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ELSEVIER ADVANCED TECHNOLOGY

According to Syntech Fibres (Pvt) Ltd, Pakistan, its new yarn is the most significant innovation in string wound cartridge filter media since the development of friction spun polypropylene yarn over a decade ago. Hamid Omar explains.

Continuous Filament Media Revolutionize String Wound Cartridges

Depth filter cartridges made from a cotton string wound media and a metal core were first introduced in the market in the mid-1930s. By the late 1970s cartridges with a polypropylene (PP) core and yarn had become popular because they had a very wide range of chemical resistance, and therefore could be used in a wide variety of applications. Initially, the string media was a roving (a bulky intermediate stage before the final textile yarn forming process). It was later replaced by 'friction spun' yarn that is 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

String wound cartridges made from roving or friction spun yarns are, however, prone to media migration. These yarns comprise short chopped fibres, typically about 75 mm in length, which make them inherently susceptible to media migration because many of the short fibres on the yarn's surface are not fully locked-in. The normal textile process (comprising fibre bale opening, carding, drawing, spinning) by which these yarns are made, can break some of the fibres into even shorter lengths, and further add to the media migration problem. Figure 1 shows roving and friction spun yarn media used in standard string wound cartridges. The loose ends of the cut fibres can be seen protruding from the surface of the yarns. Fibres that are not fully locked-in can become loose with the flow of liquid and/or through an increasing pressure differential.

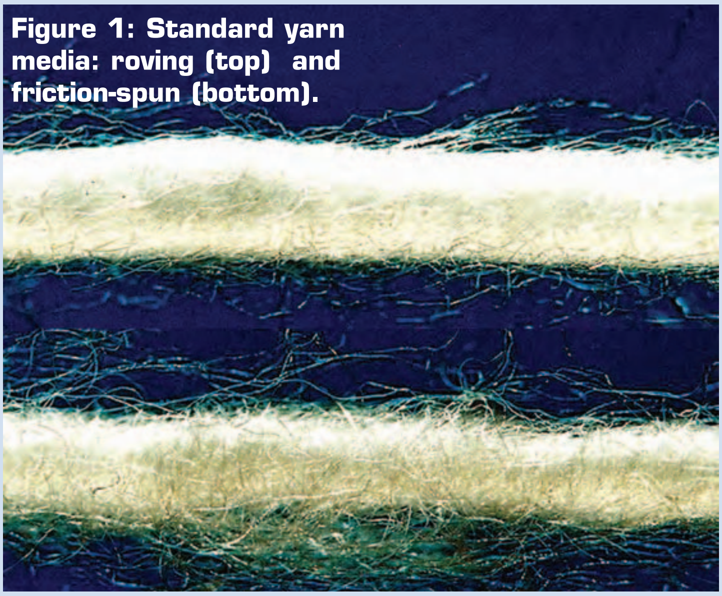


Figure 1: Standard yarn media: roving (top) and friction-spun (bottom).

Chemical Leaching

Cartridges wound from PP roving or friction spun yarn media suffer from another major problem, namely chemical leaching. In the manufacturing of these media, 'spin finish' is applied on the surface of the fibres. Spin finish contains a variety of chemicals including lubricants, surfactants, anti-static agents, antioxidants, emulsifiers, bactericides, etc. The amounts of these chemicals can vary from 0.5% to as much as 2% by weight of the media. Unless the filter is pre-washed, these chemicals can begin to leach out in the initial period of use, and can often be observed as foaming in the filtrate. The leaching of these chemicals can be detrimental to downstream processes and can pose possible health problems when used for drinking water filtration applications.

Other Shortcomings

Roving and friction spun yarn media have a compact round cross-section. Cartridges wound from these yarns do not form a stable structure, and when subjected to conditions of flow and pressure fluctuations the media is prone to shifting, which gives rise to a 'tunneling' effect and particle unloading. Figure 2 shows a standard cartridge wound from friction spun media. An unstable structure also creates a problem in achieving consistent micron ratings. Fine and coarser filters are made by winding the yarn closer together or with a gap between, respectively. As the gap between the yarns is widened, the compact round yarns tend to roll to one side or the other giving inconsistent results. Moreover, round yarns typically form a diamond pattern having gaps between adjacent yarns, as well as between layers. The liquid to be filtered obviously takes the least resistant path, which in this case is between the yarn gaps rather than through the whole media.

Continuous Filament Media

A media for string wound cartridges has been developed that overcome all the shortcomings of roving and friction spun yarns mentioned above. The new media comprises continuous filaments rather than short fibres. Each of the filaments continues throughout the whole length of the yarn, making the cartridge free from any media migration problems. The PP filament yarn is first melt-spun (extruded) by a new method, and without the use of any spin-finish chemicals. These continuous filaments, free of any process chemicals, are then randomly oriented to each other (intermixed, looped and entwined) to form a very bulky, non-round, highly stable yarn. The advantage of this random structure is that particles are forced to change direction as they proceed through the depth of the media. The physics of flow are such that it becomes possible to trap particles smaller than the size of the complex pathways. This involves a complex mixture of mechanisms, where particles are first brought into contact with the channel walls by inertial, hydraulic and Brownian molecular movement. They then become lodged in the crevices or attached to the walls or to each other by van der Vaals and other forces. The new media possess random filament loops protruding from its surface. The new yarn media is shown in Figure 3.

The loops of the continuous filament are firmly tucked into the core of the yarn. As the cartridge is wound, each single yarn traps some of the loops of adjacent yarns. This gives the cartridge a highly stable depth media, which under conditions of flow and pressure fluctuations are resistant to particle unloading because the yarns will not roll or move to the side. Filter housings commonly use a knife-edge sealing principle; the highly stable structure achieved by the new media provides an excellent sealing characteristic to the cartridge. See Figure 4 for a cartridge wound from the new filter media.

Improved Density Grading

In standard string wound cartridges, density grading is achieved by winding inner layers tight and outer layers loose. But this old technique createa a soft cartridge that is prone to particle unloading. Through improvements in winding technology and the use of computer controls, the space between each yarn is continuously varied and controlled from start to finish in making the cartridge. The inner layers of the yarns are wound close together and the space between the yarns is gradually increased towards the outer layers. This gives density grading, to trap the coarser particles in the outer layers and finer particles in the inner layers without changing the winding tension. The cartridge has a firm structure throughout the depth of the media and is more resistant to particle unloading.

Additional Advantages

The short fibres used in making roving and friction spun yarn media normally have a round cross-section. The new media for string wound cartridges are made from filaments with a multilobal cross-section. When this is combined with its high bulk random structure, it provides for excellent solid to void ratio, giving a lower pressure drop, improved dirt holding capacity and efficiency. Pressure drop is the decrease in pressure that occurs as the liquid flows through the cartridge. Every filter cartridge has its pressure drop vs. flow rate curve, which is dependent on the permeability of the media. Compared to standard media, the new media has a higher permeability, which means a lower resistance to flow. See Figure 5 for pressure drop vs. flow rate

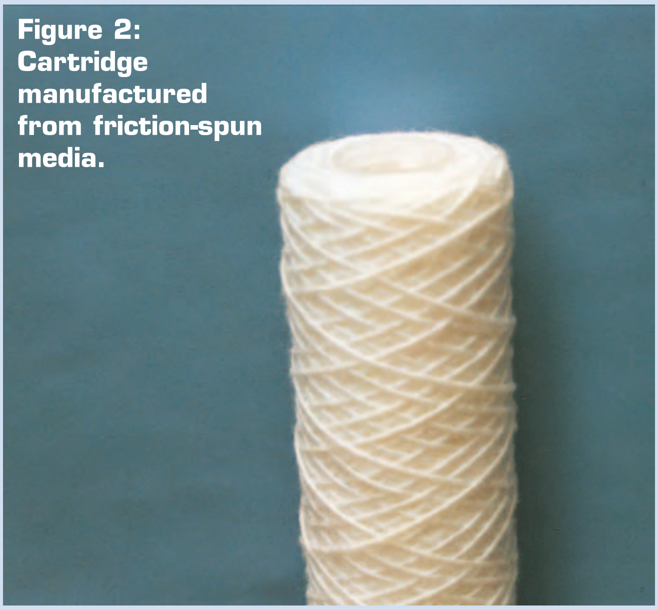


Figure 2: Cartridge manufactured from friction-spun media.

Table 1: Dirt holding capacity.

Differential Pressure (PSID)	Dust Injected grams
0.5	0
0.5	7
1.0	15
1.5	22
4.5	30
10.5	37
22.0	44
31.5	52
Test Method:	ASTM F795-88
Instrumentation:	LD 400 S/N 94060153
Fluid:	Water
Flow Rate:	3 gpm
Temperature:	Ambient
Contaminant:	ISO A4 (Coarse)
Shut Off rP:	30 PSI

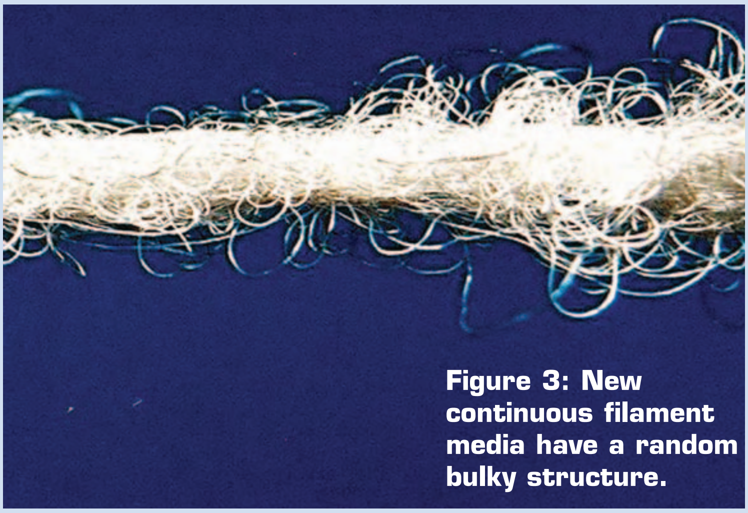
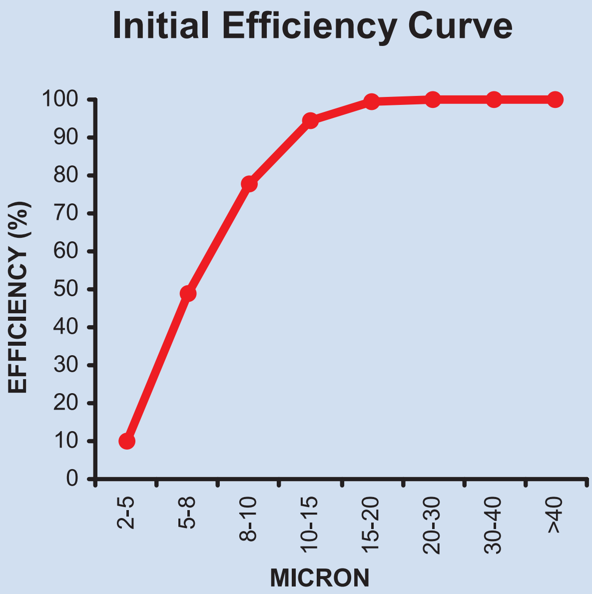


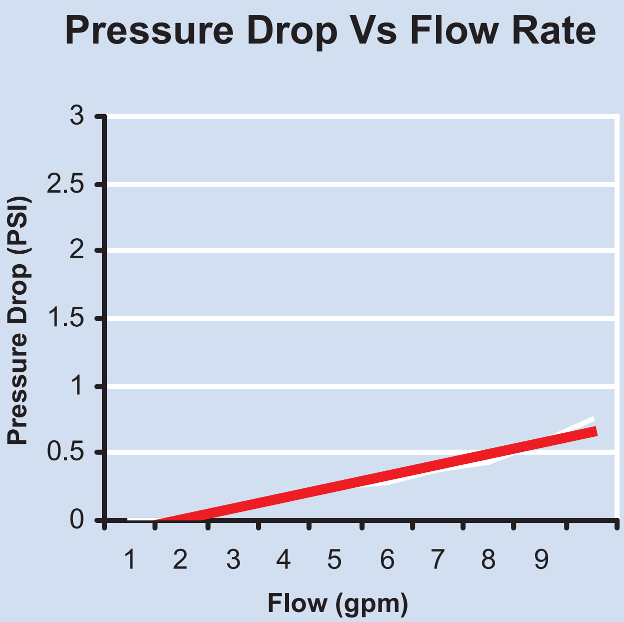
Figure 3: New continuous filament media have a random bulky structure.

Figure 4: Cartridge made from continuous filament media.



Test Method: Initial Efficiency ASTM F795-88
Instrumentation: LD 400 S/N 94060153
Fluid: Water
Flow Rate: 3 gpm
Temperature: Ambient
Contaminant: ISO A4 (Coarse)

Figure 6: Initial efficiency curve of continuous filament media.



Test Fluid: Water at Ambient Temperature
Flow is in US Gallons per minute

Figure 5: Pressure drop vs. flow rate.

curve for a 10 inch (2½ inch diameter) cartridge incorporating the new media.

Dirt holding capacity determines the useful life of a filter cartridge. This is determined by adding a specified amount of contaminant upstream at regular intervals and recording the differential pressure across the filter. The dirt holding capacity is then established by a limiting value of pressure drop (differential pressure) across the filter. The higher the amount of dirt held by the filter upon reaching the cut-off differential pressure, the longer the useful life of the filter. Tests with the new media show 52 g of dirt was held at a differential pressure of 31.5 PSI (Figure 6), which is higher compared to tests on most filters made from standard media.

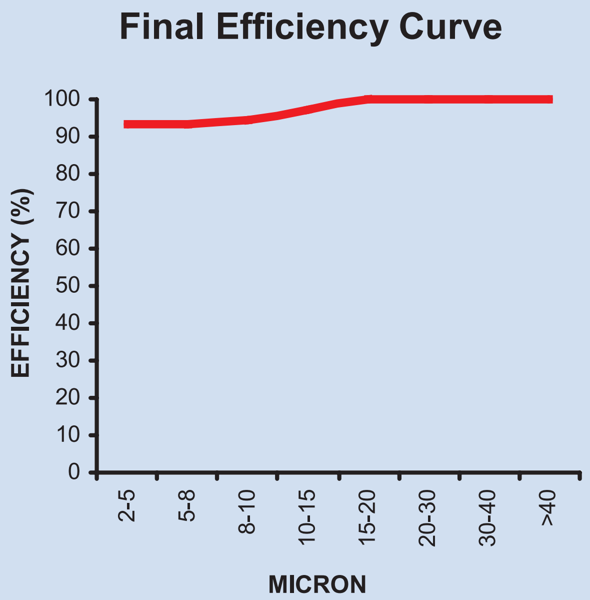
Depth filter cartridges of fibrous media have a variable pore size, and thus no absolute rating. Instead they are given a nominal filter rating or a nominal efficiency figure expressed in terms of percentage retention by weight of a specified contaminant of given size. This applies over a range of particle sizes considered, down to the absolute cut-off size. At this point the number of emergent particles will be nil and the efficiency 100%. Figures 7 & 8 give the results of initial and final efficiency test results for the 20 micron nominal rated cartridge made from the new media. These results compare very favourably to standard cartridges.

As a natural phenomena, the efficiency of a depth cartridge increases with the passage of time due to partial clogging of voids. When a new filter is put to use, initial efficiency is an important consideration to determine filtration suitability as the most amount of contaminants would pass through at this stage. A final efficiency curve shows the amount of finer particles being filtered out before reaching the cut-off pressure. According to the test results, the 20 micron cartridge made from the new media had a high final efficiency rating, i.e. 95%.

Conclusions

In summary, string wound cartridges made from the new continuous filament media have the following benefits:

- No chemicals to leach-out with the new melt spinning and yarn forming process.
- No media migration because the yarn comprises of continuous filaments.
- High structural stability, i.e. no shifting of media, excellent knife-edge sealing.



Test Method: Final Efficiency ASTM F795-88
Instrumentation: LD 400 S/N 94060153
Fluid: Water
Flow Rate: 3 gpm
Temperature: Ambient
Contaminant: ISO A4 (Coarse)
Shut Off ρP: 30 PSI

Figure 4: Cartridge made from continuous filament media.

- High bulk media with improved solid to void ratio gives increased dirt holding capacity.
- Lower pressure drop because liquid can flow through the entire media.
- Firmer media structure gives improved resistance to particle unloading.
- More consistent performance.
- Density graded - new winding technology gives denser winding in inner layers and coarser winding in outer layers.

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About the Author

Hamid Omar is the technical director of Syntech Fibres (Pvt) Ltd, of Karachi, Pakistan. The company specialises in the extrusion and spinning of polypropylene filaments and fibres for technical applications including filters. The company has developed the new PP filter media for string wound cartridges and produce Sedifiltä and Aqua Clearä brand filter cartridges.