filter, filter press, cartridge filter (micro-filtration), dialysis, electro-dialysis, reverse osmosis, and ultra filtration/nano filtration.

III. MECHANISM OF PARTICLE CAPTURE IN VARIOUS FILTERS [1]

Filtration can be classified on the basis of the particle size removal range or on the manner in which the particles get arrested during their course through the filter media for example if particle removal range is 0.2 μm to 150 μm, then the filtration technique can be put under the head of micro filtration. Similarly the way, in which the particles get trapped during their passage accordingly, they can be put under the categories of surface, depth and adsorptive/surface active filters. For example if particles get trapped on the surface of the media then such a filter is called as surface filter.

A. SURFACE FILTERS

Filter media where the pores are within the same plane are called screen or surface filters. The surface filters act as sieves. Particles too large to pass through the pores are retained on the surface. As the contaminant cake builds up on the surface, the degree of filtration often grows finer. A surface filter medium is generally thin. The surface filter traps contaminants on the outside of the filter medium as shown in figure 3.

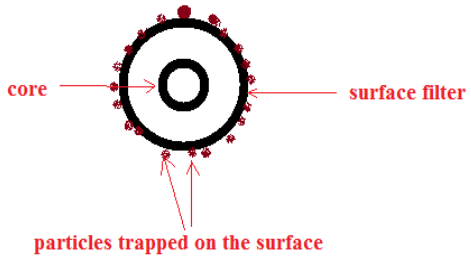

Fig. 3 Mechanism of particle capture in case of surface filter

B. DEPTH FILTERS

The depth filter is the one, which traps contaminants within the medium and is as shown in figure 4. The surface filter is particularly good at removing solids. However, gelatinous and fibrous particles can, given certain conditions, such as high pressure differentials be forced through the pores, either by changing direction in the case of fibres, or changing shape in the case of a gel. The advantage of the depth filter is that it can remove all three types of contaminants effectively. The figure 5 makes a comparison between the mechanism of contaminant capture in case of depth and surface filters.

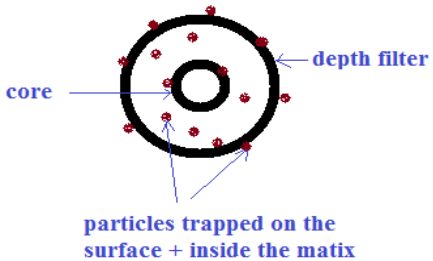

Fig. 4 Mechanism of particle capture in case of depth filter

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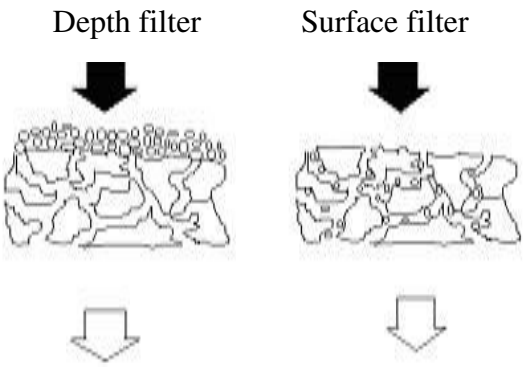

Fig. 5 Percolation of particles in case of surface filter and depth filters [1]

C. ADSORPTIVE FILTERS:

The adsorptive filter media are capable of retaining particles smaller than the rated filter pore size. This is possible in some systems because of surface charge modification of the filter media. The charge is most effective over short distances from the surface and falls off exponentially as distance increases. Accordingly such filters are used principally in the sub-micron filtration. Thus from the above classification it can be understood that the type of contaminant will also play an important role in deciding how the particles will get trapped i.e. whether on the surface or within the medium.

IV. BRIEF BACKGROUND OF VARIOUS TYPES OF CARTRIDGE/CANDLE FILTERS [2, 3]

The disposable filters can be produced using different techniques; this makes the mechanism of particle capture different in each of the case. The use of a specific filter size and type is dictated by the application for which it is chosen. Each filter has its own merits and demerits and is suitable for a certain filtration range and application; some can be used as pre-filters while some have very good dirt holding capacity.

There are four basic types of filter cartridges/candles:

- String Wound Filter Cartridges
- Melt blown (Solid) Filter Cartridges
- Pleated Filter Cartridges
- Media Cartridges: Activated Carbon (GAC), DI resin, Calcite, Alumina, and more

A. STRING WOUND FILTER CARTRIDGES

The string wound cartridge was the original cartridge filter element. A string wound cartridge filter shown in figure 6 is effective in removing diverse sized particles and are best suitable for carrying out micro filtration.

Figure 6 shows photograph of string wound filter [3]

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They are capable of removing particles in the range of 0.2 to 10 microns. They can be used to remove even coarser particles than 10 µm. It removes particles of its micron rating with excellent resistance to being blinded by larger particles. Because of the overlapping nature of the string windings, it has an effective surface area considerably larger than that of the melt blown filter. Cartridge filters as shown in [4] are also widely used in chemical, pharmaceutical, nuclear, health, microelectronics, biotechnology and water treatment industries.

While string wound cartridges predate all the other filters, with polypropylene fibre construction, a string wound is still a good general-purpose filter and in certain applications, the best choice. The choice of supply yarn to be wound on a perforated cylindrical core can be cotton, polyester, polypropylene etc., but in most of the cases it is polypropylene yarn due to advantages like greater volume of air, random fibre arrangement in the yarn structure, greater twist, round cross-section and economic production from filtration point of view as has been shown in [5-7]. These yarns can be produced on ring spinning system or on unconventional spinning systems. But yarns produced on the different spinning systems can exhibit lot of change in their properties especially compactness and hairiness. These two properties are very important as far as the filtration application is concerned. Like the melt blown filter cartridge, string wound cartridges are inexpensive. It is the second most commonly used filter cartridge on the market and is used extensively in pre-filtration applications

Typical applications include:

• 1 to 50 micron filters used in upstream/downstream for general purpose applications.

• 5-micron pre-filters installed ahead of a reverse osmosis system to remove non-uniform sized particles.

B. MELT BLOWN (SOLID) FILTER CARTRIDGES:

In comparison to string-wound, mention needs to be made of melt-blown cartridges. They were developed several years ago as a lower cost substitute for string-wound cartridges. They are made using a one-step process in which high-velocity air blows molten polypropylene resin from an extruder die tip onto a take-up screen or a mandrel to form layers of self-bonding fibre web. The only real advantage melt-blown cartridges have over conventional string-wound filters is freedom from process chemicals. They are not suitable for many industrial applications, as they tend to collapse under even moderate pressure differential. A major shortcoming of the melt blown cartridge is its poor edge sealing that result in by-pass problems. The filter consists of layers of fibres, which can separate rather easily. A melt blown filter cartridge, is as shown in figure 7 is a depth type filter that is good for the removal of relatively uniform sized particles throughout the body of the filter, not just on the surface. Grooves may be provided on their surface to increase its surface area. In spite of its disadvantages, it is one of the least expensive and most widely used filter cartridges on the market today and is used extensively for both commercial and domestic applications.

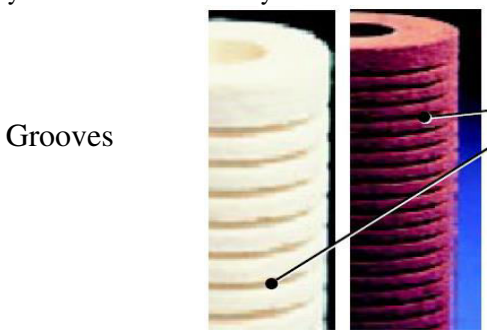

Figure 7 shows photograph of melt blown cartridge [2, 3]

Typical applications include:

• 1 to 50 micron filters used in general purpose applications, with the 5-micron cartridge being the most popular and can be installed upstream/downstream.

• 5-micron pre-filters installed ahead of a reverse osmosis system to remove particles that could clog up membranes and deteriorate performance.

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C. PLEATED FILTER CARTRIDGES

A pleated cartridge is a surface type filter cartridge that is effective in removing diverse sized particles in limited quantities. Pleated cartridges will remove particles of its micron rating with good resistance to being blinded by larger particles. Pleated filter cartridges are particularly effective on surface waters from streams and rivers figure 8. Pleated filter cartridges are constructed to provide a surface area far in excess of the diameter of the filter. The micron rating of a pleated filter is more precise than either the melt blown or string wound cartridges. Though pleated cartridges are more expensive than melt blown or string wound, they are the only choice for sub-micron filtration which lies in the range of 0.45 to 0.1 microns. Sub-micron pleated filter cartridges are used extensively as biological blocks in the production of high-purity and sterile water.

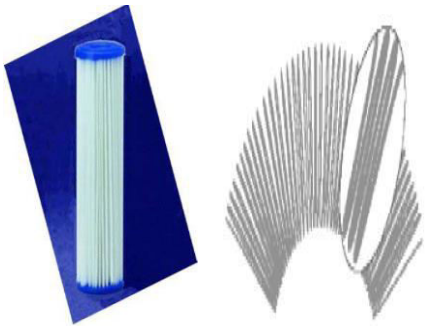

Figure 8 shows photograph of pleated filter [1, 2]

Typical applications include:

- 5-micron general-purpose filters used before and after ion exchange resin columns.
- 1 to 50 micron filter on the vent of a water storage tank to help prevent airborne particles from entering the tank during draw down in non-critical applications.
- Sub-micron post-filters installed as final filters for particle/micro-organism sensitive or critical applications.

D. MEDIA FILTER CARTRIDGES

A Media Filter cartridge is not like the mechanical filters described above. A media cartridge as shown in figure 9 is actually a water treatment device that effects chemical changes in the water. The flow rate through a media cartridge is substantially lower than that a similarly sized particle filters.

Figure 9 Photograph of media filter [2]

Replacement of media cartridges is not dictated by pressure drop. Carbon media cartridge replacement should be scheduled for every three months or more often. Deionizer (DI) cartridges should be replaced according to water quality.

Typical applications include:

- Activated Carbon for the removal of chlorine, taste and odour.
- Mixed Bed DI resin for water purification.
- Calcite media for neutralization of acidic water.
- Many other media are available to handle a wide variety of water problems.

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The water purification systems available in the market are comprised of the above variety due to which not only removal of particles takes place but also any odor etc is possible. Hence the filter should be selected according to its end use and the range of particle size to be removed.

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