Primer on Monofilament Woven Fabric Filtration Media

by

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Description:

Monofilament woven filtration fabrics can be classified many ways and into several broad categories, usually by their micron rating, void volume, weight or application such as for use in filtration or dewatering or by the degree of precision weaving. Monofilament fabrics are constructed from monofilament yarns, recognized by most people for their use in fishing or weed-wacker line. However, the level of precision required for weaving is in a much different class. For the purposes of this primer we will concentrate on "precision" woven monofilament fabrics for filtration and dewatering applications with finished fabrics measured in three popular weight per square yard ranges (1) 1 to 5 ounces (2) 8 to 15 ounces and (3) 30 ounces and above. The market size for precision monofilament fabric roll stock for filtration and dewatering, not counting the pulp and paper industry, is approximately $40-50 million in the United States and another $80-90 million in overseas markets for a total of $120-140 million worldwide. Monofilaments are often referred to as "screen" fabrics, a term originating from the sifting industry such as used when screening particles to size.

History:

Monofilament fabrics are largely a development since WW II, when synthetic fibers made from nylon, and later polyester, became available in the market. Prior to the 1940's there were attempts to supply rayon and other organic fibers as highly twisted multi-filaments, but success was limited in creating truly precision woven fabrics, as we know them today. These early fabrics were targeted principally for filtration and screen printing (silk screening). Once synthetic monofilament yarns were perfected, rapid conversion followed, including the replacement of wire cloth in a number of applications.

Material(s) of Construction:

Polyester and nylon are the most common polymers used in monofilament fabrics. Polypropylene, polyethylene, E-CTFE and PVDF follow at a distance. Occasionally, carbon yarns are interwoven in monofilament constructions to bleed off static where a danger of static discharge is an issue. Monofilament yarn size range, in nominal diameter, from 0.001" (25 microns) up to 0.040" (1,000 microns) and very consistent in diameter, with the exception of polypropylene which is difficult, to spin (extrude) without diameter variation. Yarns tend to be more rigid their multifilament counterparts. As a result, woven monofilament fabrics are stiff, especially above 3-4 ounces per square yard. This rigidity is often an asset when used in applications like insert molded filters, belting, sifter screens and self-supporting pleats.

Media Forms:

Monofilament fabrics are typically woven to 120 inches wide. The fine diameter monofilament yarns (0.001") are woven with a yarn count up to 600 yarns per inch in both the warp (machine direction) and fill or weft (cross-machine direction). These high-count textiles generally have a media rating as low as 10 micron. With post-calendering, this micron rating can be further reduced to approximately 5 micron with very narrow pore size distribution; best for backpulse liquid filter elements and rotary drum dewatering. Heavy fabrics are constructed using the 0.040" (1,000) micron diameter yarns having a finished fabric weight up to 40-50 ounces per square yard. Applications for these fabrics include municipal sludge dewatering belts. Other belts have two interwoven fabric layers, making a single composite, consisting of a beefy under-belt fabric for load bearing purposes and a fine screen top layer facing the feedstream.

Special Characteristics:

Monofilament fabrics have important attributes. They can be woven very precisely with narrow pore size distributions. As a result, they are commonly rated and referred to as surface retentive absolute rated filter media. In plain weave constructions, monofilament fabrics have straight through pores (holes), thus providing minimal flow restriction and surface loading of particulate. Twills and Dutch weaves provide excellent cake release surfaces are needed. Although these weaves provide only a modest torturous path, their use does not significantly restrict flow.

Manufacturing Methods:

Manufacturing is accomplished using traditional rapier and projectile looms to 120 inches wide, and in certain cases, not covered here, for use as pulp and paper forming fabrics to 20 feet wide. To prepare for weaving, fabrics much first be "warped", a preparation step requiring slow laborious hand work of preparing machine direction yarns one by one though a reed, a process that can take one person a week and more for a single loom. The reed resembles a comb, which guides individual warp yarns during the weaving process. For fabrics with high yarn count construction e.g. 10-20 micron ratings, the filling/weft (cross-machine direction) yarns are inserted at a rate of 300-600 "picks" per inch per minute. Thus, actual weave time can be slow with, for example, only 1-3 yards per hour produced. For more open weaves and lower yarn count fabrics, weaving is far more rapid and overall preparation costs are much less. Increasing there is a point of diminishing returns when weaving heavy fabric over 20 ounces a square yard. Process speed is reduced and costs rise because of weight, bulk and high material handling and productions costs, largely due to the size and mass of yarn and finished fabric weight.

After weaving is completed, most fabrics are "finished" with a scouring water wash to remove any weaving water-soluble oil spin finish. A subsequent drying step to "heat set" the fabric typically follows. Monofilament fabric washing for medical filtration requires special ultrapure RO or UF rinse water to ensure low levels of bacteria and endotoxin residuals on the finished fabric.

Filter Configurations and Function:

Monofilament fabrics take a number of filter forms. Fabrics are pleated for use in filter cartridges. The pleat-packs are subsequently potted or fuse-bonded to end caps using traditional filtration industry technology. Other times, fabrics are insert-molded into a flat or shaped plastic support frame or cage formed around the fabric. Insert molding is a sophisticated process requiring extensive experience to make a performance part with high yields. Another common configuration for monofilament fabrics found in belting. Fabricated belts often have sealed edges to prevent un-raveling and a clipper or some other method to join the butt-ends of the fabric to form a belt. Sometimes, a "back-weaving" process allows for the butt-end warp yarns to be interwoven to each other forming an endless belt with no apparent seam. Fabrics are also cut into flat configurations or retained in frames for various sifting or screening operations.

Market/Applications:

There is a seemingly endless list of filtration uses for monofilament fabrics. Approximately half the market applications include: aerospace air and fuel filter cartridges on commercial and military aircraft, appliance filters such as those used as lint collectors in home and industrial laundry dryers. Also, permanent screens in coffee maker filters. In transportation, monofilaments are used widely in the automotive gas tank, fuel injector nozzle and transmission pan filters. In healthcare, there are diagnostic test kits, blood filters used in open-heart surgery, burn patient therapy beds and wound dressings. The second half of the market revolves around the industrial process industries. Uses include sifting screens for abrasives, pharmaceuticals, kaolin, grains and powders. Fabrics are common on equipment rotary drums, plate and frame and dewatering belts. The belt market has many diverse applications ranging from municipal sludge dewatering, chemicals to food products such as corn gluten to name a few. Fabrics are widely used as liquid filter bags for paint filtration and are sewn as sleeves for use in rotary sifters. Additional applications include coal sector bags, fluidized beds and fish screens in aquaculture. A diverse list and critical filtration media used where efficient filtration is required.

Advantages:

The advantage of monofilament fabrics, as discussed here, is their overall versatility and number of constructions for use in a wide variety of filtration applications. By the nature of their weave, whether plain or a special weave, precision monofilaments have an exceptionally narrow pore size distribution, and in many cases, excellent porosity. Monofilament fabrics are commonly considered an absolute rated surface filtration media through an exceptionally wide range from 5 to more than 300 micron. Fabrics can be woven with two or more layers forming an asymmetric depth filtration medium or for use as a fine surface woven belt and high strength under-support layer. Monofilament yarns have a very smooth surface and are heat sealable, pleatable and come in many choices of weaves, porosity, flow rates and efficiencies. Often monofilaments can be, and are selected, as an alternative media to wire cloth for applications such as vibratory sifting or as backpulse elements or screens.

Disadvantages:

Monofilament fabrics usually require a fairly clean feed-stream, because of their low high-dirt holding capacity. However, monofilament belting, used in dewatering applications is purposely used to achieve high-capacity dirt “transport”. By the nature of the process, the monofilament belts allow liquids to drain through the belt before the “cake” is released each cycle. In the lower micron ratings, especially under 30 microns, void volume of a monofilament fabric drops significantly. Cost of these screen fabrics can be an issue. Quality monofilament fabrics are in the same general price range as stainless steel wire cloth, $15 to 40 per square yard, although this will vary. Non-precision monofilament fabrics are considerably less expensive and sometimes below $5-6 per square yard. Fabrics are not available below 5 micron mean flow pore size.

Market Penetration and Trends:

Monofilament fabrics continue to grow as the need for performance media is in greater demand in the market. However, growth is limited by an inability to be manufactured with filtration efficiency ratings below 5 micron with reasonable void volumes, the fastest growing segment of the overall filtration market. Therefore, like any filtration media, monofilaments have their place and fill niche market requirements better than many competitive materials, because of the nature of their construction.

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