What's So Super About Nickel Supercapacitors?

The growing emphasis on environment-friendliness, energy-saving and general operational efficiency means there is a greater role in the transport industry for energy storage systems of all kinds. One relatively new form of energy storage – the nickel carbon supercapacitor – is finding favour in a wide variety of applications, especially where high levels of power are needed quickly and repeatedly.

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These include engine-starting in large vehicle applications. In many countries around the world, emissions reduction legislation requires that diesel engines on trucks or buses are cut if they are going to be idling for longer than 3 to 5 minutes. This means the on-board batteries must be capable not only of restarting the engine frequently, but also maintaining the 'hotel' services on the vehicle or train while the engine is switched off.

Nickel supercapacitors offer the advantages of very high power output and short recharge time, making them ideal for the kind of frequent stop-start applications seen in transport. Typically, using a nickel supercapacitor can reduce the number of batteries needed in a diesel engine starting application by half, as well as providing longer service life and reliable starting even in extreme conditions.

Making diesel greener and leaner

New 'no-idle' regulations are just one of the ways the transport industry is being called upon to become cleaner and greener. While their main purpose is to reduce carbon emissions and improve the environment, they also represent an opportunity for operators to deploy new technology that will save energy, improve cost-efficiency and maintain business performance.

No-idle regulations will affect how all buses, trucks, trains and other diesel-powered vehicles are operated. For example, buses will need to cut the engine at busy city centre stops when picking up and dropping passengers.

Most diesel-powered vehicles need to maintain on-board electronics, air-conditioning and other battery-powered mechanical services, even with the engine turned off. In a typical diesel-powered vehicle today, lead-acid batteries are used both to start the engine and to run the electronics while the vehicle is in operation.

One consequence of the no-idle regulations, therefore, is that the main batteries could be drained quickly, and potentially not have enough power to restart the engine.

In response, some fleets are turning to Auxiliary Power Units (APUs) to run the AC and other on-board electronics while the engine is not running. However, these battery-powered units or small internal combustion engines involve considerable additional cost and extra levels of maintenance.

Other systems have been developed to monitor the battery and let the driver or operator know when it's time to restart the engine before the battery reaches a low state of charge. Such systems can seriously reduce the life of standard lead-acid batteries, however, given the number of times the battery may be called upon to restart the engine during a 10-hour rest stop, for example. What is more, the five minutes of running time permitted may not be long enough to fully recharge the battery again - further shortening its life.

Figure 1: Frequent stop-start operations on bus services do not impact the reliability of buses when a supercapacitor supplies engine starting power

The challenge is not an entirely new one. The US Government's Tank-Automotive and Armaments Command (TACOM) – which oversees performance requirements on all the US military's wheeled vehicles – looked into various battery systems to determine the best for both engine starting and 'silent watch'. It concluded that no single battery can do the job.

Figure 2: The supercapacitor on this oil drilling truck enables it to restart its engine reliably after long periods drilling for oil in remote areas and in spite of extreme temperatures.

New technology combinations

Engine starting and powering on-board electronics are two very different functions that require different power capabilities. To start an engine requires a large amount of current, and therefore power, and a non-trivial amount of energy. However, once the engine is running the current draw is quite low, but the energy still needs to be substantial enough to keep the vehicle in operation.

Figure 3: A typical supercapacitor installation

Today's modern vehicles have high levels of functionality, such as GPS and other 'hotel' loads, which use more battery power while the engine is off.

The goal is to have a system that will enable the vehicle to operate on batteries for a longer time, and be able to restart the engine regardless of the batteries' state of charge.

Manufacturers are looking at various battery chemistries and systems to meet this need, including dual-battery systems to improve starting success by setting aside a set of batteries just for starting. However, this does not address the general performance problems that affect lead-acid batteries, and operators need to buy twice as many batteries.

As the TACOM study itself concluded, the need is best met through a combination of technologies: specifically an asymmetrical nickel supercapacitor combined with a low-cost, deep-cycle battery. Using this dual system can solve the problem of starting by enabling the use of higher-energy, longer-lasting batteries, as well as delivering a significant cost saving.

Saft nickel supercapacitors (SNCs) with an asymmetrical, aqueous construction have several distinct advantages:

- they are relatively safe, as they are water-based – spills are non-toxic, and they will not catch fire if exposed to open flame
- they offer rapid charging – within 20 to 30 seconds after an engine start, with no limit on charging rate
- once charged, they can be stored 'on the shelf' for up to a year and still provide sufficient cranking power to start an engine
- they do not cause catastrophic failure under abusive conditions, such as over-voltage, as the individual cells will vent and not take out the entire module. They can be replenished if venting for extended periods of time

- they have no need for balancing electronics, and have a simple, robust design which also increases the time for which the charge is retained
- they are low-energy devices that may be recharged from almost any source, even the vehicle's depleted battery
- 15 year service life with no maintenance requirements.

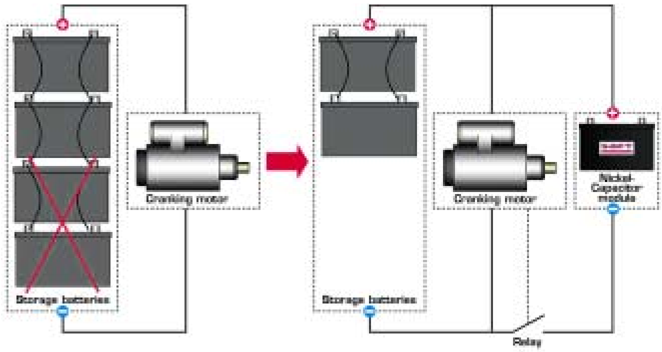

Figure 4: A supercapacitor can cut the number of batteries needed by half

Extreme temperature performance

SNCs offer additional advantages when operating in extreme temperatures. Lead-acid batteries can lose up to 50 percent of their power at 0°F/-32°C, while nickel supercapacitors still hold 90 percent of their initial charge at this temperature. Higher temperatures have an even greater effect on shortening the life of lead-acid batteries. Typically a lead-acid battery lasts only one to two years under extreme temperatures. In demanding stop-start applications, such as in delivery trucks, a lifetime of only eight months is not unheard-of.

Nickel supercapacitors are virtually unaffected by high temperatures, their power performance is better than 75 percent, all the way down to -40°F/-40°C, they allow for more than 300,000 engine starts, and offer a lifetime of 15 to 20 years – 10 times that of a lead-acid battery, regardless of the environment.

Several manufactures are now considering combining nickel supercapacitors with either nickel-cadmium (Ni-Cd) or lithium-ion (Li-ion) batteries, which offer lifetimes of 15 years or more. Using SNCs for engine starting also increases the life of the other batteries as much as twofold. Furthermore, in most applications, this combined approach can cut the number of batteries needed by half.

To maximize the advantages of SNCs in engine starting, Saft recommends isolating them from the vehicle's main battery, which prevents dead lead-acid batteries from draining the supercapaictor's power when the engine is off. Isolation increases the life of batteries by keeping them purely for onboard 'hotel' loads, without the added starting drain, and allowing the use of lower-cost, longer-lasting deep-cycle batteries. Also, the main batteries can be drained down to nothing and the engine will still crank over.

No-idle regulations are now a reality, and they impose greater strain on the lead-acid batteries typically used in diesel engine starting applications. With their inherently safe electrolyte, simple, no-balancing electronics, and low leakage rate, SNCs are the clear choice for augmenting vehicles' energy systems with a power device that will reliably start the diesel engine over and over again for at least the lifetime of a typical bus or truck.

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