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Advances in String-Wound Sediment Filter Cartridges

Summary: *In the last 65 years, string-wound filter cartridges have made vast improvements in regard to reducing contaminants and chemicals in various water supplies. Early factors such as media migration and chemical leaching provided major roadblocks to cartridges' effectiveness. A new development discussed here, but not yet on the market, looks to rectify those issues.*

By Hamid Omar

In the mid-1930s, the first string-wound depth filter cartridge entered the U.S. market. It was made from a woven wire mesh core surrounded by a cotton yarn, which was wound to form the depth filtration medium. The yarn itself was a tightly twisted medium and the major filtration essentially took place at the points of crossings of the yarns—which formed a diamond-shaped pattern—rather than through the yarn.

Roving & friction-spun yarns

By the late 1960s and early 1970s, polypropylene core and other synthetic media became popular as they offered resistance to growth of microorganisms and offered a wide range of chemical compatibility—or resistance. Typical textile yarns were replaced by "rovings"—a slightly twisted roll or strand of usually textile fibers—due to lower cost and improved filter life as more of the liquid could pass through the roving itself.

In the following years, roving, which is an intermediate stage before the final textile yarn forming process, was replaced by friction-spun yarns in the winding of string-wound cartridges. Friction-spun yarn is more economical to produce, is relatively bulkier and offers reduced resistance to flow of liquids leading to further improvement in life and performance of string-wound cartridges. See Figure 1 for a typical string wound cartridge.

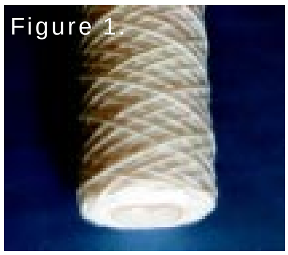
Figure 1.

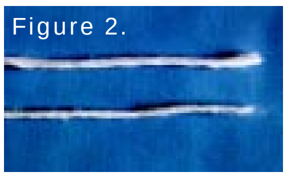
Figure 2.

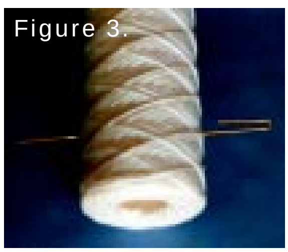
Figure 3.

Media migration

Despite their great popularity, string-wound cartridges have many major drawbacks. Rovings and friction-spun yarns (see *Figure 2*) are made from short chopped fibers. Such yarns containing short fibers are inherently prone to media migration, as all the fibers are not completely locked in place. Media migration is further aggravated by the tremendous amount of aggressive handling involved in the textile yarn forming process. As the fibers go through the bale opening, carding and drawing processes involved in the automated systems of a textile plant, some get broken into shorter lengths. These add to inconsistent performance factors for filters because of both movement and particles that may escape.

Leaching of chemicals

String-wound cartridges made from synthetic yarns produced by any standard textile process have another major drawback—they comprise about 1 percent by weight of chemicals that start to leach out as soon as the filter is put to use. These chemicals may be applied to the surface of the fibers to enable processing on textile machines. They consist of lubricants, surfactants, antistatic agents, antioxidants, bactericides, emulsifiers, etc. Unless the filter has been pre-washed, instructions on the cartridge normally say that after installing a new cartridge, let the water flow for "so many minutes" to precondition the filter.

The problem is that the sediment cartridge is the first stage of most systems and flushed water containing the chemicals goes downstream into other treatments like the carbon filter, UV lamp, water softening resin, reverse osmosis (RO) membrane, etc. These chemicals can be detrimental to performance of all such downstream processes in addition to any possible adverse health effects. For example, a carbon filter is used to remove a range of chemical for aesthetic and health reasons. It's also used as a pre-RO filter to remove chlorine. Chemicals leaching out of a cartridge filter are both adsorbed and deposited on the surface of the carbon, reducing the life and ability of the carbon filter to work efficiently.

Rolling & tunneling

Roving and friction-spun yarns that form the media for string-wound cartridges have one more major drawback—the yarns have a smooth and compact round cross section. They are subject to conditions of flow and pressure fluctuations and these smooth round yarns easily shift and roll leading to a "tunneling" effect and particle unloading. See Figure 3 for a standard closely wound string cartridge. As shown, a paper clip can easily pass through the media with a little pressure. If a paper clip can pass through the filter any sediment can, too. String-wound cartridges made with smooth round yarns also pose a big technical problem in producing required micron ratings and may not give consistent results.

Micron ratings

A micron rating is basically achieved in three ways. First, choose the diameter of the individual fibers. This, however, doesn't have a major influence on micron rating in case of compact round yarns as most of the liquid takes the least resistant path between the yarn gaps rather than through them. Second, wind the yarn close together or with a gap; but as soon as the gap is widened, the round yarns tend to "roll" to one side or the other. Third, control the yarn winding tension. Higher tensions give finer ratings, but also raises the pressure drop and drastically reduce filter life and dirt-holding capacity. Loose tension gives a coarser rating but makes the cartridge soft and prone to dump contaminants—dirt unloading—or allow them to pass through when pressure fluctuates in the system and as the differential pressure rises.

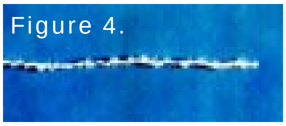
Figure 4.

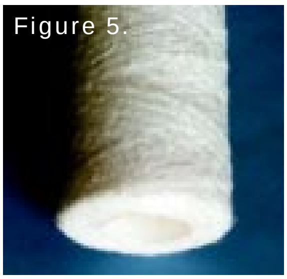
Figure 5.

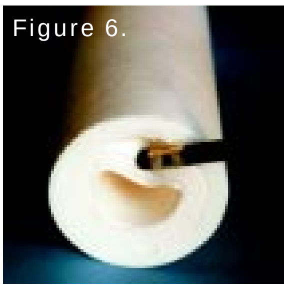
Figure 6.

Latest developments

The latest development in string-wound cartridges has overcome problems with roving and friction-spun yarns and has all the features of melt-blown cartridges. The media of the new string-wound cartridge is made from continuous filaments—each individual filament continues throughout the entire length. There are no short fibers, making the cartridge free from any media migration. These continuous filaments are melt-spun in a way that no chemicals like spin-finish, wetting and antistatic agents, surfactants, emulsifiers, etc., are required. These chemical-free continuous filaments are then randomly oriented to each other, intermixed, looped and entwined forming a non-round, highly stable, bulky yarn (see *Figure 4*).

Random short loops protrude from the surface of the yarn. As the filter is wound, each single yarn traps part of the loops of the adjacent yarn giving a highly stable structure. The yarns get locked in place and will not roll or move to a side. This stable structure also gives excellent sealing. It easily passes the paper clip test. Yarn that doesn't shift easily also makes the filter resistant to particle unloading. With advancements in winding technology (computer controls) and pitch, the number of crossings and space between each yarn can be continuously varied and controlled from start to finish of the cartridge winding. The inner layers of yarn can be wound closer together and the distance between the yarns can be gradually increased toward the outer layers. This achieves density grading without changing the winding tensions for more consistent performance in string-wound cartridges. Coarser particles are trapped in the outer layers and finer particles in the innner layers. In this cartridge, the liquid flows through the entire yarn structure—there are no typical diamond-shaped holes (see *Figure 5*).

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Melt-blown 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're 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 fiber web. The only real advantage melt-blown cartridges have over conventional string-wound filters is freedom from process chemicals. They aren't suitable for many industrial applications, as they tend to collapse under even moderate pressure differential. Most filter housings use a "knife-edge sealing" principle (see *Figure 6*) that offers a more exact seal. A major shortcoming of the melt-blown cartridge is its poor edge sealing that results in "by-pass" problems. The filter consists of layers of fibers, which can separate rather easily.

Conclusion

In short, today's string-wound filter cartridges have come a long way and provide a very efficient and cost effective solution. Some of the benefits are:

- *New melt-spinning and yarn forming process*—no chemicals to leach out,
- *Continuous filaments*—no short fibers means no media migration,
- *High structural stability*—no shifting of media, excellent knife-edge sealing,
- *Random yarn structure*—gives improved filtration efficiency,
- *Higher void-to-solid ratio*—more bulky yarn gives increased dirt holding capacity,
- *Lower pressure drop*—liquid flows through the entire yarn structure,
- *Firmer structure*—gives improved resistance to particle unloading,
- *Better performance*—from more consistent micron rating, and
- *Computer-controlled winding*—gives clear density grading inside to outside as strands are wound.

About the author

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