Developments in
String Wound Filter Cartridges

By Hamid Omar

String wound filter cartridges are the most commonly used filtration media for reducing contamination in water and other liquids. Filtration applications include reverse osmosis and water softening prefiltration, boiler feed water for steam generation, cooling towers and heat exchangers, bottled water, edible oils, oil and gas production, process water for textiles, electroplating and anodizing solutions, as well as in the beverage, pharmaceutical and chemical industries. Standard cartridges are made from 'roving' or 'friction spun' yarn and factors such as media migration and chemical leaching were amongst the major drawbacks to the cartridges effectiveness. With a new innovative development in the filter media for making string wound cartridges, problems such as media migration and chemical leaching have been eliminated.

Filter cartridges, made from cotton yarn media and a metal core were first introduced in the mid-1930s. By the late 1970s cartridges with a polypropylene (PP) core and yarn had become popular as they had a wide range of chemical resistance and could be used in many applications. Before, the PP string media was a 'roving' – an intermediate product stage in the final textile yarn forming process. In the later years it was replaced to a great extent by 'friction spun' yarn that is only similar in appearance to a roving but is relatively bulkier, giving improved dirt-holding capacity and reduced resistance to the flow of liquids.

Media Migration Problem

Despite their great popularity, standard string wound cartridges have a number of shortcomings. Both the roving and friction spun media are made from short chopped fibres, which are usually 50 to 75mm in length. Many of the short fibres on the yarn's surface are not fully locked into the main body, making them susceptible to media migration, as they tend to come loose with the flow of liquid and increasing pressure differential. Figure 1 shows the 'roving' and 'friction spun' yarns used in making standard string wound cartridges.

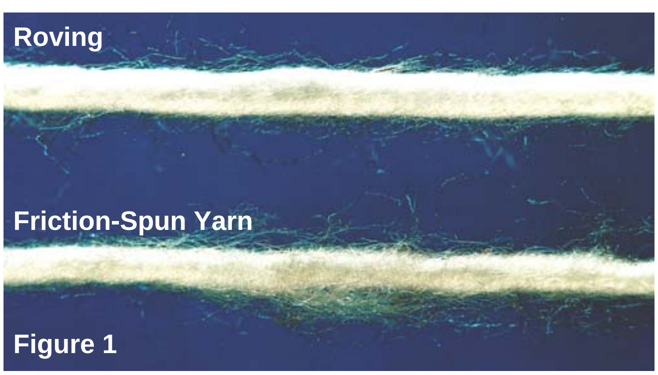

Figure 1

Loose ends of the cut fibres can be seen protruding from the surface of the yarns. The normal textile yarn forming process of fibre bale opening, carding, drawing, and spinning, by which these yarns are made, breaks some of the fibres into even shorter lengths, further aggravating the media migration problem.

Standard Cartridge made from friction-spun compact round yarn with typical diamond shaped open spaces

Figure 2

Chemical Leaching Problem

Another major problem with cartridges made from roving or friction spun yarn is of chemical leaching. In the manufacturing process of these yarns, 'spin-finish' is applied on the surface of the fibres. Spin-finish contains a number of chemicals like lubricants, surfactants, antistatic agents, antioxidants, emulsifiers and bactericides, etc. The quantity of these chemicals can be from 0.5% to as much as 2% by weight of the cartridge. Unless the filter is pre-washed, these chemicals start to leach out and can often be observed as foaming in the filtrate. The leaching of these chemicals are detrimental for the downstream processes like the activated charcoal filter, water softening resin, reverse osmosis membrane (RO) etc. The chemicals can also pose possible health problems when used for filtration of drinking water. For example, carbon filter is used to remove a range of chemicals for aesthetic and health contaminants. Carbon is also used as a pre-RO filter to remove chlorine. Chemicals leaching out from the cartridge filter are both adsorbed and deposited on the surface of the carbon, reducing the life and the effectiveness of the carbon to work properly.

Other Shortcomings of Cartridges made from Roving and Friction Spun Yarns

Filter cartridges made from these yarns, which are smooth and round in cross section, do not form a stable structure. See figure 2 for standard cartridge wound from friction spun yarn. When subjected to conditions of flow and pressure fluctuations, these smooth round yarns are prone to shifting which gives rise to 'tunneling' effect and particle unloading. Unstable structure also poses a problem in achieving consistent micron ratings. Different micron ratings are achieved by winding the yarn close together or with a gap. As the gap between the yarns is widened, the smooth round yarns tend to shift or roll to one side or the other giving inconsistent results. Moreover these smooth round yarns typically form a diamond pattern having gaps between adjacent yarns as well as between the layers. The liquid takes the least resistant path between the yarn gaps rather than through the whole media. See figure 3 for a standard closely wound cartridge.

Standard closely wound fine micron rating cartridge. Unstable structure formed by the smooth yarn enables a paperclip to be easily pushed through the filter media

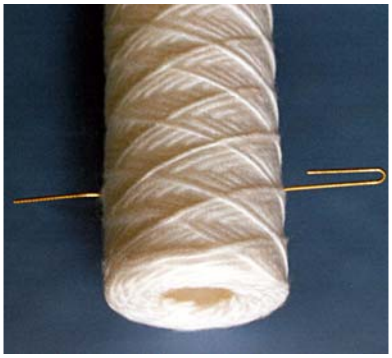

Figure 3

As shown, a paper clip can be made to easily pass through the standard filter with a little pressure. If a paper clip can pass through the filter any contaminants can, too. Pushing in the paper clip has shifted the yarns to a side – this is the reason of 'tunneling' and particle unloading with the standard string wound cartridges.

New Development in String Wound Media

The new development in the media for string wound cartridges has overcome all the above shortcomings of roving and friction spun yarns. The new media comprises continuous filaments rather than short chopped fibres. See figure 4.

New continuous filament media of stable, random and bulky non-round structure

Figure 4

Each of the filaments in the new media continues throughout the whole length of the yarn, making the cartridge free from any media migration problems. There are no short fibres. The continuous filaments are melt-spun (extruded) by a newly developed method without the use of any spin-finish chemicals. These chemical-free continuous filaments are then randomly oriented to each other, intermixed, looped and entwined into a non-round, highly stable, bulky yarn. Random short loops can be seen protruding from the core of the yarn. As the filter is wound from this new media, each single yarn traps part of the loops of the adjacent yarn giving a highly stable structure. The yarns get locked into place and will not roll or shift to a side. A paper clip cannot be made to pass through it. The stable structure makes the filter resistant to particle unloading and also gives excellent knife-edge sealing. See figure 5 for a filter cartridge made from the new yarn media.

Filter cartridge made from new continuous filament media. There are no voids or gaps between the yarn layers

Figure 5

With advancements in winding technology (computer controls), the pitch, 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 near the core can be wound close together and the distance between the yarns can be gradually increased towards the outer layers. Such improved winding allows achievement of density grading without changing the winding tension. This gives more consistent performance and better resistance to particle unloading. Dirt holding capacity of a true graded density cartridge is increased as the coarser particles are trapped in the outer layers and the finer particles in the inner layers. The new media along with the new winding technology forms a stable cartridge without the typical diamond pattern – the liquid flows through the entire yarn structure.

Typical melt blown coreless cartridge. A little push by a pencil shows how easily the edges collapse. Poor edge sealing results in by-pass problems

Figure 6

Melt Blown Core-less Cartridges

Melt blown cartridges were developed several years ago as a lower cost substitute for string-wound cartridges. They are made in a one step process in which molten PP from an extruder is blown onto a take-up screen to form layers of self-bonding fiber web. The only advantage melt-blown cartridges have over the conventional string-wound filters is freedom from process chemicals. These cartridges are not suitable for many industrial applications, as they tend to collapse under even moderate pressure differential. Most filter housing use a knife-edge sealing principle. A major shortcoming of the melt-blown cartridge is its poor edge sealing that results in by-pass problems. The blown cartridge consists of layers of fibres, which tend to separate rather easily. Figure 6 demonstrates how easily these layers separate.

Conclusion

In short, string-wound cartridges made from the new improved media provide a very efficient and cost effective solution. The benefits include:

- No chemicals to leach out with the new melt spinning process.
- No media migration – the yarn comprises continuous filaments.
- High structural stability – no shifting of media, excellent knife-edge sealing.
- High bulk media with improved solid to void ratio gives increased dirt holding capacity.
- Lower pressure drop – liquid flows through the entire media.
- Firmer media structure gives improved resistance to particle unloading.
- More consistence performance, and
- Density dreaded – new improved winding technology gives denser winding in inner layers and coarser winding in outer layers.

About the Author

Hamid Omar is the technical director of Syntech Fibres (Pvt) Ltd., of Karachi, Pakistan. The company specializes in the extrusion and spinning of polypropylene filaments and fibres for textile and technical applications including filters. The company has developed the new improved filter media for string-wound cartridges and produce Aqua Clear ™ and Sedifilt ™ brand filter cartridges. Omar can be contacted at Fax: 021 5060407, e-mail: ***syntech@fascom.com*** *or website:* ***www.syntechfibres.com/filter***