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Hi-Tech Flywheels Spin Kinetic Energy into Electricity

A flywheel is basically a heavy disk, wheel, or drum rotating on a shaft. What causes a flywheel to spin and what determines the thing it produces depends in many instances on when in history it was used. Historians tell us that flywheels have been in use since approximately 3500 B.C.

Photos courtesy Beacon Power Corp.

Photo 1—Aerial view of the new Beacon Power flywheel generating facility

Since their invention, flywheels have stayed relevant because of their amazing ability to function as an energy intensifier, energy equalizer, and storage medium for energy derived from intermittent resources. In ancient times, they were found on potter's wheels, water wheels, and spinning looms. In modern times, we find them in a seemingly infinite number of places, including automobile engines, industrial machines, earth satellites, and even children's toys.

The U.S. electric grid is now beginning to adopt flywheel farms to store electricity as kinetic energy. Here, this ancient technology is used as a mechanical battery. The basic concept behind the flywheel battery is easy to understand. When electricity generation exceeds demand, the extra electric power is used to spin high-tech flywheels to turn the electricity into stored kinetic energy. When the demand for electricity exceeds that being generated by the power plants, these high-tech flywheels spin their stored kinetic energy back into electricity.

To accomplish this task, each flywheel shaft is linked to a magnetically levitated motor/generator. When electricity exceeds demand, the motor/generator acts as a motor to spin up the speed of the flywheel. When demand exceeds electricity, the motor/generator acts as a generator that allows the spinning flywheel to convert its kinetic energy back into electricity as the flywheel slows under the load of turning the generator.

What makes this electricity very special is the fact that it is created without burning any fossil fuels and the production process doesn't create any greenhouse gasses. By using flywheel technology to meet spikes in demand, the need to burn more fossil fuel at an existing plant or the need to build a new fossil fuel electricity-generating plant is, at least for the moment, abated. Photo 1 shows an aerial view of the new fully operational Beacon Power 20 MW flywheel plant in Stephentown, NY.

Since July of this year, Beacon's 160 flywheel generators in Stephentown have been taking excess electricity out of the New York State electric grid for storage as kinetic energy and then converting it back to electricity as it is needed. This activity prevents electrical spikes and dips that can easily damage electronic equipment. The goal here is to keep the electric grid's electricity output at a steady 60 Hz.

The need for off-grid energy storage and re-generation is significant, and a number of technologies are being used to address the need. Since flywheels have played a role in technology for over 5,000 years, I selected them as the off-grid energy storage system to explore in this column. You might want your students to explore other off-grid technologies. Topics for their research could include new emerging systems based on lithium-ion batteries, flow batteries, fuel cells, ultra-capacitors, and even molten salt batteries.

The goal of these off-grid systems is to prevent ac (alternating current) from fluctuating when demand quickly spikes up or down. What makes flywheels and other off-grid storage systems important is that they can act more quickly than the frequency

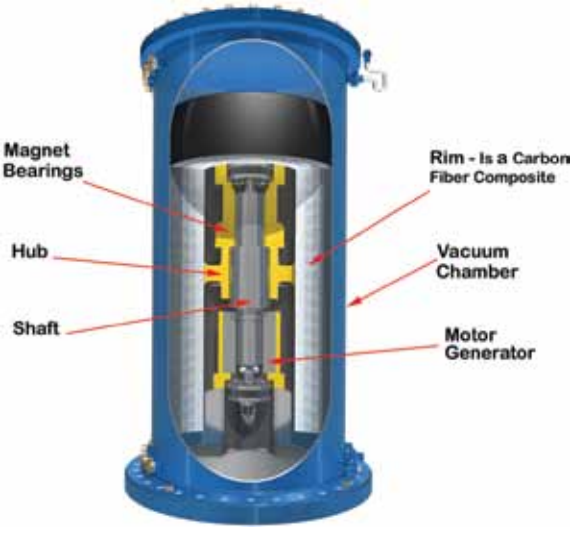

Photo 2—Internal features of the Smart Energy 25 flywheel. Just as in a maglev train, the internal parts are levitated so they don't touch the metal shaft or unit housing as they spin at 1,500 mph.

Photos 3 and 4—The Smart Energy 25 flywheel parts are fabricated to extreme tolerances, carefully assembled, and tested to guarantee that they can withstand the extreme speeds that they will operate at.

regulators that currently accelerate and decelerate power plant turbines.

The Beacon Smart Energy 25 flywheel rotor assembly includes a carbon fiber composite rim, metal hub, metal shaft, motor/generator, and magnetic bearings all spinning together in a vacuum chamber. The system has been specifically designed to keep friction loss of energy to a minimum. See the schematic diagram (Photo 2) to see how all of these parts fit together.

The fabrication and assembly process demands extreme accuracy. (See Photos 3 and 4.) If parts are off in size or alignment, the unit would rip itself apart when it starts to spin at up to 16,000 revolutions per minute. This spinning speed equals about 1,500 miles per hour—twice the speed of sound. The reason the flywheel can spin so fast and thus absorb so much energy is because all parts are fabricated to extreme tolerances, they are rotating in a vacuum, and they are levitated by magnets so they don't touch the shaft that they spin around.

The need for off-grid energy storage is expected to explode as more of our future electricity needs are supplied by wind, solar, wave, and other new intermittent green energy power systems. These systems will definitely need a method for storing the energy they produce when it is abundant and then releasing it back into the system when the energy that they produce is not sufficient to meet needs. An off-grid system like one involving flywheels will need to jump into action when the wind doesn't blow, the sun doesn't shine, or ocean waves don't have enough oomph for these green systems to supply significant electricity to the electric grid.

You can see a video that shows how the Beacon Smart Energy 25 flywheel works online at http://beaconpower.com/includes/videos/flywheel-video.html?KeepThis=true&TB_iframe=true&height=430&width=478. If you have problems with this link you will find the video on my website at www.technologytoday.us/page13.html.

Recalling the Facts

1. Why is the flywheel energy system described as a sustainable green technology?

2. It is very unusual to find a land-based system that can sustain Mach 2 speeds. How does the Beacon Smart Energy 25 flywheel manage to spin so fast without ripping itself apart?

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