Nonwoven Filter Media – A Look Back, Trends and Future Market Needs

Clint Scoble
Principal Filtration Consultant
Filter Media Services, LLC, Cincinnati, OH

Nonwovens in filtration probably sounds to the layman like an obscure, niche, boring topic. To those of us in the inside, either in the filter media area or in applying filter media to processes, products and filtration equipment, it is a complex, highly diversified and highly fragmented industry, both the media side and the filtration arena. The two parts of the *Nonwovens in Filtration* subject require that we address each side independently and then bring them together at the end.

One analogy used to describe filtration is that it is a very large church with an equally large number of pews, many of which do not communicate or resemble each other. A list of the major filtration segments would include the following pews:

Automotive (engine air, fuel, oil, cabin air)

Clean Room

Coolant and Lubricant

Dust Collection (Filter Bags, Pleated Cartridges, Pleated Bags, Cleanable)

HVAC, Paint Spray Booth, Buss Duct, Make Up Air, Gas Turbine, Oil Mist, Coalescers

Hydraulic and Line

Liquid Process Filters (All Types, Cleanable)

Medical, Pharmaceutical, Ultra Pure

Potable Water

Respirator, PPE

Reverse Osmosis

Swimming Pool and Spa

The first major distinction between the items listed above is whether the filter media or manufactured filters are single use, essentially storage filters, or whether they are cleanable and capable of regeneration by a backwash, shake or mechanical filter cake removal process. Most of the *pews* are either 100% single use or 100% cleanable. Because cleanable filter media or manufactured filters require a wider range of performance characteristics, this presentation will focus on those products.

Single use filters may be characterized by an orientation toward low cost using less expensive filter media, often multiple layer, depth or storage design, held, fixed or supported in place with minimal media movement. When the media or manufactured filter is filled with solids, blinded or will not effectively allow liquid or air flow, the media or manufactured filter must be replaced with a new filter. The most basic example of this is the common home furnace filter. However, much more complicated, technically engineered single use filters are used in HEPA, clean room and medical filters. Many single use pews also have their own media measuring systems where particle sizes, loadings and flow rates are used to challenge the media to provide efficiency, flow and pressure drop ratings or categorizations (ASHRAE and MERV for example). In addition, there are industry specific test procedures.

Lastly, a tremendous range of fibers, fabric designs and filter configurations are used in the single use filter area.

In cleanable filter media, there is a similar emphasis on cost. However, there are additional requirements of filter cake release, durability, flexibility and resistance to mechanical wear adding to efficiency, flow and pressure drop. Because a cleanable filter requires these additional features, cleanable filter media tends to be heavier, may focus more on surface cake buildup than depth filtration, will have special surface characteristics and may use chemical treatments to achieve certain performance levels. Rating systems are used to some degree but, because the potential end use applications are almost infinite, using a standard Arizona Road Dust to evaluate a filter media which might be used in flour milling for example, is relatively meaningless.

Although there are exceptions to every rule in filtration, the primary cleanable filter areas are reverse osmosis, industrial dust collections and large industrial liquid process filters. Also, some swimming pool and spa filters are sold and designed as being cleanable by either backwash or manual means.

Every industry has its *Holy Grails*, those product capabilities which make the best performing, longest lasting, highest capacity item, in turn making the end product more saleable and more valuable to the end user. Filtration is no different and the biggest *Holy Grails*, and some secondaries, are:

I. Holy Grails of Filtration

1. Higher Efficiency
2. Lower Pressure Drop
3. Higher Airflow
4. Longer Life
5. Lowest Cost vs Performance/Benefit

II. Secondary Grails

1. Greater Storage/Dirt Holding Capacity
2. Resistance to Blinding/Plugging
3. Optimum Cleanability
4. Improved Resistance to thermal, chemical, hydrolytic and oxidative degradation
5. Specific Performance Characteristics
   A. Static Dissipating
   B. Anti-bacterial, Anti-microbial
   C. Oil/Water Repellant
   D. Abrasion Resistant
   E. Spark Resistant

In addition, current world, social, economic and environmental conditions have created a new set of *Grails* to add to the above:

III. New Grails

1. Disposibility/Recyclability
2. Sustainability
3. "Green" Impact in Production (minimal environmental impact)
4. Energy Savings

How these new Grails will impact our industry, its producers and their products is still, to a degree, an unknown but major media manufacturers are already moving to meet these objectives and to capitalize on them as well.

The other half of the *Nonwovens in Filtration* equation is the nonwoven media, how it has evolved, what is available today and where it used to be. A brief history of filter media starts with ancient civilizations filtering water, wine and beer with woven fabrics made from natural fibers such as flax, cotton, wool or silk. Pressed wool felts evolved according to legend when travelers strapped bunches of wool fibers to their feet. Woven and pressed felt fabrics predominated in the filtration industry until the mid-20th century when needled felts became an integral part of industrial dust collection. Wet strength paper and cellulose/paper blends found their way into liquid filtration along with unidirectional rayon. The growth of synthetic fibers, starting with nylon in 1938, added significant opportunity for filter manufacturers to broaden their products. New textile processes were developed using these new synthetic resins and fibers. Adding to weaving and needling are today's better known, high volume, nonwoven fabric manufacturing processes, including:

- Spunbonds
- Meltblowns
- Point/Ultrasonic Bonds
- Hydroentangled (spun laced)
- Airlaids
- Wetlaids
- Stitchbonds
- Chemical (other others) bonds
- Thermal Bonds

Synthetic fiber non-wovens have dominated the filtration industry since the 1970's because of (5) basic advantages:

1. High volume, low cost production processes producing lower cost media (compared to wovens)

2. Variability of weights, permeabilities, surfaces, widths, and other basic characteristics

3. Pleatability/Moldability or formability

4. Performance in efficiency, flow, Δp, durability and adaptability

5. Availability (most serve multiple market segments)

For cleanable filters of all types, today the most commonly used textiles are:

1. Needled Felts

2. Spunbonds

3. Wovens

4. Hydroentangled (spunlace)

In dust collector bags, liquid filter bags, and liquid filter cloths, there are very few spunbond fabrics used. However, when we add pleated cartridges, pleated dust bags or elements, RO (Reverse Osmosis) and cleanable pool & spa cartridges, the spunbond category probably dominates all other types in total square media area produced.

In industrial filtration, there are an equally large number of industrial grade, synthetic resins and fibers used. These include:

Polyethylene (W)

PVC (W, F)

Polypropylene (W, F, S)

Nylon (W, S)

Polyester (W, F, S, O)

Co- and Homopolymer acrylics (W, F)

Aramid (W, F, O)

Polyphenylene Sulfide [PPS] (W, F)

PVDF [Kynar] (W)

Polymide (P84) (W, F)

PTFE (W, F)

Fiberglass (W, F, O)

(W) Wovens; (F) Needled Felts; (S) Spunbonds; (O) Other

Significant developments in filtration-focused industrial nonwovens over the last four decades include:

1. The growth of a wide range of nonwoven processes.

2. Adaptation of nonwovens designed for other markets into filtration (Reemay, Tyvek, spunlaced as examples)

3. Growth of pulsejet collectors using needled felts vs shaker collectors using woven fabric

4. Evolution of needling processes from scrim supported to self supported

5. Expansion of pleated cartridges, pleated bags and filter elements into new filtration segments

6. Application of membrane laminates effectively repurposed, less efficient nonwovens into high efficiency media (R.O., pleated cartridges, dust bags)

7. Environmental legislation forcing the use of more filtration equipment (1970, 1990, present day)

8. Development of microfibers and nano-fibers

If we consider that some of the current nonwoven media manufacturing technology has been used in filtration for over 50 years, it begs many questions as to the future of these technologies. Currently, there is still no filtration media more effective than needled felts in high pressure liquid filtration and dust collection. What has changed over the last five decades is that environmental limits have been tightened, industrial processes produce finer solids and economic pressures have required more filtration out of less equipment. In spite of those changes, 50 year old textile based media still is the most effective way to separate a solid from a liquid or gas stream.

It may be safe to assume that most major, broad based mass market filtration applications are known and are currently being supplied with adequate filter media. As a result, many companies have carved out niches with specialty products which meet specialized market needs or attempt to address and improve on the *Holy Grails*. One example of this is the lowly furnace/HVAC filter. Often referred to as the most basic, inexpensive, low efficiency filter, new versions have been developed with high efficiencies, mold and allergen filtering capabilities and other features attractive to modern germ-phobic households. A $2 throwaway filter has morphed into a $10 - $20 high tech filter.

Since the "*one size fits all*" concept has never been applicable to filtration, niche and specialty development does work and can enhance margins as well as customer loyalty.

Of the new *Green* grails, the most important to manufacturers is the energy reduction concept. If a filter can reduce energy use or produce a filter cake which requires less energy to process in subsequent processes, it becomes highly saleable. Longer life, an original *Grail*, is also highly valuable as it reduces overall filter cost, reduces disposal cost and reduces labor and maintenance costs. Greater efficiencies reduce product loss and/or meet tighter emission standards. All of the holy, secondary and green Grails, if achieved, provide tangible benefits to the end use, and saleable, profitable, defensible sales for the manufacturer.

One development today deserves special mention. Nano-fibers are becoming more available at the same time that nano particles are being developed by manufacturers. A small percentage of nano-fibers will significantly increase filter media efficiency. There will be a need for using nano-fibers in media such as carded and needled felts which will then be used to filter nano-particles in slurries and air streams. Being able to make nano-fibers more broad based and usable in a wider range of basic nonwoven media should be an industry priority.

A few additional ideas or industry needs, in addition to the *Holy Grail* items are discussed in the following paragraphs. New ideas and market needs may come from the end users or from modifying and improving on existing ideas or features.

One example of an end user need comes from the food processing industry where certain filters may be changed on a regular basis even when they have not reached end of life. This is due to cleanliness requirements from regulating agencies which require regular and periodic production stoppages for complete sanitization of equipment and filters. In these situations the equipment is chemically cleaned and then put back into service. However, the textile filters are either discarded and replaced with new units or have to be laundered (a process which generally adversely affects filter performance).

In this situation, a fiber which is FDA approved for food contact which could also demonstrate resistance to and prevention of bio-growth might allow the end use to avoid the cost of replacing or laundering filter bags. This could result in significant savings in material, labor and downtime.

Another example is the use of hydrophobic and oleophobic treatments on cleanable filter media to improve filter cake release. These are chemical bath treatments which are durable but do lose effectiveness over the life of the filter. If a fiber or fiber process could be developed to provide inherent oil and water repelling characteristics, this product would have immediate marketability and use in a wide range of applications, possibly both cleanable and single use.

A third example is OSHA's current emphasis on fugitive and uncontrolled dust accumulation which correspondingly also impacts dust filtration equipment. Most synthetic fibers exhibit high resistivity and potentially may be a source for static build up, arcing and explosions. To make a filter media more conductive and to facilitate the movement of static to ground, many methods have been used. These include epitropic and stainless steel fiber admixtures, chemical coatings, aluminized coatings, carbon/resin coatings and even carbon lines printed on a media. All have varying degrees of durability, cost, convenience, potential for product contamination and effectiveness. A market potential exists for development of an inherently conductive fiber or fiber manufacturing process usable in a wide range of filtrations applications.

Other market needs or ideas would include:

1. Non-PTFE membranes

2. Fibers with "tell tales," (the ability to change color, or alter in some way, which would communicate exposure to toxins, excess temperature or wear, end of life, etc.)

3. Fibers which could convert and/or neutralize pollutants, toxins, CO or other harmful gasses or solids

4. Fibers which could be charged and have polarity reversed, creating a textile electrostatic precipitator

5. Greater use of nano-fibers, microfibers, splitable fibers, to fill the gaps between standard, fine, micro and nano-fibers

6. A longer lasting activated carbon coating for fibers which would rival A/C depth filters

In conclusion, nonwoven filter media use in filtration is broad based and is the dominant technology used today. In spite of the age of the manufacturing process and products, they still meet current needs which have evolved over the last 40-50 years. New products and new requirements will come from the markets as well as the people and companies active in them. The best opportunities will come from specialized and niche segments. There is still a need for new products and technologies, especially disruptive technologies such as nano-fibers.

Clinton B. Scoble
Filter Media Services, LLC
431 Ohio Pike, Suite 119 South
Cincinnati, OH 45255
Cell 513-720-9063
Office 513-528-0172
Fax 513-624-6993
email: cscoble@filtermediaservices.com or clint.scoble@fuse.net

2/22/2011