

Meltblown polyester solves a food processing filtration problem

L. R. White

Meltblown polyester was found to be a cost-effective filter medium that would ensure a particle- and bacteria-free product.

The traditional place of nonwovens as filter material in the food processing industry has been in filter presses, vacuum filters, and belt filters. Cartridge filtration, which is used for cold sterilization, removal of catalyst fines, and final filtration before packing, uses relatively little nonwoven products. For this purpose, a meltblown filter medium in a pleated cartridge-type element was used as a final process filter.

The problem

A major company in the food and drug industry needed a filter cartridge for its final filtration system. The company was already using cartridge filters, but the cartridge replacement cost and the frequency of replacement were too high. We were asked to engineer a cartridge specifically designed for this purpose.

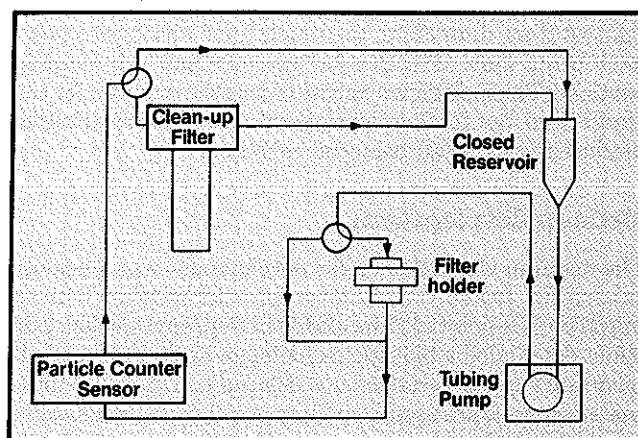
The product at this stage consisted mostly of deionized water. It also contained 5% acetic acid, 2% sodium acetate, and occasional slugs of pure toluene at 90°C. Sterilization was accomplished by flushing the system with 85°C deionized water with a hypochlorite disinfectant added. This toluene, acid, temperature, and disinfectant posed a real material compatibility problem complicated by the requirement that all materials used had to be listed by the FDA as approved for food contact. The function of these filters was to remove any particulates, bacteria, or yeasts from the product. This filtration was carried out at flow rates of 320 gal/min through each vessel, with each vessel containing 16 filter cartridges. At stake was a million dollars worth of product per day.

Medium selection

The criterion for the medium's performance was that there could be no biological growth in downstream cultures. Based upon such a stringent submicronic filtration requirement, the first choice would have been a membrane rated at 0.2 or 0.45 μm . At costs of \$3-5/ft² of medium, however, a pleated cartridge with 35 ft² would contain \$105-175 worth of filter medium. Our targeted selling price was a price of under \$50.

Because of its relatively low cost, proven filtration

1. Test setup for the filter medium evaluation



performance, and ready availability, the next choice was a high-efficiency, microglass, HEPA-type medium. Unfortunately, the client immediately rejected the use of glass medium in its process, so that approach was quickly dropped.

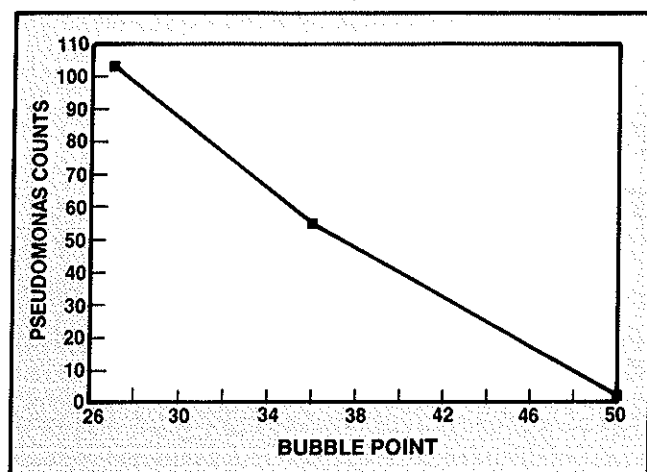
From a material compatibility standpoint, polypropylene was rejected because it had already been known to degrade in the process fluid. Polyester seemed promising, however, and samples of both spun-bonded and meltblown polyester were subjected to extraction tests with no discernible weight loss in the process fluid.

To establish filtration performance, initial evaluations were made with a test setup as depicted in Fig. 1, using a particle counter equipped with a laser sensor that could count down to particle sizes of 0.5 μm . A Masterflex tubing pump circulated 18-M Ω water produced by a Barnstead Water 1, portable, pure water system through a 47-mm membrane filter holder containing the medium. Latex spheres were injected upstream of the test filter, and the particle counter indicated the separation efficiency of the test medium for the size of the bead injected.

To evaluate the filter performance of the nonwoven medium vs. the meltblown medium, samples were obtained of each, both of which calendered to a Frasier air flow of 0.2 ft³/m² and a bubble point around 27 in. of H₂O. Using the test setup, we found that the meltblown medium would remove some 0.45- μm beads and virtually all of the 1- μm beads. The spun-bonded material, while calendered to an equal density, was not effective even with the 1- μm beads.

White is senior research and development engineer, The Hilliard Corp., 100 West Fourth St., Elmira, N.Y. 14902

2. Bubble point vs. the number of pseudomonas counts



The difference in performance was attributed to the relative fiber diameters, the much finer meltblown polyester being more effective for micron and submicron particles. The meltblown polyester was the medium for the application, but further development would be required to produce the required bacterial retention.

Medium development

The medium we settled on for development was a heavily calendered, four-ply, meltblown polyester medium with an initial bubble point of 27 in. of H₂O in isopropyl alcohol. Our client demanded a biological challenge by an independent laboratory using *pseudomonas diminuta*. Typically, these pseudomonads are used for 0.2- μ m membrane evaluation—not the kind of evaluation one would choose for a nonwoven filter medium test. Nevertheless, the client must be satisfied, so we agreed to the test.

Membrane testing

To our advantage, the client personnel asked for pseudomonad challenges to represent what they felt were typical of their product stream. This criterion turned out to be only 100 counts per mL of sample. Pseudomonads can penetrate even a 0.2- μ m membrane in large concentrations, yet the same membrane would be 100% effective at low concentrations (1). Also in our favor was the fact that the client changed the filters at least weekly to preclude bacterial grow-through, because bacteria can grow through virtually any medium, given enough time.

Although some have found that no relationship seems to exist between bubble point (2-4) and microbial retention at high concentrations (5), we found that a correlation did exist at the low concentrations of the pseudomonads we were working with, as depicted in Fig. 2.

We also discovered that multiple layers of medium increased its biological retention capabilities, as shown in Fig. 3. Ultimately, two layers of four-ply, 36-in., bubble point medium was chosen as the best compromise between cost and reliability. A single layer of four-ply, 59-in. bubble would have been equally effective in microbe retention, but the two layer approach gives an additional safety margin in the event that one of the layers has a hole or less-than-perfect area in it. As Table I shows, the two layers of the 36-in. bubble medium also have a considerable higher permeability than the single layer of 50-in. bubble medium.

3. Layers of filter medium vs. pseudomonas counts

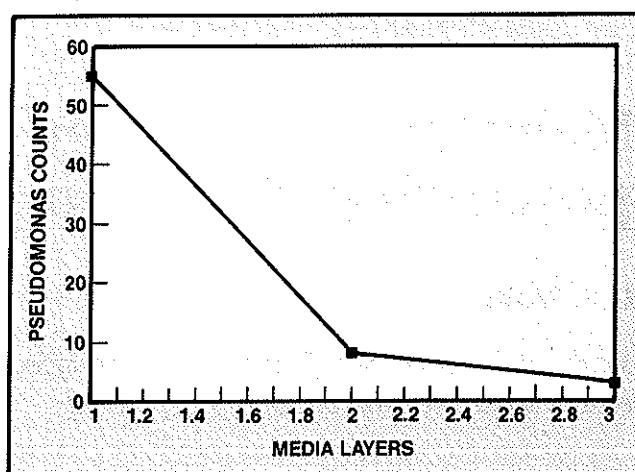


Table II shows the equal latex bead retention effectiveness of the two mediums.

Client testing

The ultimate test of the effectiveness of the chosen medium is in the actual process for which it was designed. The client, with a million dollars worth of product per day at stake, was naturally reluctant to place a new medium in service without first thoroughly testing it. First, the personnel ran extraction tests to satisfy themselves that the chosen materials were indeed compatible with their process. The next step to validate the medium was to filter small batches of the process fluid in their lab and monitor the filtrate for biological growth. Due to the proprietary nature of their fluid, they performed all of this phase of testing.

Having passed their laboratory evaluations, the filter was placed first in a low-risk, deionized-water filtration system. Finally, it was placed in a closely monitored product stream. At first, the cartridges were changed daily for fear of bacterial grow-through. With constant monitoring of the downstream product, the filter's service time was gradually increased to a week, with still no grow-through. Following these tests, the filter cartridge design using meltblown medium was approved and put into service.

The meltblown medium worked, but why? The latex bead challenge tests showed that this medium didn't become an absolute filter until the bead size reached 1 μ m or larger. How then could it be expected to retain pseudomonads that are used for validating 0.2 μ m membranes?

One answer lies in the low challenge level of the product stream. The medium was able to retain up to 97% of an organism measuring 0.3-0.4 μ m in diameter by 0.6-1 μ m in length (Fig. 2). This phenomenon is explained by adsorption (5), or surface attraction of the microbes to the fiber structure, as opposed to mechanically screening them as a membrane would. Also, in the actual process stream, we weren't dealing with *pseudomonas diminuta* but with bacteria and yeasts that are much larger.

Conclusions

Multi-ply meltblown filter medium, when calendered to an appropriate density, can often compete with membranes at a fraction of the cost. The meltblown filters will not perform in the absolute submicronic realm of membrane mediums,

I. Gurley porosity

Medium	Porosity, s
1-layer, 36-in. bubble	64
2-layer, 36-in. bubble	147
1-layer, 50-in. bubble	552
For 300 cm ² .	

II. Bead retention efficiency for both mediums

Bead size, μ	Bead retention, %	
	2 layer, 36 in.	1 layer, 50 in.
< 0.75	0	0
< 1.0	50	50
> 1.5	100	100

but they do perform well in what could be termed as "near-membrane" separation. This ability makes them useful in two areas. The first area of use is as prefiltration for membranes to extend their life. The second use is as a substitute for membranes that are used in applications for which their absolute integrity is not mandatory. For example, a membrane may be selected for its submicronic separation, but an absolute rating is not critical. For this, a meltblown medium would be the better choice.

Meltblown polyesters were first considered for this project as an alternative to glass because glass was not acceptable for food contact. In working with meltblown polyesters, other advantages became evident. The inherent

strength of a meltblown polyester compared to the relatively fragile glass sheet makes it ideal for rigorous industrial purposes. On the negative side, glass seems to have higher permeabilities for a given bubble point. Also, there is a much better selection of glass mediums for the filter designer to choose from, but relatively few in meltblowns.

Increased promotion of meltblown polyesters as filter medium would increase the development time and money spent to improve filter grades. A wider selection of mediums would become available, costs would go down, and the filter engineer would have a better selection. Meltblown polyesters are a filter medium with tremendous untapped potential waiting to be released.

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