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November 2012  
A WoodwardBizMedia Publication  
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***Shearing,  
mixing  
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# Shear business for biodiesel

*As demand for renewable fuel increases, inline high shear and static mixers get the nod*

By Timothy Erdman

The push is on for biodiesel. Last year, the biodiesel industry set a new production record of nearly 1.1 billion gallons, easily exceeding EPA's renewable fuel standard. The National Biodiesel Board has projected another 11,000 jobs or so that could be added by next year. This past September, the Environmental Protection Agency reported that 100 million gallons of biodiesel were produced in the previous month. Year-to-date production amounts to about 757 million gallons, and another new record is in EPA's sights.

In keeping with other types of renewable energy, the production level spawned jobs, more than 39,000 of them across the country. This translates into around \$2.1 billion in household income.

"B20" biodiesel is to petroleum diesel fuel what ethanol is to gasoline: 20 percent biodiesel and 80 percent petroleum diesel fuel. In that respect, biodiesel is being viewed as a petroleum diesel additive. It can reduce undesirable elements like unburned hydrocarbons, carbon monoxide and particulates. It can also impact exhaust emissions, lowering levels of sulfur oxides and sulfates.

Found in just about every state, production plants use a range of feedstock, such as soybean oil, animal fats, palm and jatropha. Another resource is recycled cooking oil. Across the U.S., biodiesel is the first and only EPA-designated advanced biofuel produced on a commercial scale. The NBB claims that since 2005, biodiesel has reduced lifecycle greenhouse gas emissions by 41.6 billion lbs, equal to taking more than 3.5 million passenger vehicles off the road.

The biofuel is produced through a process known as "transesterification," where triglycerides like oil or fat react with alcohol, using sodium hydroxide or some other strong alkaline as the catalyst. Alkyl esters — biodiesel — result, along with glycerin as a byproduct.

## Mixing it up

The Penn State Cooperative Extension lists several methods of making this biofuel, citing the continuous flow stirred reactor as the most common. Suppliers like Charles Ross & Sons Company and Koflo Corp. are staking out claims in biodiesel production. Ross makes devices like "inline high shear mixers" for use in combination with stirred reactors. These are rotor/stator type mixers used for solids dispersion, particle size reduction, emulsification and homogenization," said Christine Banaszek, Ross's application engineer. They also have pumping capability.

"Our Inline high shear mixers are typically used for mixing



Figure 1. Inline High Shear Mixers are offered with a variety of interchangeable stator designs to fine-tune particle size reduction, emulsification, residence time, temperature rise and throughput.

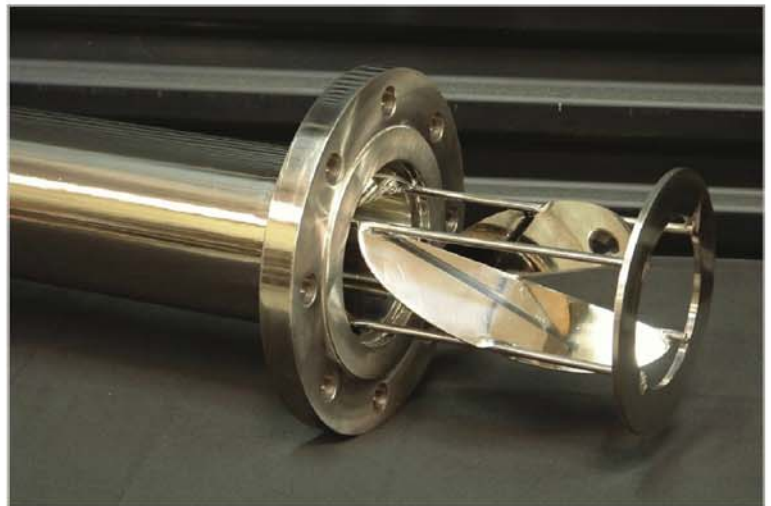


Figure 2. Ross Low Pressure Drop (LPD) Static Mixers can be supplied as complete plug-in modules or as mixer inserts for installation into an existing pipe or housing.

an alcohol solution and feedstock oil," Banaszek said. "In the presence of a catalyst, the triglycerides in the oil react with the alcohol to produce biodiesel and glycerin. Proper mixing helps to maximize contact between the reactants, and thus yield as well."

At conventional speeds, these mixers can run at approximately 3,000'-4,000'/minute. Where the process requires extremely fine particle or droplet size, ultra-high shear mixers are



designed to run more than 11,000 fpm.

High shear mixers were developed years ago as batch-style, top-entering mixing devices. Today, an inline configuration enables them to act as centrifugal pumps. Not self-priming, the mixer must be gravity-fed or pumped, in order for fluids and materials to be introduced into the mix chamber. According to a Ross-written white paper, gravity usually feeds the product into the rotor/stator assembly, since the mixer is typically positioned on the floor or on a platform below the liquid level.

"Most inline high shear mixer models will easily move materials up to around 10,000 centipoise depending on

Figure 3. Ross Double Planetary Mixers equipped with High Viscosity "HV" Blades (U.S. Patent No. 6,652,137) are capable of handling very dense or thick applications up to around 6 million centipoise.

the formulation's shear-thinning properties," the paper states. "An auxiliary pump enables a rotor/stator mixer to process moderately viscous products."

**Static mixers**

Back to Banaszek.

"We also supply another type of inline mixing device for biodiesel, our Low Pressure Drop static mixer," she said. "Fluids pumped through a piece of pipe containing the static mixer are forced to split into layers, recombine, rotate and/or swirl. In short, the static mixer increases turbulence within the pipe. This helps

to uniformly distribute or dissolve minor components into a main liquid stream. For instance, a static mixer may be used to blend sodium methoxide catalyst into methanol, while another static mixer downstream would be used to mix the alcohol/catalyst solution into feedstock oil."

As its name suggests, the static mixer has no moving parts. External pumps move fluids through it instead. Inside a pipe, mixing elements await the material and streams split, divert and form the basis for mixing. The LPD prides itself on efficiency and is designed for easy installation in new and existing process lines where allowable pressure drop is limited.

**When viscosities go ultra-high ...**

While static and inline high shear mixers tend to the relatively youthful biodiesel industry, more mature industries from hot melt adhesives to electronics manufacturing issue the call for power and process flexibility, a combination found in something called the "double planetary mixer."

"Our Double Planetary Mixers are used for conditioning biomass prior to reaction," Banaszek explained. "These machines move material by rotating two identical blades on their respective axes as they orbit on a common axis.

"The blades contact virtually every point of the batch in just 36 revolutions," she added, "imparting a very thorough mixing action regardless of the product's flowability. Double Planetary Mixers handle a wide range of feed forms – from powders, granules, pellets and other solid forms to low and high viscosity fluids."

Unlike the double-arm kneader, a standard DPM, whose sizes range from ½ pint to more than 750 gallons, has no packing glands or bearings submerged in the product zone. The company's patented helical High Velocity ("HV") blades provide axial and radial flow, and are made for ultra-high viscosity: try 6 million centipoise! If that's more than you need, you can scale down to rectangular stirrers for low-to-high viscosities.

**Designing for lean**

In traditional batch-style biodiesel reactors, technologies like high shear mixers and inline static mixers help increase efficiencies.

In Cary, Ill., biodiesel static mixers made by Koflo utilize the company's standard Series 275 static mixer. These are designed for the transesterification of oil and methanol in a closed loop biodiesel unit. A number of models are designed according to flow rates and pressure losses for the biodiesel industry. Meanwhile, each static mixer is made of schedule 40 304 stainless steel, with 6 mixing elements and male NPT threaded ends.

Developments such as these give ample opportunities for biodiesel producers to optimize manufacturing efficiencies and improve product quality, while reducing costs at the same time. And where the rubber meets the road – that should be every biodiesel producer's bottom-line objective. 🌱

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**Making inroads at Yellowstone**

The growth of the biodiesel industry, according to the National Biodiesel Board, is creating new demand for fats and oils, which is leading to breakthroughs in feedstock development and technologies. This has promising implications for such biomass materials as algae, camelina and pennycress, which number "among the promising next-generation feedstocks that could help meet our nation's energy demands in the future." For more interesting facts on biodiesel, visit [www.biodiesel.org](http://www.biodiesel.org).

About 17 years ago, Yellowstone National Park began powering one of its trucks with biodiesel provided by the University of Idaho. Several hundred thousand miles later, the same truck is still in use, without any engine damage, and still runs on biodiesel. Other national parks have taken Yellowstone's cue and now use biodiesel in their vehicles too.