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Forklifts Hoist Fuel Cells To Commercial Status: *Hydrogen-Powered Industrial Vehicles Lead the Way to Mass Market*

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The mass market for automobiles has long been considered the Holy Grail for the hydrogen fuel cell sector but in reality, industrial vehicle markets are likely to adopt the technology well before the automotive market.

The material handling market in particular is anticipated to be an adopter of fuel cell vehicles. With 570,000 material handling units sold worldwide each year it represents a very significant market for this technology. Battery electric vehicles, which make up approximately half of the material handling market, offer the first access to this market because they already operate on an electric vehicle platform, thus facilitating the integration of fuel cell technology.

In a development/deployment project lead by Hydrogenics and including NACCO Materials Handling Group, Inc., General Motors of Canada and Federal Express, two Hyster Class 1 5,500 lbs. capacity battery-powered forklifts were converted to hydrogen technology through the integration of a hybrid fuel cell power pack developed by Hydrogenics.

The hybrid power pack incorporates a HyPM 10 fuel cell power module for base load requirements and energy-storing ultracapacitors to handle load peaks, long duration transients, and to capture braking energy. To complete the system, additional power pack components include a hydrogen storage tank, thermal management and power electronics and controls.

The process of converting the battery-powered forklifts to run on hydrogen fuel cells was a relatively simple one. Indeed, one of the goals of the design was to minimize the modifications done to the forklift truck, making the solution a transferable one for other new or used electric trucks. The fuel cell power pack was seamlessly integrated into the existing battery compartment, fitting within the cubic boundaries where the lead acid battery is normally placed. Perhaps the biggest issue to deal with was weight. The fuel cell power solution was lighter than the original battery. While this is often a benefit over incumbent technology, in a lift truck designed specifically for battery power, the lead acid battery provides a portion of the counterbalance. As a result, additional weight needed to



be added to provide sufficient counterbalance.

Forklifts represent a good market to test the waters for early commercial viability, primarily in that they operate in somewhat controlled environments. They do not require the large public infrastructure that is sometimes cited as an impediment to mass-market adoption of fuel cells. They operate primarily as 'captive fleets' where hydrogen refueling is centralized to their operation. Also, their duty cycles, on a day in day out basis, are fairly predictable, allowing for some variation. Plant managers know how and when they are going to be used from day to day. Also, because forklifts are so often used inside, as is the case in the GM and FedEx demonstrations, you can take inconsistent weather out of the testing variables. All of this makes it much easier to compare and get a more accurate sense of how fuel cells perform compared to competitive technologies.

There are a number of hydrogen refueling options available to companies like GM and FedEx. These include delivered gas from a local supplier, or on-site generation through either electrolysis or natural gas reformation.

The source of hydrogen for Hydrogenics deployments is on-site generation using water and electricity from GM and FedEx and a Hydrogenics HySTAT refueler. The HySTAT produces hydrogen through electrolysis, a process that uses electricity to split water molecules into their constituent elements, oxygen and hydrogen. At GM, the process of hydrogen generation and dispensing occurred inside the manufacturing building. The operators were able to fill their vehicles without going outside, a necessity due to the cold and snow experienced during the deployment. When hydrogen levels in the storage tanks became low, the system automatically produced more hydrogen in order to ensure a continuous supply.

Deployments such as the one at GM provide an opportunity to compare fuel cell technology versus incumbent technologies under

a real world duty cycle and therefore test the value proposition. The deployment at GM's Oshawa Car Assembly Plant ran for approximately three months and logged more than 900 hours of operation. The GM operators embraced this new technology in their lift trucks. "The lift is faster and quieter. There is a longer distance before refueling versus battery replacement. [The fuel cell forklift] is cleaner operating; there is no battery acid smell," according to a GM shift 2 forklift operator. The two forklifts used at the GM plant have now been redeployed at FedEx's facility at the Toronto International Airport for a two month period.

The value proposition for fuel cells in the material handling market is dominated by productivity improvements. Productivity is increased through fast refueling (a full tank takes approximately two minutes to fill), extended run time and consistent and abundant power.

In contrast, battery electric forklifts need more frequent battery changes that require more time. While a battery change can be as fast as five minutes, battery changes can take upwards of 30 minutes if there is a queue and operators are forced to 'wait in line', a typical occurrence as the number of battery change rooms is often limited due to the infrastructure and personnel required by each of these stations.

In addition to these productivity improvements, fuel cell powered forklifts have several advantages over ICE or battery powered forklifts including:

Environmental Footprint: The absence of harmful emissions from fuel cell powered forklifts is especially important for indoor facilities. While battery-powered forklifts don't have emissions either, there are environmental complications when you need to dispose of the batteries.

Reduced Infrastructure: Fuel cell forklifts eliminate the need for multiple battery packs per truck, a battery recharger per truck, battery swapping equipment, battery charging station space and battery swapping personnel.



Safety: Fuel cell forklifts could positively impact plant safety as they could reduce the distance traveled to change batteries, as hydrogen refuelers could be conveniently located throughout the facility.

Improved Ergonomics: The integration of fuel cells as a power source for forklifts will allow forklift truck manufacturers to develop more ergonomic trucks that rely on distributed electric drive components. Manufacturers will no longer be forced to design around a large battery box. By building forklifts that rely on distributed electric drive components, forklifts can be made more ergonomic. These forklifts could improve productivity and reduce injury and damage due to accidents.

But forklifts are only one way that organizations are adopting fuel cells in fleet vehicles. In addition to fuel cell powered forklifts, Hydrogenics has initiated early introductions of fuel cells in other potential off-road mobility applications, as well as to urban delivery fleet vehicles. Purolator Courier Ltd., Canada's largest overnight courier company, introduced a fuel cell hybrid electric vehicle into



A fork lift ready for refueling at a hydrogen station

its Toronto curbside delivery fleet this spring, along with a number of other hybrid electric vehicles.

After analyzing the environmental impacts of its operations and services, Purolator identified fleet fuel usage and vehicle air emissions as the best way to reduce its environmental footprint. Under their 'Greening the Fleet' program, hybrid electric vehicles are expected to eliminate up to 50 per cent, and fuel cell hybrid electric vehicles up to 100 percent, of the greenhouse gases currently emitted with conventional gasoline/diesel delivery vehicles. Purolator has announced that if the experience of these vehicles lives up to its expectations, then as Purolator replenishes its fleet each year the company intends to add additional vehicles to its 'green' program.

It may take another 15 years for fuel cells to be widely marketed in automobiles, but well before then we expect to see fuel cell forklifts significantly improving the productivity of some of the most demanding manufacturing facilities and distribution centers around the world.

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