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**Power Feature**

***Oldest Technology on the Planet Making a Come-back in UPS***

By Alison Campbell

Flywheel technology, which dates back to Neolithic man, is coming into its own as a supplement to battery back-up power in larger uninterruptible power supply (UPS) installations. Concerns over an increase in power interruptions and more reliance on a reliable flow of clean energy to keep systems and equipment up and running is driving the phenomenon.

Alongside a multitude of advantages, modern flywheels carry a smaller footprint than a similar rated (kW) set of VRLA batteries (normally used in UPS installations) and can lessen the drain on a battery set for very short interruptions in power supply, thus extending battery life and providing additional back-up. Flywheels also yield no harmful emissions and do not require specialist, licensed disposal like batteries, so addressing environmental concerns.

But if they really are such a clean alternative, you may ask, why is their relevance only now emerging?

Several reasons: firstly, energy usage overall is climbing like never before, giving rise to more concern about the implications of power loss. Some industry insiders are predicting a 50% increase by 2030, whilst National Grid is forecasting a more modest peak demand growth of 10% between now and 2014. Whatever the figure, demand continuers to increase. Almost all wireless and telecoms equipment nowadays requires a source of mains or ‘grid’ power.

Secondly, grid power is no longer reliable so users are looking to do everything they can to protect sources. According to energy watchdog, Ofgem, the average number of minutes customers were off supply in 2004/05 across Great Britain was 94.3, an increase of 13.2 on 2003/04.

Lastly, gone are the days of cheap energy. Prices have been rising steadily over the last two decades, forcing users to find ways to cut consumption or source cheaper alternatives and more efficient protection solutions.

However, with flywheels, cost can be a major stumbling block. They are far more expensive to manufacture and install than VRLA batteries and so are being used primarily in larger UPS installations over 250kVA, otherwise they are currently cost-prohibitive.

Despite this, UPS protection (and its various alternatives of increasingly more reliable, sustainable products, such as flywheels) is now very much at the forefront of the business agenda.

A basic UPS schematic consists of a rectifier, inverter (which converts the input power supply from ac to dc) and a battery, which in the event of a mains power failure keeps the load running for the time it takes an alternative power supply to start up.

The size and number of batteries that comprises this back-up function depends upon the size of load to be protected and the duration for which back-up (or extended runtime as it sometimes called) is required.

Batteries also require cooling, which can place additional strain on already overworked electrical resources, and they need good ventilation as they give off harmful emissions.

They are susceptible to temperature change and need to be kept at a constant 20-25 degrees centigrade to prolong life. Ten degrees centigrade above or below this range will shorten life by up to 50%. Flywheels are not so susceptible and will easily operate efficiently in anything up to 40 degrees centigrade.

Although the capital cost of batteries can be much less expensive than flywheels, their lifetime costs can be significant. They require regular checking for alarm and fault conditions (one faulty battery could render the whole string redundant) and maintenance. Once they come to the end of their design life, batteries need professional, licensed disposal to meet regulatory requirements. They cannot be merely thrown away into landfill.

Because batteries use a chemical process to generate energy, over time they will corrode and therefore have a much shorter design life than flywheels, which utilise non-corrosive, non-chemical Kinetic energy. Flywheels are designed to last for 20 years, whereas the standard design life for batteries is five years (although ten, 15 and 20-year options are available but not as standard).

Modern flywheels work on the principal of Kinetic energy: a motor generator is used to rotate a mass at high rpm in a vacuum on frictionless bearings inside a floor-mounted cabinet. Electrical energy is discharged to the load, in the case of a UPS, by connecting to the dc busbar. Speed of rotation is dependent upon the size of the mass and can vary from 7000rpm for a steel mass to much higher (around 50,000rpm or higher) with composite materials.

Until recently, use of flywheels in power protection has been limited to steel wheels coupled with motor/generator sets, so that the increase in rotary inertia (and hence stored kinetic energy) allowed longer ride through during utility power interruptions. Runtime for such systems rarely exceeded one second at full load and delivered less than 5% of the additional stored energy, which was highly inefficient.

Today's flywheels incorporate rotors machined from a solid forging of high-strength steel, which spins at high-speed in stand-by mode ready for a power disturbance that requires immediate dc energy delivery.

The magnitude of the engineering challenge should not be underestimated. A one-foot diameter flywheel, one foot in length, weighing 10.45kg (23lb), spinning at 100,000rpm will store 3kWh of energy. At this rate, the surface speed at the rim of the flywheel will be 3,570mph (4.8 times the speed of sound). The centrifugal force on particles at the rim is equivalent to 1.7 million G. The strength of material used for the flywheel rim must, therefore, be over 500,000 psi to stop the rotor from flying apart.

Advances in power electronics and innovative techniques for harnessing the energy stored in rotating mass flywheel systems is being integrated with the power electronics of conventional UPS to provide extended runtime for critical loads, such as computer rooms, data centres and sensitive communications equipment.

Much of today's communications equipment, whether telecoms or wireless, requires a source of reliable, clean energy. It runs at low voltages which means it is more susceptible to the short interruptions and power fluctuations commonly associated with raw mains power. The seconds that lapse between an interruption in power flow and the start-up of a standby generator pose a serious issue. Without full, uninterruptible power protection there might as well be no back-up power at all.

The application of flywheel technology in UPS systems is being demonstrated in two ways: firstly, fully integrated flywheel-based UPS and secondly, flywheel systems used as replacement or supplement to conventional UPS batteries.

The flywheel provides power during the period between the loss of mains power and either its return or the start of a sufficient back-up power system (i.e. diesel generator). Flywheels can discharge at 100 kilowatts (kW) for 15 seconds and recharge immediately at the same rate, providing 1-30 seconds of runtime. Back-up generators are typically online within 5-20 seconds. They can also be used in parallel to increase runtime.

In large data centre UPS applications, the use of flywheels can lessen battery management requirements. In the case of a load protected by four, 500kVA UPS, with battery sets and a generator, a flywheel could be used as a supplement to the battery set on one UPS and thus the site only has to consider the management of three.

Modern super dc flywheels store kinetic energy in a high-speed rotating drum which forms the rotor of a motor generator. When surplus electrical energy is available it is used to speed up the drum. When the energy is needed, the drum provides it by driving the generator. As an alternative to steel, some high-energy flywheels use composite rotors made with carbon fibre materials. These rotors have a high strength-to-density ratio, and rotate at speeds up to 100,000rpm in a vacuum chamber to minimise aerodynamic losses. The use of superconducting electro magnetic bearings can virtually eliminate energy losses through friction, thus making them relatively noiseless.

As flywheels use only $1/10^{th}$ the power of batteries or other back-up products, over the course of an average 20-year design life their use will prevent battery greenhouse gas emissions and the dumping of more than 6,818kg (15,000lb) of lead and hundreds of gallons of sulphuric acid.

It is unlikely that VRLA batteries will disappear within the next forty years. Although the technology has hardly changed since their development; they are an established commodity and relatively cheap to manufacture. Aside from the ‘green issues’ associated with their usage and disposal, which can be offset by smart management techniques, they are a reliable technology.

But just as Neolithic man was famed for his invention of an abundance of tools for human development, UPS specialists view flywheels as a useful addition to our growing arsenal of power protection devices for the modern era.

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