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The Process Industry's Top 10 Technologies For 2010

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New Developments In:

- Nanotechnology
- Ultrasound
- Automation
- Energy Efficiency
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- Materials Composition
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Aalborg® VT6 PTFE Needle Valves Speed Compression Adjustments > See pg. 25

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Fueling Energy Savings

As hydrogen fuel cell technology becomes more developed and integrated into more lift trucks, gains should be realized not only in energy savings, but also improving just-in-time fulfillment, which drives efficiency beyond just the process in question, while resonating well throughout an organization's supply chain.

Let's start with some simple facts about the use of hydrogen fuel cells in lift trucks. Using a proton exchange membrane stack, these power supplies rely upon liquid-cooled hydrogen fuel, which comes in liquid form, but is transitioned into gas by in-plant refueling equipment. These stacks can be purchased already integrated into the truck or retrofitted in varying power levels that are customized according to the class of truck. This functionality outlines three benefits of hydrogen fuel cells in fork trucks. First, there's the energy savings incurred when compared to electric models. Not having to connect a fleet of vehicles to battery chargers for 30 minutes twice a day tremendously helps lower consumption rates.

Limited floor space is also addressed. Not only do hydrogen refueling stations (which closely resemble automotive gas pumps in size and stature) consume less space within a facility, but they can also be located throughout the plant as opposed to the larger space required for battery-charging equipment. And although they seem complex, many of these fueling systems are pretty simple as they're comprised of three main components: a compression system to aid in the liquid-to-gas conversion, buffer storage and a dispensing mechanism. In some instances, drop-down hoses from ceiling-mounted piping can also be provided to save even more space.

Finally, productivity levels are enhanced by avoiding the downtime associated with battery charging, and the slowed operation of a weakening power source. While battery charging can range from 15 to 45 minutes, the average fuel cell currently in use or development can be refueled in about three minutes.

The Challenges

Although the benefits are strong, the adaptation of hydrogen fuel cells in fork trucks could be slowed by initial investment costs. Additionally, maintaining vehicles with these types of power supplies present some unique challenges.

Fuel cells run in the neighborhood of $13,000 more than their traditional counterparts, but only one is needed per truck. Comparatively, electric models use two batteries, yet fuel cells still cost almost $10,000 more. However, looking at the typical usage patterns of a Class 3 forklift, implementation of a hydrogen fuel cell vs. an electric battery would save up to 10,000 labor hours during the equipment's lifetime, according to fuel cell manufacturer Ballard Power Systems. The U.S. government also grants tax breaks equaling up to 30 percent of the purchase price—for the cell, forklift and/or fuel delivery system.

The average fuel cell can be refueled in about three minutes.

From a maintenance perspective, these more complex lift truck power sources may create a demand for training that helps simplify some of their nuances. For example, consistent air flow is required to cool the fuel cell stack, as well as supply oxygen for the hydrogen reaction needed to create the electricity to power the truck. If air flow to the fuel cell stacks becomes obstructed, it can impede efficiency and, in severe cases, cause the fuel cell to shut down.

Repeated restrictions can shorten the life of these very expensive stacks. Preventive maintenance is as important to the fuel cell as it is to the truck itself. These types of operational mechanisms create special challenges, as do additional training, infrastructure and safety investments associated with handling hydrogen.

As is the case with most new technologies, there are incentives and drawbacks with hydrogen fuel cell implementation. However, in looking at the positive takeaways that can be realized, hopefully the benefits for the industry can be seen and advanced in helping to get wider spread adoption. In turn, the prohibitive cost hurdles that might prevent early adapters from getting onboard can be mitigated.

Bigger Yields In Algae Utopia

Led by chief technology officer Dr. Vikram Pattarkine, researchers at Origin Oil are focusing on algae as a third-generation feedstock that doesn't rely on arable land or energy crops with inconsistent yields. But growing algae in large, open bioreactors is prone to contamination, and traditional methods for extracting the oil are energy-intensive. Pattarkine is addressing these problems through the development of a closed bioreactor and a Quantum Fracturing™ process.

The Helix Bioreactor™ contains an array of internal light sources that are arranged in a helical pattern and tweaked to different wavelengths and frequencies to maximize their efficiency. A dynamic biofeedback control system responds to changing conditions in the algae culture by adjusting the lighting parameters, creating a disco-like utopia where food is plentiful, gate-crashers are locked out and reproduction is irresistible.

During the growth process, the CO_2 and nutrients used to feed the algae are fractured into a micro-bubble slurry and injected directly into the culture to increase the efficiency of nutrient absorption. This use of fluid fracturing and mass transfer has been dubbed Quantum Fracturing. The same concept is used when the oil is extracted from the algae; carefully pulsed electromagnetic fields and pH modification using CO_2 combine with Quantum Fracturing to break cell walls

and release oil. In the conventional process, algae biomass goes through an extensive dewatering process before oil can be extracted.

So how does the yield compare to other feedstocks in terms of oil extracted per hectare? "We're still calculating the exact numbers, but our preliminary estimates are phenomenal," says Pattarkine.

The result is a high-yield, consolidated Single-Step Extraction™ process that eliminates the need for dewatering, and accomplishes oil extraction and separation in a single step. Unlike other energy crops, the algae can be grown and processed in a consistent controlled environment to produce the crude oil used to manufacture biodiesel and other biofuels.

The Helix Bioreactor™ contains an array of internal light sources arranged in a helical pattern.

What About Energy Crops?

- Jatropha euphoria swept the world earlier this century due to the plant's drought resistance, ability to grow well in marginal soil and relatively high oil content. But support for jatropha is waning with Friends of the Earth releasing a report that questions the plant's ability to yield commercially viable amounts of oil and BP's recent withdrawal from a joint venture with D1 Oils.
- Fast-growing switchgrass uses an extensive root system to gather water from deep below the ground surface, making it ideal for arid or non-irrigated land with hard, shallow soil. It requires lower energy inputs than corn and soy due to its low maintenance and fertilizer requirements, and has a large energy output. Although the yield per acre is better than many other feedstocks, the amount of land required to produce enough ethanol to replace 100 percent of the U.S.'s fossil fuel requirements has been estimated at nearly half a billion acres, which is huge considering that the total area used for farmland is less than 1 billion acres.
- Camelina is a member of the mustard family that has yellow flowers containing twice as much oil per acre as soy. It doesn't need much water and is tolerant of cold, arid land unsuitable for food crops. Great Plains Oil and Exploration company is partnering with farmers around the country to grow the plants, namely in Montana, while it sets up facilities to convert the crop into biodiesel.
- Sweet sorghum's high sugar content and capability to grow almost anywhere in the U.S. has it emerging as a promising biofuel feedstock. In Destiny, FL, where real estate developer Anthony Pugliese and Subway Restaurants' founder Fred DeLuca are building "America's first eco-sustainable city," the crop is being grown to test for the high yields, water efficiency and pest resistance that were reported in early investigations.

The Catalyst For Better Fuel Cells

The U.S. Department of Energy (DOE) is actively pursuing cheaper automotive fuel cells as part of its push for alternative energy solutions. Specifically, proton exchange membrane fuel cells—powered by hydrogen and the oxygen contained in air via a reduction-oxidation reaction—are seen to have the greatest potential for use in the auto industry.

In 2008, the system cost for automotive fuel cells was $95 per kilowatt. By 2015, the DOE wants to bring the cost down to $30, roughly the same as that of a gasoline engine. To achieve this target, the expensive platinum electrode catalysts—used in fuel cells since the 1960s—have been singled out for replacement.

A group from the University of Dayton recently discovered that nitrogen-doped carbon nanotubes could be the solution the DOE is seeking. The results, published in Science, show that electrodes containing vertically aligned nitrogen-containing carbon nanotubes (VA-NCNTs) have much better electrocatalytic activity for the oxygen reduction reactions required to generate electricity in alkaline fuel cells. The VA-NCNTs also display long-term stability and are not susceptible to the carbon monoxide poisoning that can deactivate platinum catalysts. Most importantly, the carbon nanotube-based electrode can potentially be produced more cheaply than the platinum version.

Since reporting his group's results in February, Dr. Liming Dai has been working with a "major energy company" to test the viability of

Carbon Nanotubes Caught On Film

The use of carbon nanotubes in consumer products and solar cells is set to increase this year, driven largely by advances in thin-film nanotechnology. With proprietary carbon nanotube synthesis, ink formulation and coating processes in place, Unidym is testing a number of applications for its thin, transparent, ultra-conductive carbon nanotube-coated plastic films. In October of last year, SAMSUNG used Unidym's film to demonstrate a color display the size of a piece of paper, proving that carbon nanotube-based films are a viable alternative to indium-tin oxide-coated films currently used in displays.

Electronics giant LG Display has also jumped on board, entering into an agreement with Unidym to develop a version of its carbon nanotube films for use in its displays.

Unidym is also positioned to play a major role in the development of thin-film solar cells, which replace the large wafers used in silicon cells with ultra-thin layers of light-absorbing material. Essential to this technology is a transparent layer of conductive film that acts as an electrode by collecting the current generated by the cells.