Customer Application Brief Filtration in Nylon 6,6 Manufacturing

Introduction

Nylon, an exceptionally strong, elastic, and abrasion resistant polymer, is used to manufacture a growing family of consumer products. Primary nylon uses are for carpet, tire cord, molded products, textiles, apparel and home furnishings. Critical in the production of many of these products is the use of high quality, low cost Nylon 6,6. This Customer Application Brief (CAB), describes how the use of high efficiency filtration systems for raw materials and process streams in the manufacture of Nylon 6,6 pellets and fibers reduces manufacturing costs and improves quality and productivity.

The Process

A flow chart depicting a simplified Nylon 6,6 manufacturing process is shown in Figure 1. As illustrated, a typical Nylon 6,6 process in which adipic acid, hexamethylene diamine, and water are added to a reaction vessel to form hexamethylene diammonium adipate, commonly known as "nylon salt" solution. The adipic acid is either manufactured at the site by oxidation of or brought into the facility by rail car or tanker. Prior to an evaporation process, a slurry of TIO_2 pigments and water used to deluster fibers is added to the nylon salt. After evaporation, the "salt solution" flows into a series of heat jacketed vessels where water is continuously removed. Polymerization begins in the reactor where polyhexamethylene adipamide, (Nylon 6,6), is formed. After several stages of polymerizing reactors the nylon is sent through transfer line filters, manifolds, metering pumps, and screen packs after which the nylon is extruded through spinnerets and then may go through several finishing steps.

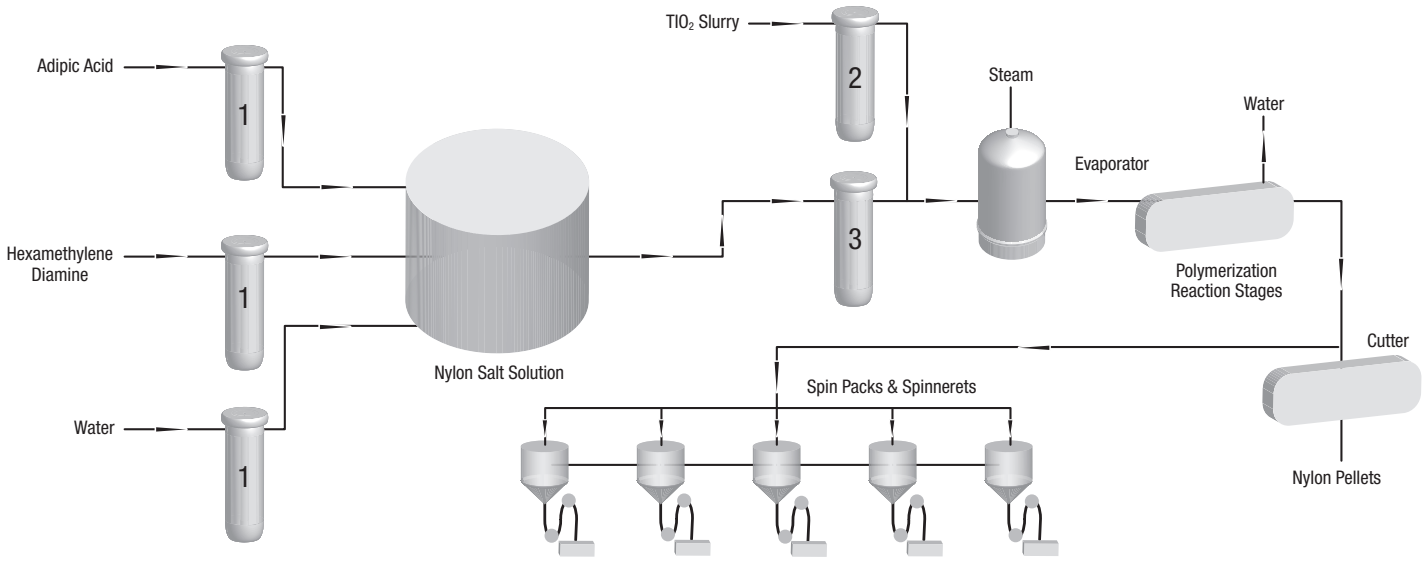

Figure 1. Typical Nylon Production Process

The Problem

Contaminating particles and gels formed or introduced during the Nylon 6,6 manufacturing process significantly impact quality and productivity for end-users of nylon fibers and pellets. Particles or gels imbedded in nylon fiber can cause a dramatic increase fiber breakage during end-user conversion. In the manufacturing process, fibers are stretched to orient the polymer molecules to increase their strength. Contaminants embedded in the fiber cause weak spots and make the fiber more susceptible to breaking during the stretching process. Frequent fiber breakage results in significant downtime and processing problems at the end-user.

Users of nylon pellets, such as automotive parts extruders, can experience costly maintenance and production downtime due to particulate plugging of extrusion dies and screen packs. These manufacturers also require that the nylon be free of contaminants to meet strict molded product quality specifications.

Sources of Contamination

These gels and particulate are both introduced to the process in various feed streams and additives and created during the process in various manufacturing steps.

Introduced to the process

- Improperly or partially dissolved adipic acid crystals will contaminate the nylon salt intermediate. Hexamethylene diamine and DI-water which are added to the adipic acid must also be free of contaminants such as DI-resin beads and particles introduced from transportation and storage.
- Oversized TIO_2 particles insufficiently dispersed during pigment grinding and agglomerated TIO_2 pigment particles can be introduced with the pigment slurry.
- Oil can be added from centrifugation.

Created during the Process

- Solid particles including iron oxide and other debris and high molecular weight deformable gels can be formed through several stages of dewatering and the polymerization process.

Figure 2 - Betapure™ NT-T Series Filters

The 3M™ Solution

High quality filtration of nylon salt raw materials, DI-water, additive slurries, and the nylon salt solution requires a filter design that effectively removes and retains particles and gels in the Nylon 6,6 manufacturing process. Betapure™ NT-T series filters are the ideal filtration solution for the various nylon process streams. Betapure NT-T series filters provide consistent particle removal efficiency throughout the usable life of the filter. 3M absolute rated polypropylene Betapure NT-T series filters provide excellent removal efficiency, unmatched flow capability, and exceptionally long life. The filter design enhances cartridge rigidity, virtually eliminating cartridge compression and the resulting flow restriction and particle unloading. Rigid depth filter cartridges are the most efficient and cost effective means of filtering these process streams. Unlike non-rigid filter media, rigid depth media with fixed pore structures ensure that particles previously retained within the filter‘s matrix do not unload due to fluctuations in pressure. Contaminants removed should be evenly distributed throughout the entire depth of the media and not trapped at just the outermost surface of the filter cartridge. The unique Betapure NT-T series technology permits the distribution of fluid flow and contaminant capture through the depth of the filter cartridge (Figures 2 and 3). The even distribution of contaminated fluid throughout as much as 85% of the depth of the cartridge utilizes far more of the available filter area than is utilized by the typical polypropylene depth filter.

Capture of contaminants throughout the filter structure maximizes the length of time between filter cartridge change-outs. Rigid depth filter cartridges that utilize a fixed structure of uniform pore size are the most efficient and cost effective means of filtering TIO_2 pigment slurries. The uniform pore size of the media, if properly selected, will retain unwanted oversize particles and allow desirable smaller particles to pass and remain in the slurry.

DI water used in preparing the adipic acid, TIO_2 slurries, and the nylon salt solution should be filtered upstream and downstream of the mixed bed deionizers to ensure that no resin particulate or iron oxides contaminate the nylon salt intermediate. 10 micron absolute Betapure™ NT-T series filtration is recommended upstream and downstream of the mixed bed deionizers. These filters eliminate the introduction of solid contaminants in DI water used as make-up water for both the salt solution and the pigment slurry.

Figure 3. -Betapure™ NT-T Series Media Layers

Adipic acid and hexamethylene diamine should be filtered to remove any debris from transport or storage, to promote efficient nylon salt formation. 10 micron absolute Betapure NT-T series filtration is recommended to ensure uniform purity of all the raw materials charged into the nylon salt solution vessel.

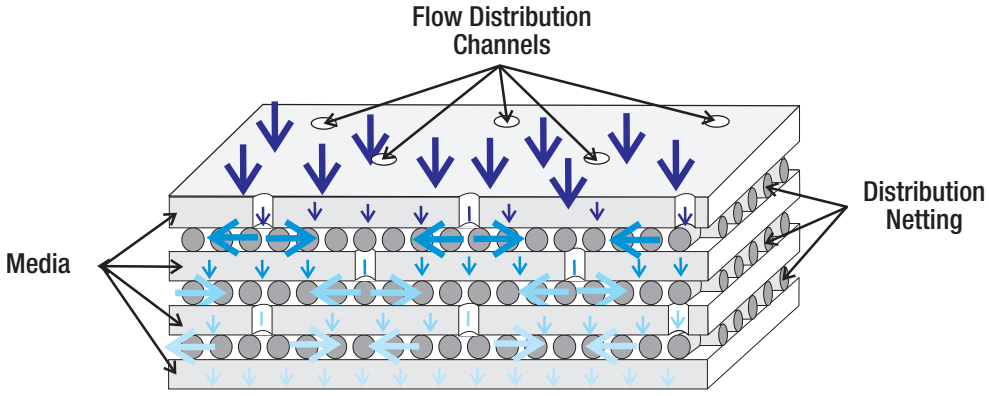

Figure 4. - Betapure™ NT-T Series Flow Distribution

The TIO_2 slurry should be pre-filtered for effective removal of insufficiently dispersed or agglomerated TIO_2 pigment particles. 10 micron absolute Betapure NT-T series filtration will provide excellent long term protection of the melt filters and screen packs, and can significantly impact process economics by reducing the production downtime spent during their change-out and replacement.

Nylon salt solution is filtered to remove any contamination like iron oxide, oil from upstream centrifugation, or other debris that can remove polymerization efficiency and nylon quality. 10 micron absolute Betapure NT-T series filtration is recommended for salt solution streams used for carpet, tire cord, textiles, apparel and home furnishings. 3 micron absolute Betapure NT-T series filtration is recommended for salt solution streams in the manufacture of nylon pellets used to make high quality performance molded products.

Conclusion

The Betapure NT-T series filter solution recommended by 3M™ for DI water filtration, nylon salt raw materials, pigment slurries and the nylon salt solution will provide high quality Nylon 6,6. The polymer will be essentially free of solid, semi-solid, and oversize additive agglomerates, and will provide consistently high fiber and pellet quality. Efficient filtration will in addition provide excellent long term protection of the nylon melt filters and screen packs. This can impact process economics by dramatically reducing the production downtime spent during their change-out and replacement.

Table 1. - Filter Recommendations for Nylon Feedstreams

Refer to Figure 1	Fluid	Filter Recommendation
1	DI water	Betapure™ NT-T Series, 10-µm abs
1	Adipic acid	Betapure™ NT-T Series, 10-µm abs
1	Hexamethylene diamine	Betapure™ NT-T Series, 10-µm abs
2	TIO_2 pigment slurry	Betapure™ NT-T Series, 10-µm abs
3	Nylon salt	Betapure™ NT-T Series, 10-µm abs
3	Nylon salt for Pellets	Betapure™ NT-T Series, 3-µm abs

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