ANALYSIS OF FLYWHEELS

Dr. Dinesh Kumar Soni, Dept. of Mechanical Engineering
Rabindranath Tagore University, Bhopal

Abstract

Energy storage systems (ESS) give a way to improving the effectiveness of electrical frameworks when there are uneven characters among free market activity. One energy storage technology now arousing great interest is the flywheel energy storage systems, since this technology can offer many advantages as an energy storage solution over the alternatives. Flywheels have qualities of a high cycle life, long operational life, high round-trip proficiency, high control thickness, low ecological effect, and can store megajoule (MJ) levels of energy with no maximum breaking point when designed in banks. This paper exhibits a basic audit of FESS with respect to its fundamental parts and applications, a methodology not caught in before surveys. Furthermore, prior audits do exclude the latest writing in this quick moving field. A depiction of the flywheel structure and its primary segments is given, and various kinds of electric machines, control hardware converter topologies, and bearing frameworks for use in flywheel storage systems are examined [1], [2].

Keywords: renewable, energy, flywheel, efficiency, electrical, storage

Introduction

Energy storage systems (ESS) can be used to balance electrical energy supply and demand. The process involves converting and storing electrical energy from an available source into another form of energy, which can be converted back into electrical energy when needed [3], [4]. The forms of energy storage conversion can be chemical, mechanical, thermal, or magnetic. ESS enable electricity to be produced when it is needed and stored when the generation exceeds the demand. Storage is beneficial when there is a low demand, low generation cost, or when the available energy sources are intermittent. At the same time, stored energy can be consumed at times of high demand, high generation cost, or when no alternative generation is available. A flywheel stores energy that is based on the rotating mass principle. It is a mechanical storage device which emulates the storage of electrical energy by converting it to mechanical energy. The energy in a flywheel is stored in the form of rotational kinetic energy. The input energy to the FESS is usually drawn from an electrical source coming from the grid or any other source of electrical energy. The flywheel speeds up as it stores energy and slows down when it is discharging, to deliver the accumulated energy. The rotating flywheel is driven by an electrical motor-generator (MG) performing the interchange of electrical energy to mechanical energy, and vice versa .The flywheel and MG are coaxially connected, indicating that controlling the MG enables control of the flywheel. he main characteristics of flywheels are a high cycle life (hundreds of thousands), long calendar life (more than 20 years), fast response, high round trip efficiency, high charge and discharge rates, highpower density, high energy density [7,9], and low environmental impacts [2,3,9,28,29,61]. The state of charge can be easily measured from the rotational speed and is not affected by life or temperature [9].On the downside, flywheel self-discharge at a much higher rate than other storage mediums and flywheel rotors can be hazardous, if not designed safely. Flywheels have a long life time and very low operational and maintenance requirements. The cycle life is also high, compared to many other energy storage systems, as flywheels do not require long charge-discharge cycles. In addition, flywheels are used in combination with batteries in UPS systems requiring longer durations. A flywheel can deal with shorter interruptions, while batteries can be saved for longer outages. This will save the battery from frequent charge-discharge, which will further increase its lifetime [5], [6]. Usually, flywheels and batteries are combined for applications requiring a mix and match between energy density and cost, which cannot be otherwise achieved with one of these storage systems. Many manufacturers around the world have developed flywheel systems for UPS. Flywheels can assist in the penetration of wind and solar energy in power systems by improving system stability. The fast response characteristics of flywheels make them suitable in applications involving RES for grid frequency balancing. Power oscillations due to solar and wind sources are compensated for by storing the energy during sunny or windy periods, and are supplied back when demanded. Flywheels can be used to rectify the wind oscillations and improve the system frequency; whereas, in solar systems, they can be integrated with batteries to improve the system output and elongate the battery's operational lifetime [7], [8].

Conclusion

The study has obtainabed a critical review of FESS with reference to its main components and applications. The structure and components of the flywheel are introduced and the main types for electric machines, power electronics, and bearing systems for flywheel storage systems are described in detail. The main applications of FESS in power quality improvement, uninterruptible power supply, transportation, renewable energy systems, and energy storage are explained, and some commercially available flywheel storage prototypes, along with their operation under each application, are also mentioned. FESS offers the unique characteristics of a very high cycle and calendar life, and are the best technology for applications which demand these requirements. A high power capability, instant response, and ease of recycling are additional key advantages.

References

[1] J. Lee, T. Nomura, and E. M. Dede, "Asymptotic homogenization of magnetic composite for controllable permanent magnet," *Compos. Part B Eng.*, vol. 161, pp. 128–140, Mar. 2019.

[2] S. Saidi and A. Djebli, "Analysis of the effects of materials on the resistance of the flywheel," in *Procedia Manufacturing*, 2018, vol. 22, pp. 675–682.

[3] V. Kale and M. Secanell, "A comparative study between optimal metal and composite rotors for flywheel energy storage systems," *Energy Reports*, vol. 4, pp. 576–585, Nov. 2018.

[4] M. A. Conteh and E. C. Nsofor, "Composite flywheel material design for high-speed energy storage," *J. Appl.*

Res. Technol., vol. 14, no. 3, pp. 184–190, Jun. 2016.

[5] X. Peng *et al.*, "Design and fabrication of Fe–Si–Al soft magnetic composites by controlling orientation of particles in a magnetic field: anisotropy of structures, electrical and magnetic properties," *J. Mater. Sci.*, vol. 54, no. 11, pp. 8719–8726, Jun. 2019.

[6] J. E. Martin, L. E. S. Rohwer, and J. Stupak, "Elastic magnetic composites for energy storage flywheels," *Compos. Part B Eng.*, vol. 97, pp. 141–149, Jul. 2016.

[7] A. Saeed *et al.*, "Steps toward sustainability: Energy through flywheels," in *7th International IEEE Conference on Renewable Energy Research and Applications, ICRERA 2018*, 2018, pp. 111–116.

[8] M. A. Awadallah and B. Venkatesh, "Energy storage in flywheels: An overview," *Can. J. Electr. Comput. Eng.*, vol. 38, no. 2, pp. 183–193, Mar. 2015.