

CHEMICAL ENGINEERING

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THE GREEN REVOLUTION

Advanced phase-separation technology helps processors clean up



Pall's AquaSep® Plus liquid-liquid coalescer eliminates haze problems from refinery fuels like gasoline, diesel and jet fuels

Kermit the Frog once said, “It isn’t easy being green.” While this may be true, industry is still making the effort. Both in the U.S. and abroad, processors are not only striving to produce environmentally friendly products, but also are becoming more mindful of the impact of their operations. More often than not, cleaning up both products and processes requires the use of phase-separation equipment. And, recent advances in separation technology are especially helpful when producing more eco-friendly fuels, cleaning up wastewater and increasing energy efficiency — what some would call the “Big Three” of today’s green revolution.

Worldwide, the cost for purifying water, wastewater and process filtration is \$271 billion/yr, and the process treatment segment of that market, which includes phase separation, is \$82 billion/yr, with \$28 billion attributed to the U.S., according to a recent report by McIlvaine Co. (Northfield, Ill.; www.mcilvainecompany.com). Of those \$82 billion, about \$20 billion are equipment related and the other \$62 billion are chemical and operational costs.

While the phase-separation market has traditionally seen little growth, there has been a slight up tick associated with new applications related to clean fuels production and water purification, according to Bob McIlvaine, president of McIlvaine Co.

Worldwide, the growth for process treatment is about 6%/yr, and is primarily related to the expansion of basic industry in the developing world, according to McIlvaine. “However, there is some growth related to

the oil and gas industry and upgrading of refineries,” he explains. “There are investments related to cleaning up heavy oil sands and making them into acceptable crude, and other investments for phase separation to treat produced water.”

McIlvaine adds that these applications are helping drive the development of new separation technologies. “Any time there are new applications, there are bound to be refinements in technology,” he says.

Indeed, most manufacturers of phase-separation equipment are advancing their technologies to help combat the distinct problems associated with the new low-sulfur fuels and more rigid water regulations. And, as the need to increase energy efficiency becomes greater, manufacturers are stepping up in that area as well.

New fuels spur new technology

The increased demand for biodiesel, ethanol and low-sulfur fuel formulations has led not only to the rapid development and expansion of production plants, but also to the creation of additional pollutants that may be discharged to the sewer, says Greg Aymong, vice president for wastewater treatment systems with Highland Tank (Stoystown, Pa.). “Whether it’s vegetable oils or glycerin from the production of biodiesel (see also the Newsfront on p. 31), ethanol to create ethanol-based fuels or synthetic motor fuel additives, you end up with more contaminants and it becomes necessary to take care of the various types of separable and soluble products that are created in the process,” he says. “There are many challenges associ-

ated with the production of this new bouquet of fuels, and while wastewater treatment systems are available, the technology may be different for each plant and refinery.”

For example, the U.S. Environmental Protection Agency (EPA; Washington, D.C.) mandate for clean fuels with lower sulfur levels has led some refineries to increase the number of hydrotreaters used, says Thomas Wines, senior marketing manager, fuels and chemicals with Pall Corp. (Port Washington, N.Y.). In this process, hydrogen gas goes through a catalyst and reacts with different fuels to remove the sulfur. It then becomes hydrogen-sulfide gas that is typically separated using an amine solvent system. “You also have to protect those hydrotreater catalysts, so you have particle filters and liquid-liquid coalescers to prevent water or caustic streams from getting into and deactivating or fouling the catalysts,” says Wines.

In cases where a refinery adds an ultra-low-sulfur hydrodesulfurization (HDS) plant to meet clean-fuels requirements, some problems may arise, according to Bernhard Kalis, technical director with Amistco (Elvin, Tex.). One common issue is a high concentration of pentane and heavier liquids in the gas feed to the amine treaters due to inadequate removal by liquid-gas separators in the HDS unit. These liquids interact with the amines in the absorber and can cause severe foaming. Sulfur absorption is reduced and amine carryover increases.

Kalis recommends two possible remedies. One is to retrofit the applicable knockout drums with high-capacity, high-efficiency mist eliminators. The

Newsfront

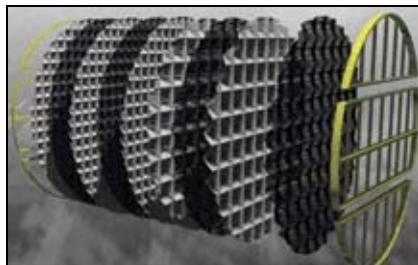
vessels involved are the inlet knock-out drums in the amine treaters and the sour-gas knockout drum in the clean fuels plant. These improvements will minimize liquid carryover to the amine absorbers and avoid expensive upsets of the treater units that are due to foaming in the absorber, he says.

The other possibility pertains to the solvent-recirculation system in the amine treaters. Hydrocarbon liquid, including the heavier fractions that cause foaming, accumulates in the solvent as immiscible droplets, explains Kalis. The hydrocarbon level in the solvent is held down by a liquid-liquid skimmer, which is typically a simple gravity-settling tank.

Improved separation of this vessel will reduce the hydrocarbon content of the recirculating solvent and alleviate foaming, says Kalis. The best approach is to retrofit the skimmer with a properly designed high-capacity, high-efficiency liquid-liquid coalescer assembly, which will eliminate the burden of immiscible hydrocarbon liquid in lean solvent returning to the absorber towers, thus curing the foaming, he explains.

Another problem, according to Kalis, may be sulfur-plant capacity limitations. With greater throughput, sulfur gases cannot be completely converted to elemental sulfur, and liquid sulfur may be entrained in the tail gas, says Kalis. The result is an increased flow of sulfur to the tail-gas incinerator, which means that sulfur oxide emissions in the stack gas increase to unacceptable levels.

"In many cases the main problem is that the diagonal, mesh-type mist eliminators in the condenser hoods



This image is an example of a composite layered mist eliminator using Kimre media. Filament sizes and materials, in combination with physical mesh layer arrangement, optimize the range and effectiveness of particle removal

flood with liquid and may even become partly plugged with solidified sulfur, greatly reducing mist-elimination efficiency," explains Kalis.

Often, the sulfur condenser can be retrofitted with a vane-mesh mist eliminator combination to prevent flooding of the mesh pad with liquid sulfur. The vane unit would be mounted upstream of the mesh to remove most of the liquid sulfur as larger droplets, and the mesh serves to scrub the remaining finer mist.

"The pad we use is a special high-capacity, high-efficiency variety," says Kalis. "And the result is more condenser capacity, longer catalyst runs and minimal plugging of the mesh mist eliminator."

With the addition of these new formulations, many refineries are running at full capacity, which means they don't have leeway for contamination. "If they are running at 50% of capacity, they can often live with some contamination, but at 100%, it's critical to have an efficient process, so filtration and separation become vital," says Wines. For this reason, he says, liquid-liquid coalescers are used in various intermediate stages and to get the final product free of water. Pall also has a new bulk separator, called the Lucid™ Separator, that's said to be more efficient and compact compared to traditional separators. The bulk separator is applied to the process where crude oil is washed with water in a desalter vessel. "What comes out of the desalter is the oil on one side and brine contaminated with oil on the bottom. We put the Lucid Separator there to remove the oil and clean up the water that comes off it," he says.

Stricter water regulations

As Wines mentions, refineries are making an effort to clean the water that comes off the oil, but there are other areas where separation equipment is used to clean produced water, as well.

For example, as the price of oil is increasing, wells previously considered too expensive to operate are now being used. In many cases, produced water, water that is affected by oil and sand during drilling, results. "As we see more of these drilling activities, we see much more of this produced



Highland separators with Corella coalescers reduce the level of oil and oil-coated solids discharged by petroleum storage facilities. The Corella inclined parallel-plate coalescers combine the features of both a flat-plate coalescer and a corrugated-plate coalescer into a new self-cleaning design

water," says Wines. "Right now we are using the Lucid Separator for these applications, but we think the future of produced-water cleanup is to combine the Lucid Separator with ceramic crossflow membranes."

Currently, the EPA requirement for discharge in produced water is about 29 to 30 ppm oil, but requirements are expected to become tighter in the next few years. Though ceramic crossflow technology has been applied in the food processing industry, it is somewhat new to oil and gas applications, but Pall is confident that new developments will allow its use on produced water.

"We've been able to improve the ceramic with a honeycomb design, which has given the technology more surface area but made it more compact," says Wines. "As regulations tighten and as oil producers look for more automated solutions, these ceramic systems will become more favorable."

EPA's National Pollutant Discharge Elimination System (NPDES), a permit control program, is another area where improved separation technologies are proving essential. As authorized by the Clean Water Act, the NPDES program controls water pollution by regulating point sources — discrete conveyances such as pipes — that discharge pollutants into U.S. waters. For many industrial sources, including refineries and chemical processing plants, wastewater discharge

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may contain pollutants at levels that could affect the quality of receiving water. Therefore, they must adhere to the permit program, which establishes specific requirements for discharges.

“NPDES regulations mainly impact industrial facilities and require separation technology with regards to sheen regulations, which limit petroleum hydrocarbon discharges to between 10 and 15 ppm; and, in some cases, there are non-detectable limits for petroleum hydrocarbons and benzene limitations,” says Aymong.

“We sometimes joke that the inspector is standing at the end of the pipe counting molecules, but in reality it is a serious problem as it is very difficult to get to the required discharge levels and many processors are further challenged by changing flows and pollutant characteristics. In some applications they are dealing with solid contaminants that may not be listed on the NPDES permit, but will adversely impact the equipment required for petroleum removal,” he explains.

Such challenges can become problematic, so these applications require advanced phase separation because they are dealing with various contaminants and are targeting smaller and smaller micron-sized pollutants.

For example, when the task comes to removal of petroleum hydrocarbons, it is usually done with an oil/water separator. These units have historically been equipped with coalescing devices to enhance the separation process, and have advanced over the years. “In 1986 we were targeting 150-micron oil droplets to get to a level of performance of about 100 ppm. More recent models were designed to effec-

tively target 60-micron droplets, and with the addition of other coalescing devices we are now targeting 5- and 10-micron droplets,” says Aymong. “There’s a big quantum leap in technology there.”

Further, he says Highland has developed a technology that physically adsorbs petroleum hydrocarbons from water down to the molecular level. “We are moving beyond targeting micron size and are targeting molecules, and getting down to a very fine level of performance that results in removal to the parts-per-billion and non-detectable ranges of petroleum hydrocarbons in water for certain areas that have very strict environmental regulations.”

Not only is phase-separation equipment vital to water cleanup, it can be applied to water conservation as well. Phosphoric-acid and sulfuric-acid production are on the rise in the Middle East and Northern Africa, but because water is not plentiful in those areas, there are trends toward conservation. In the typical process, mesh-style mist eliminators are used for the phase-separation process of the actual production, but scrubbers are now being added to the process to recover liquids, according to Fred Mueller, sales and marketing manager with Kimre (Miami, Fla.) “We have some proprietary designs for those systems, which conserve water and use less energy.”

Energy-efficient technologies

As Mueller mentions, lower energy usage is also important in today’s “green” climate. Kimre has developed

a patented high-performance, interlaced mesh structure for use where traditional tower packing, chevrons and mesh pads would be applied. The technology is said to provide excellent mass and heat transfer, particulate removal and mist elimination. The mesh structure features an open mesh pad in which approximately 93 to 95% of the mesh fibers are perpendicular to the gas stream, which provides improved capture by both impaction and interception and lower pressure drop than traditional mesh-style pads. Our products are widely used in the phosphoric acid industry because there are all kinds of foreign materials in such gas streams; these contaminants can be tolerated, and the energy requirements are lower, says Mueller.

He adds that Kimre is receiving inquiries from other energy-conscious industries and that the advanced technology is able, in many applications, to achieve the same separation levels at about half the pressure drop as other technologies, thus saving energy.

It would seem that while it’s not easy to be green, advanced phase separation technologies ease the pain of producing clean fuels, recycling or conserving water and complying with emission targets, all while using less energy. ■

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