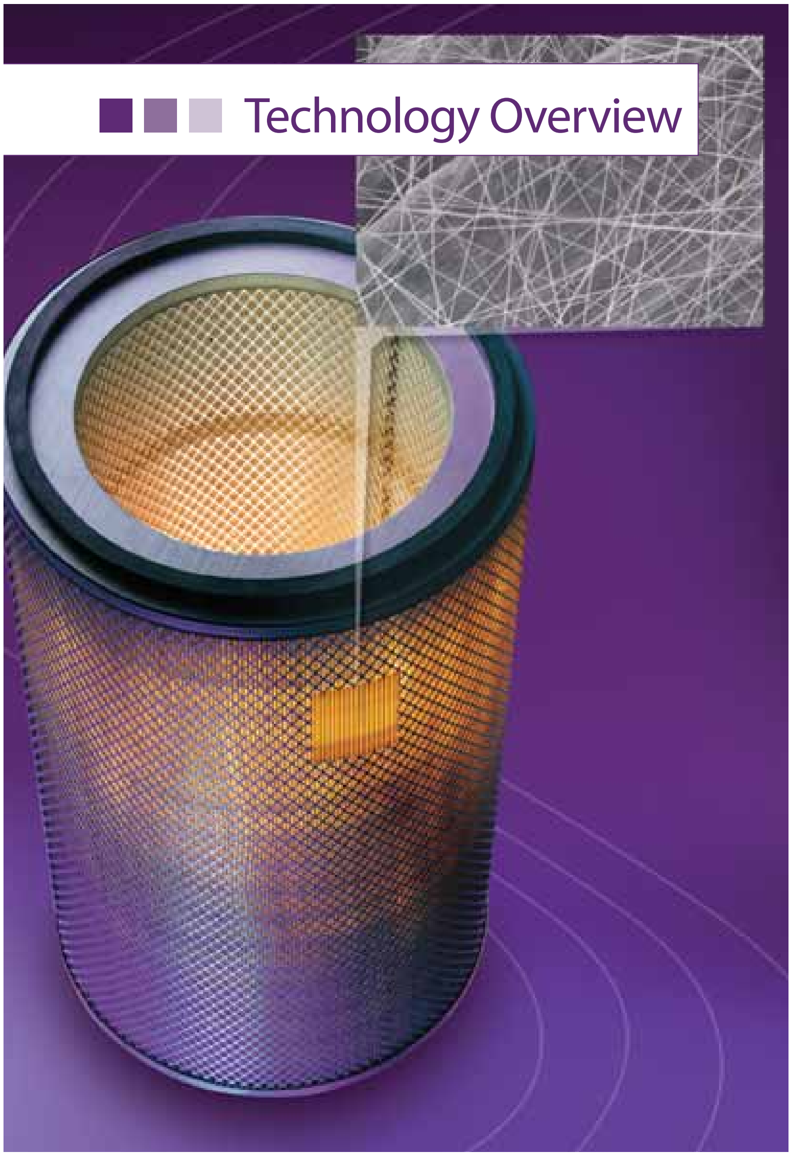
Technology Overview



Cartridge filters with nanofiber technology are capable of filtering submicronic particles.

The nanofiber factor

Nanofibers can make a big difference in cartridge filter performance

By Travis Haynam

Maintaining good indoor air quality in a factory isn't just a matter of choosing the right air pollution control equipment and configuring it to meet the needs of the facility. Selecting the correct filter technology that complements the equipment can have a meaningful impact on the equipment's performance, the system's efficiency, and the overall cost of collecting airborne contaminants in the workplace.

While most people have heard of nanotechnology, many are not aware of how it is used in air filtration and the performance enhancements that it provides. These nanofibers—fibers 1,000 times smaller than the diameter of a human hair—can help to improve filtration efficiency, filter cleanability, filter life, and energy consumption when the cartridge filters are used properly.

Discussion of Cartridge Filters

Three main types of standard cartridge filters are used in nearly 80 percent of all dust collection applications: blended cellulose, melt-blown media, and nanofiber media. (The other 20 percent of dust collection applications use spun-bond or other specialty filters because of unique collection requirements. These specialty filters can be two to three times the cost of standard cartridge filters.)

Blended cellulose filters are made of one homogenous layer of either straight cellulose media or cellulose blended with a synthetic fiber such as polyester. These filters are depth-loading, which means that as contaminated air moves through the filter, particulate becomes embedded deep in the media's fiber structure, clogging the pores. As a result, the filter's lifespan is short because the filters are not as easily cleaned. Also, the filter's airflow capacity—the amount of air it can pull through—is decreased. This increases pressure drop.

The second type of cartridge filter is made of cellulose-based filter media with a melt-blown surface layer. This layer is added to improve the efficiency of the cellulose media by providing a more dense fiber structure for capturing dust particles. The relatively large fiber diameter and thickness of the melt-blown layer, however, create a secondary layer of depth loading, which can make these types of filters difficult to clean, again leading to a shortened filter life.

The third type of cartridge filter is a cellulose-based filter media with a nanofiber surface layer. Nanofiber filters promote surface loading—keeping the particulate on the surface of the media instead of allowing it to embed itself deep within the filter. With the dust particles on the surface, they are removed more easily during cleaning, leading to longer filter life.

The diameter of a nanofiber (0.07 to 0.15 micron) is about 100 times smaller than the diameter of a melt-blown fiber (about 10 microns). When added to a dust collection cartridge filter, nanofibers form a permanent, meshlike surface with exceptionally small openings—or pores. These tiny openings are capable of filtering even submicron particles (less than 1 micron) from the contaminated air stream.

Because of the small diameter of the nanofiber, a layer of nanofibers is also very thin. A layer of only about 0.1 to 0.5 micron thick is needed to capture submicron particles. In comparison, a melt-blown layer is about 50 microns thick. The thinness of the nanofiber layer is important because it promotes surface loading and improves cleanability.

Nanofibers also contribute to tiny pore size distribution. When applied, the nanofibers create extremely small pores in uniform sizes on the filter surface. In contrast, a melt-blown layer could have nonuniform pores up to 40 microns in diameter throughout the deep layer. The smaller pore size helps to prevent particulate from becoming embedded deep within the filter substrate.

Why Surface Loading Matters

When considering cartridge filter options, it is important to understand how surface loading capabilities can affect energy costs, filter life, and emissions.

Depth loading of particulate, either within a melt-blown surface layer or into the filter substrate, makes it much more difficult for a reverse jet pulse cleaning system to dislodge the contaminant from the media and regenerate the filter to an acceptable stabilized pressure drop. As particulate builds within the filter, static pressure increases, and the system must pulse more frequently to return to optimum (design) static pressure drop.

This can affect fabricators in several ways:

• Compressed-air usage. This has a direct impact on a user's bottom line. Compressed air, used during the pulse cleaning process, can be one of the most expensive utilities in a plant and for an air pollution control system. The easier it is to remove particulate buildup from a filter, the less often the system needs to pulse.

• Extended filter life. Improved cleanability means fewer pulses and less buildup within the filter substrate. Both reduce stress on the filter, extending its life. This longer life leads to fewer replacements, as well as reduced maintenance and downtime for filter changeouts.

• Reduced emissions. An unavoidable byproduct of the pulse jet cleaning process is a small percentage of the particulate that is released back into the atmosphere. A filter that requires less pulse cleaning results in reduced amounts of particulate escaping into the air.

Why Low Pressure Drop Matters

Selecting the correct filter technology that complements the equipment can have a meaningful impact on the equipment's performance, the system's efficiency, and the overall cost of collecting airborne contaminants in the workplace.

Pressure drop refers to how easy it is to pull air through a filter. A filter with a lower pressure drop can work with a smaller blower with less horsepower requirements, resulting in reduced energy costs.

Making a filter more permeable—or porous—leads to lower pressure drop for the filter. However, a filter may also need to trap submicron particles efficiently, a task seemingly at odds with the idea of permeability.

Historically, filter manufacturers have struggled with this balance. Some make the media pore sizes smaller by adding a melt-blown layer. This does increase efficiency, but results in a higher pressure drop. It also adds an additional thickness to the media, restricting airflow and reducing cleaning effectiveness.

Nanofiber technology is recognized as a balanced solution. The nanofibers are very fine, and the pore sizes very small—creating a filtering layer 0.1 to 0.5 micron thick that can capture even submicron particulate. In effect, this nanofiber layer does all the work, so the substrate's purpose is primarily structural. That substrate can be highly permeable, resulting in the perfect combination of the lowest possible pressure drop with the highest possible filtering efficiency.

Beyond MERV Ratings

As cartridge filters have became more and more efficient, filter manufacturers have moved toward comparing filters based on the ASHRAE minimum efficiency reporting value (MERV) rating, rather than the traditional mass efficiency rating. This is because MERV classifies efficiency based on particle size instead of particle mass and better illustrates the strides made in filter efficiency.

The higher the MERV rating (1 to 20), the better the filter is at removing particulates, especially very small particulates, from the air. Some of the newer nanofiber filtration technology has achieved a MERV rating of 15, meaning the filter is at least 85 percent efficient at capturing particle sizes 0.3 to 1.0 micron and 90 percent efficient at capturing 1.0 micron or greater. In contrast, the efficiencies of a MERV 13 filter drop to 75 percent for particles 0.3 to 1.0 micron. MERV 10 filters are rated to capture only 1.0 micron and larger particles.

MERV ratings should be certified by independent lab tests per the ASHRAE standard 52.2-1999, the most current industry-accepted measurement of filter efficiency and ability to capture submicron particles. These tests are done with new, out-of-the-box filters.

While the MERV rating is the most accurate efficiency measurement available, fabricators should not select a filter just on its MERV rating. As discussed earlier, other criteria, such as pressure drop, cleanability, compressed-air usage, and filter life, are important features of a filter's total performance and life cycle cost. The best way to determine the right filter performance technology for an application is to consult an expert. ■

Travis Haynam is director, engineering department, United Air Specialists, 4440 Creek Road, Cincinnati, OH 45242-2832, 800-252-4647, trahay@uasinc.com, www.uasinc.com.

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