Biodiesel Production

Introduction

Several eco-friendly fuel technologies have been developed recently as adjuncts or even complete replacements to conventional fuels. These "biofuels" (so called because they are derived from renewable plant feedstock) are designed for use in various combustion engines (automobile and marine) as well as in oil-fired burners. The most common biofuel technologies include ethanol, methanol, butanol, and biodiesel. Biodiesel production, in particular, is forecasted to undergo rapid capacity build-up in the United States, Europe, and South America. Current trends indicate that production capacity will grow at 55% annually over the next few years. This Customer Application Brief (CAB) focuses on biodiesel production.

Biodiesel is a clean-burning diesel replacement fuel that can be used in compression-ignition (diesel) engines and oil-fired heating systems. It is manufactured from the following non-petroleum based sources:

- Virgin vegetable oils (soy, canola [aka rapeseed], palm, and corn)
- Animal fats (poultry, fish oils, tallow)
- Used cooking oils and grease

The product must be filtered at various stages of manufacture, both to help protect process equipment and to maintain compliance with final quality specifications. This Application Brief addresses the benefits of effective filtration, including proper final product quality and lower maintenance costs.

The Process

Biodiesel is manufactured in a transesterification process by reacting an oil-based feedstock, such as virgin vegetable oil, animal fats, or used cooking oils, with methanol, in the presence of a catalyst (such as lye or sodium methylate). Excess methanol is used to drive the reaction to completion. The reaction generates methyl ester (crude biodiesel), methanol, and glycerin. The methanol is recovered and recycled, while a decanter separates the heavier glycerin from the crude biodiesel. The crude biodiesel must be further purified to reduce residual catalyst or soaps. While a water wash is often used for purification, the industry is gradually moving toward a "dry wash" process using a magnesium silicate-based additive. The magnesium silicate preferentially binds to polar compounds, such as soaps, glycerides, and methanol. The purified biodiesel is then sent to storage tanks prior to final loadout.

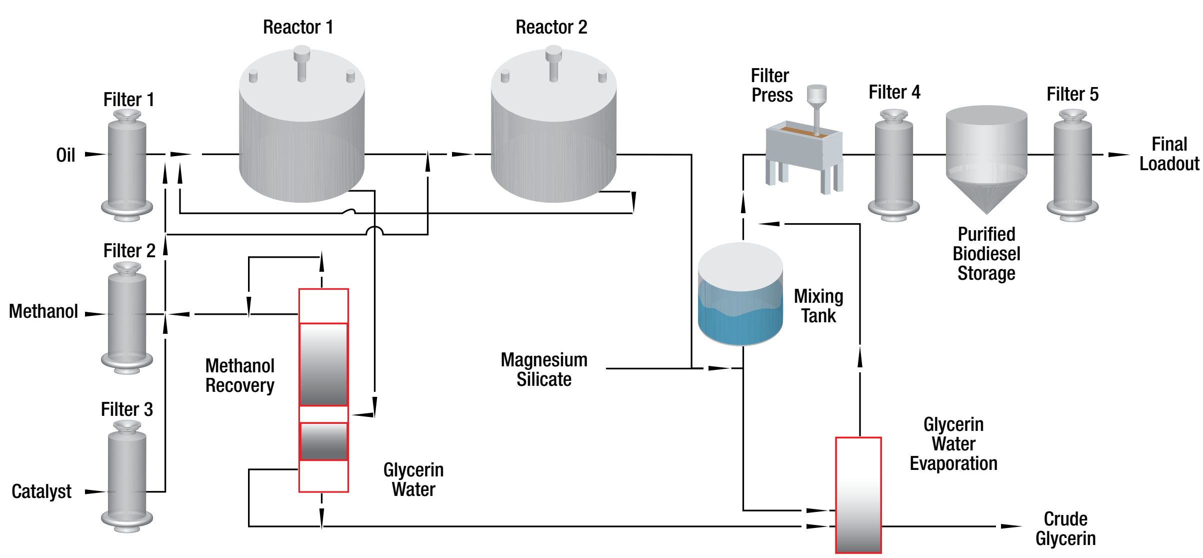

Figure 1. - Typical Biodiesel Production Process

The Problem

Contamination of the raw materials can cause both production and quality problems for the biodiesel plant. Contaminants may be picked up in the tanker or the piping transporting the oil feedstock to the biodiesel plant, or in the tanks storing methanol or the catalyst. Recycled cooking oil typically contains various food particles from previous usage. These contaminants can clog piping, valves, and pumps, and deposit on process tank walls and bottoms, accelerating corrosion of process equipment. Additionally, solid particles introduced to the reaction process can encourage foaming of the glyceride soaps formed in the transesterification process. High levels of foaming can lead to off-spec product, and can result in maintenance costs to clean the reactor surfaces and lost revenues as the system is shut down for cleaning.

Contamination in the final product can significantly affect the biodiesel's performance as a fuel source. As a precaution, the industry relies on two specifications for final product quality. In North America, ASTM D 6751 specifies 0.05% maximum water and sediment by volume, while EN 14214 specifies 500mg/kg for Europe. Most biodiesel plants use a filter press to pre-filter the purified biodiesel, followed by a polishing step to reduce residual magnesium silicate and rust and scale particles from the process equipment and piping. These particles can present several problems for diesel engines, including blocked fuel injectors, fuel tank corrosion, and clogged fuel filters. It is therefore critical to control such contaminants in order to minimize problems for the end user.

The Solution

3M Purification absolute-rated Betapure™ BK series and Betapure™ NT-T cartridges are ideally suited to help protect process equipment for high effluent quality of the final biodiesel product. 3M Purification recommends five stages of filtration to provide optimal operation of the biodiesel system.

Stage 1 - As noted before, the presence of solids in the raw oil can contribute to foaming of the glyceride soaps. Depending on the source of the raw oil, typical contaminants are in the 30 - 80-micron range. 30-micron absolute-rated Betapure BK series depth filter cartridges are recommended at the inlet feed location to properly clean the raw oil prior to transesterification.

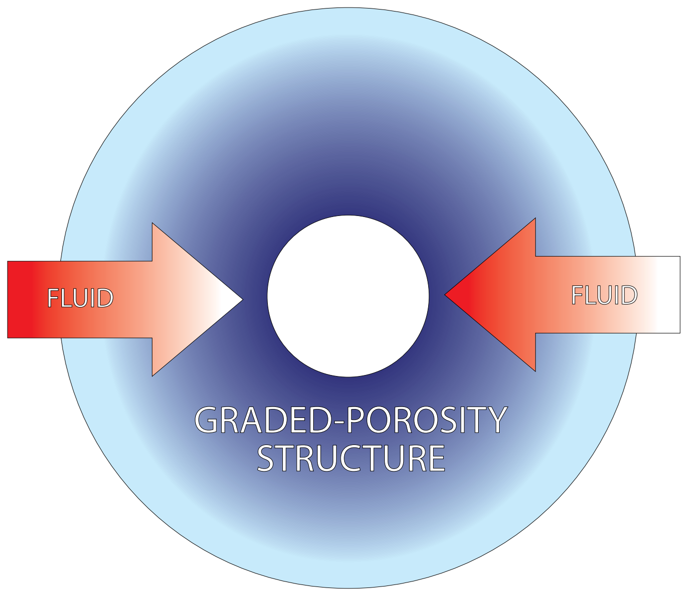

Figure 3. - Graded Pore Structure

Stages 2 & 3 - 30-micron absolute rated Betapure NT-T depth filter cartridges are recommended to filter out foam-contributing contaminants from the methanol and catalyst upstream of the reactor.

Stage 4 - 10-micron absolute rated Betapure BK series depth filter cartridges are very effective as polishing filters for the final purified biodiesel product prior to storage. This polishing step reduces any remaining impurities in the biodiesel that may lead to corrosion of the storage tank or contribute to an off-spec product.

Stage 5 - 10-micron absolute rated Betapure BK series depth filter cartridges are recommended at final loadout to reduce any contaminants picked up in the storage tank that may contribute to an off-spec product.

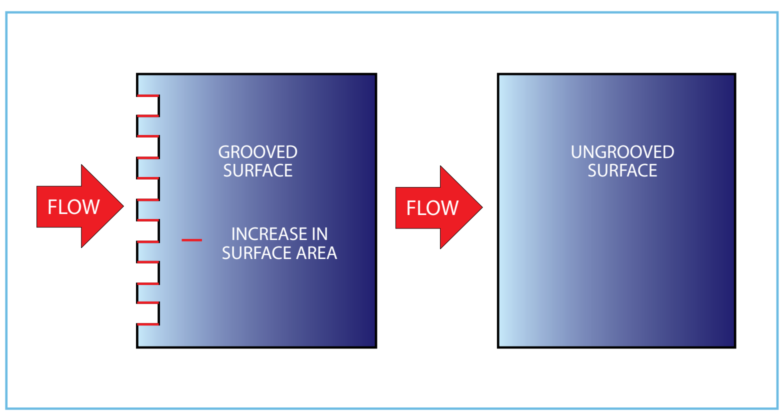

Figure 3. - Betapure™ BK Series Grooves

Betapure BK series filter cartridges are manufactured using a proprietary process that achieves a true graded pore structure with a clean and smooth inside diameter eliminating the need for a center core. Figure 2 illustrates that the openings between the fibers become progressively smaller as the fluid flows from the outer surface to the inner core of a graded porosity structure. Each fiber is locked in this arrangement by a thermosetting binder to create a rigid structure. The overall effect is to sort, classify and stop particles by size as they progress through the cartridge. Larger particles are trapped in the upstream region of the filter and finer particles toward the inner core of the filter. Contaminants at or near the filter's absolute rating are reduced in the inner section of the filter cartridge.

Betapure™ BK series cartridges also feature an optimized groove pattern that increases the surface area by over 65% when compared to smooth cylindrical cartridges (see Figure 3). The grooved surface prevents premature blinding of the outer surface by large particles and allows full utilization of the depth structure. Maximum surface area with a true graded pore structure means that Betapure BK series can provide significantly greater service life than competitive filter cartridges of comparable efficiency.

Figure 4. - Betapure™ NT-T's three distinct layers

Betapure NT-T filter construction combines a unique polypropylene filter media with fluid distribution netting to form multiple layers. Critically positioned media flow channels allow greater movement of fluid from layer to layer. Three distinct media sections, made from multiple media/netting layers, are combined to form a filter cartridge (Figure 4). The outer and middle sections contain multiple layers of interleaved filter media and fluid distribution netting (Figure 5). Within each media layer, a portion of the fluid travels through the media while the balance of fluid is delivered directly to the next distribution layer through the flow channels. The fluid distribution netting provides longitudinal and latitudinal flow paths to evenly distribute fluid flow across the surface of each successive filter media layer. The inner-most layers of media, equal to one third of the filter's depth, are supported by a rigid polypropylene core. They contain no flow channels and constitute the final qualifying section ensuring absolute rated performance.

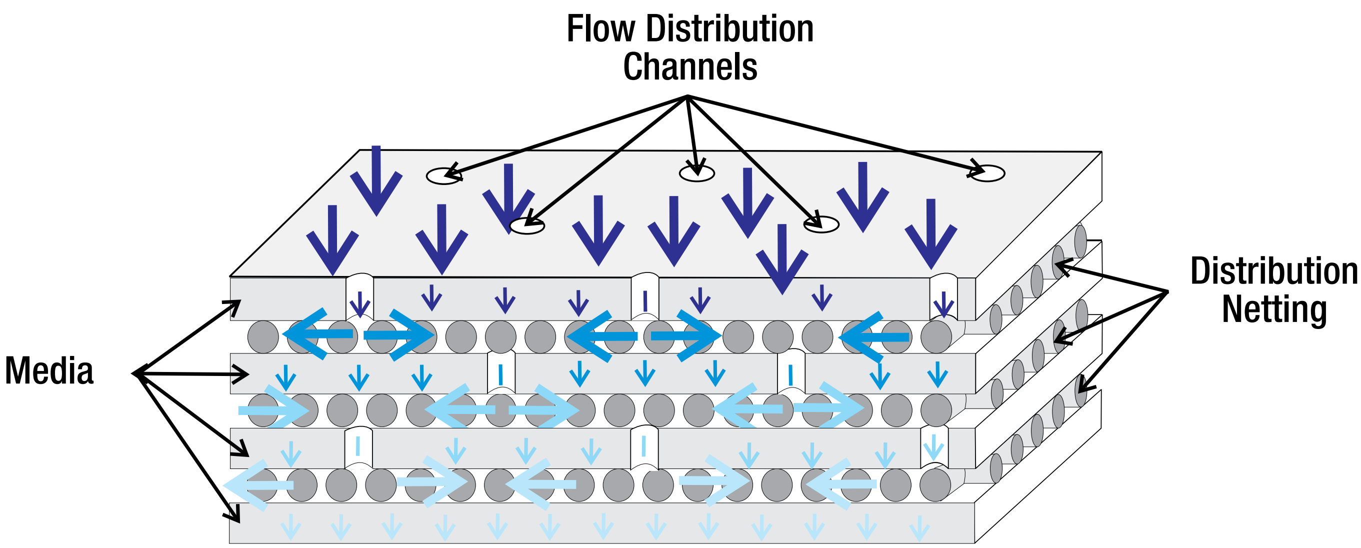

Figure 5. - Betapure™ NT-T Unique Flow Pattern

Recommendations

3M Purification Betapure BK series and Betapure NT-T filters are recommended for proper process protection and product quality in biodiesel manufacturing. Filter recommendations are summarized in Table 1, below.

Table 1 – Recommendations for Biodiesel Filtration

Filter Position (see Figure 1)	Description	Recommendation
1	Inlet Oil Feed	Betapure™ BK Series 30 micron absolute
2	Methanol Feed	Betapure™ NT-T 30 micron absolute
3	Catalyst Feed	Betapure™ NT-T 30 micron absolute
4	Purified Biodiesel Polish	Betapure™ BK Series 10 micron absolute
5	Final Loadout	Betapure™ BK Series 10 micron absolute

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