What is flywheel energy storage

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Flywheel energy storage (FES) works by accelerating a rotor (flywheel) to a very high speed and maintaining the energy in the system as rotational energy. When energy is extracted from the system, the flywheel"s rotational speed is reduced as a consequence of the principle of conservation of energy; adding energy to the system correspondingly results in an increase in the speed of the flywheel.

Most FES systems use electricity to accelerate and decelerate the flywheel, but devices that directly use mechanical energy are being developed.[why?][1]

Advanced FES systems have rotors made of high strength carbon-fiber composites, suspended by magnetic bearings, and spinning at speeds from 20,000 to over 50,000 rpm in a vacuum enclosure.[2] Such flywheels can come up to speed in a matter of minutes - reaching their energy capacity much more quickly than some other forms of storage.[2]

A typical system consists of a flywheel supported by rolling-element bearing connected to a motor-generator. The flywheel and sometimes motor-generator may be enclosed in a vacuum chamber to reduce friction and energy loss.

First-generation flywheel energy-storage systems use a large steel flywheel rotating on mechanical bearings. Newer systems use carbon-fiber composite rotors that have a higher tensile strength than steel and can store much more energy for the same mass.[3]

Since flux pinning is an important factor for providing the stabilizing and lifting force, the HTSC can be made much more easily for flywheel energy storage than for other uses. HTSC powders can be formed into arbitrary shapes so long as flux pinning is strong. An ongoing challenge that has to be overcome before superconductors can provide the full lifting force for an FES system is finding a way to suppress the decrease of levitation force and the gradual fall of rotor during operation caused by the flux creep of the superconducting material.

The maximal specific energy of a flywheel rotor is mainly dependent on two factors: the first being the rotor"s geometry, and the second being the properties of the material being used. For single-material, isotropic rotors this relationship can be expressed as[9]

For energy storage, materials with high strength and low density are desirable. For this reason, composite materials are frequently used in advanced flywheels. The strength-to-density ratio of a material can be expressed in Wh/kg (or Nm/kg); values greater than 400 Wh/kg can be achieved by certain composite materials.

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Several modern flywheel rotors are made from composite materials. Examples include the carbon-fiber composite flywheel from Beacon Power Corporation[13] and the PowerThru flywheel from Phillips Service Industries.[14] Alternatively, Calnetix utilizes aerospace-grade high-performance steel in their flywheel construction.[15]

For these rotors, the relationship between material properties, geometry and energy density can be expressed by using a weighed-average approach.[16]

One of the primary limits to flywheel design is the tensile strength of the rotor. Generally speaking, the stronger the disc, the faster it may be spun, and the more energy the system can store. (Making the flywheel heavier without a corresponding increase in strength will slow the maximum speed the flywheel can spin without rupturing, hence will not increase the total amount of energy the flywheel can store.)

Traditional flywheel systems require strong containment vessels as a safety precaution, which increases the total mass of the device. The energy release from failure can be dampened with a gelatinous or encapsulated liquid inner housing lining, which will boil and absorb the energy of destruction. Still, many customers of large-scale flywheel energy-storage systems prefer to have them embedded in the ground to halt any material that might escape the containment vessel.