IJIREEICE

ISSN (Online) 2321-2004
ISSN (Print) 2321-5526

International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering

Vol. 9, Issue 7, July 2021

DOI 10.17148/IJIREEICE.2021.9726

Flywheel Energy Storage System

Prof. Vishal V. Mehtre[1], Vaibhav Krishna[1], Vaibhav Bhaskar[1]

Department of Electrical Engineering, Bharati Vidyapeeth (Deemed to be University) College of Engineering, Pune[1]

Abstract: This paper establishes the design approach of flywheel energy storage system (FESS) in a uninterruptible power supply. The Flywheel Energy Storage (FES) system has emerged as one of the best options. After brief introduction to the FES system and its theory of operation, the paper focuses on the important role of the FES system in enhancing the operation of the distribution network. Supported by illustrated circuits, the FES system in the improvement of the power quality of the network. A flywheel energy storage technology was ended, with a special focus on the progress in automotive applications. In order to improve the efficiency and lifetime, then it discusses a newly proposed design of the FES system that emerged recently, which includes the use of Superconducting Magnetic Bearings (SMB) and Permanent Magnetic Bearings (PMB). In conclusion, the paper analyses the FES systems great potentials that could be exploited in improving the reliability of the electrical system.

INTRODUCTION

Flywheel energy storage systems (FESS) store electric energy in terms of the kinetic energy of a rotating flywheel and convert this kinetic energy into electric energy when necessary. A FESS is a
viable technology for energy storage because it is environmentally safe, can sustain infinite charge/discharge cycles, and has higher power-to-weight ratio than chemical batteries. FESSs commonly use active magnetic bearings (AMBs) for contact-free operation to maximize the efficiency of the system the most important trade-off 'sin a flywheel energy storage system is between high power or high energy. A high-power application is relatively simple seen from a flywheel design perspective. A standard high-power electric machine is fitted with some extra weight to sustain the power for a long enough time. A focus on high energy means that the requirements on the mechanical properties of the rotor put limits on the power transfer units or suspension. Energy requirements on the mechanical properties of the rotor put limits on the power transfer units or suspension. Energy flywheels are a main area of research, since this opens up possibilities for new end applications. He ups necessitate the energy buffer such as electric double capacitors (EDLCs), batteries, or flywheels as the UPS has to supply the power to load until an emergency generator begin. Table I shows the description of every energy storage strategy. The battery can accomplish a high energy density at low cost. though, one of the troubles in the battery energy storage is the short lifetime. In meticulous, the lifetime taking place the ambient and the number of charge and discharge time. In addition, the battery cannot manage with speedy charge and discharge owing to the large internal resistance in the battery. On the other hand, an EDLC has a high charge and discharge efficiency. Besides, the rapid charge and discharge are probable because the internal resistance is extremely small. Though, similar to the battery, the lifetime is decreased rapidly owing to the authority of the ambient temperature

PRINCIPLE OF OPERATION

A flywheel stores energy in a rotating mass. Depending on the inertia and speed of the rotating mass, a given amount of kinetic energy is stored as rotational energy. The main idea is that the flywheel is placed inside a vacuum containment to eliminate any frictionless that might be caused by the air and suspended by bearings for stable operation. Then, depending on the need of the grid, the kinetic energy is transferred either in or out of the flywheel which is connected to a machine that works as either the motor or generator. In the motor mode, electric energy supplied to the stator winding is converted into torque and applied to the rotor, causing it to spin faster and thus gaining kinetic energy. While in the generator mode, the kinetic energy stored in the rotor would apply torque which is converted to the needed amount of electric energy. Fig shows the basic layout

CONSTRUCTION OF FLYWHEEL ENERGY STORAGE SYSTEM

Fig.1 shows the configuration of the first prototype FESS that employs a general induction motor and ball bearings. In this system, it is possible to store the kinetic energy of 3.0 MJ at 2900 r/min. The typical ball bearing and the general-purpose motor can be applied in such low rotation speed region. In addition, the flywheel vacuum case and the motor are separated by the magnetic coupling. As a result, the windage loss can be greatly reduced because it is possible to reduce the pressure in a vacuum case by the vacuum pump. Moreover, the vacuum in the vacuum case does not affect the heat dissipation of the motor because the motor and the vacuum case are separated. Therefore, the general-purpose motor can be applied to drive the flywheel without adding special cooling mechanism.

IJIREEICE

ISSN (Online) 2321-2004
ISSN (Print) 2321-5526

International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering

Vol. 9, Issue 7, July 2021

DOI 10.17148/IJIREEICE.2021.9726

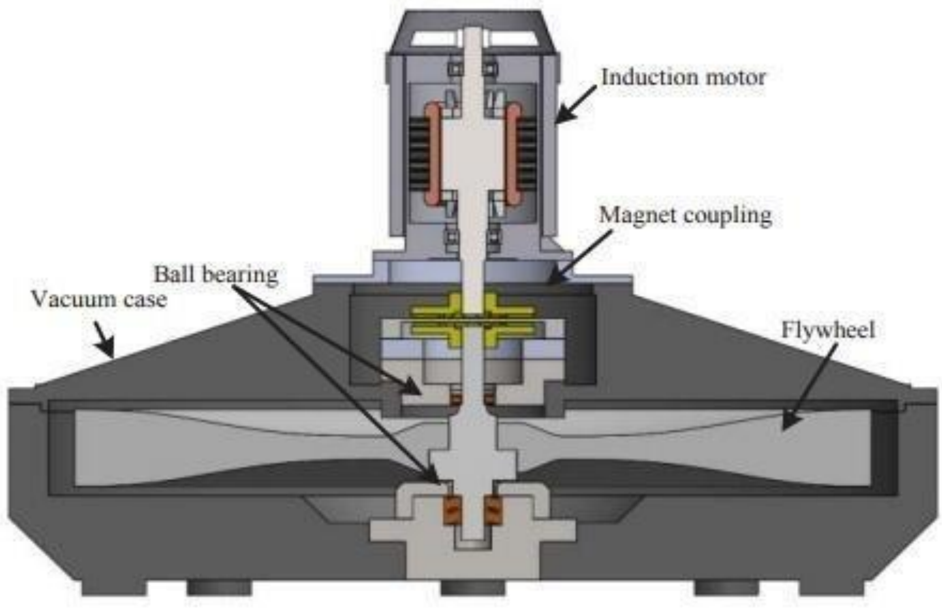

Fig 1. Flywheel energy storage system

BASIC DESIGN APPROACH

There are two approaches in designing a flywheel unit: The first stage is to obtain the amount of energy required for the desired degree of smoothing in addition to the moment of inertia needed to absorb that determined energy. The second stage is to define the flywheel geometry, which caters to the required moment of inertia in a reasonably sized package. A. Design Parameters There are many parameters to be considered in the design of the flywheel energy Speed fluctuation the speed fluctuation is defined as the change in the shaft speed during a cycle, given by the following equation:

Fl = W max − $Wmin$ ....(i)

Coefficient of speed fluctuation. The coefficient of speed fluctuation is one of the parameters set by the designer. The smaller this chosen value, the larger the flywheel would be and the greater the cost and weight to be added to the system. However, the smaller coefficient would result in the smoother operation of the flywheel energy unit. The coefficient can be found by the following equation:

Cf = W max −$Wmin$ /W ....(ii)

Where W: the nominal angular velocity.

The typical value of Cf is set to be between 0.01 up to 0.05 for precision machinery work. 3) Design equations the kinetic energy in a rotating machine is given by

Ek= ½ I w 2................(iii)

The kinetic energy in any system could thus be found

from Ek = E1 ₋ E2

Ek= ½ Is (2wavg) (Cfwavg) ....(iv)

E1 – E2 = Cf Iw2

The above equation can also be used to obtain an appropriate flywheel inertia Im corresponding to the known energy exchange Ek at a specific value of coefficient Cf.

A- FLYWHEEL ENERGY DESIGN USING SMB AND PMB

The Flywheel energy storage approach is currently considered as one of the most successful figures of energy storage, and many attempts have been made to improve this technology. Among these latest developments is the use of a superconducting magnetic bearing (SMB) together with a permanent magnetic bearing (PMB). According to Komori (2011) this approach has resulted in higher energy storage compared with conventional flywheel systems, and would lead to reduced overall costs and cooling costs. One of the main issues in operating the flywheel system is the large vibration transmitted to the rotor during operation, causing difficulties in controlling the speed of the rotation. The purpose of this specific design, using SMB and PMB, is to support the rotor in the flywheel system; the main function of the SMB is to suppress the vibrations in the rotor, while the PMB passively controls and maintains the position of the rotor.

IJIREEICE
ISSN (Online) 2321-2004
ISSN (Print) 2321-5526

International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering

Vol. 9, Issue 7, July 2021

DOI 10.17148/IJIREEICE.2021.9726

B-DESCRIPTION OF THE DESIGN

Fig.2 shows a schematic description of the flywheel energy storage system using a SMB and a PMB. It should be noted that the SMB is placed into the bottom of the system's rotor, while the PMB is set at the top of the flywheel rotor. This is because the damping effect of the SMB is effective if it is placed in the lower side of the rotor, while PMB has no damping effect. The flywheel is constructed so that the centre of gravity is lower than the centre of the supporting point. Thus, the centre of gravity still lies in the centre position of the upper magnet of the SMB part, which would give the system more inertia and make it more stable under both rotating and non-rotating condition

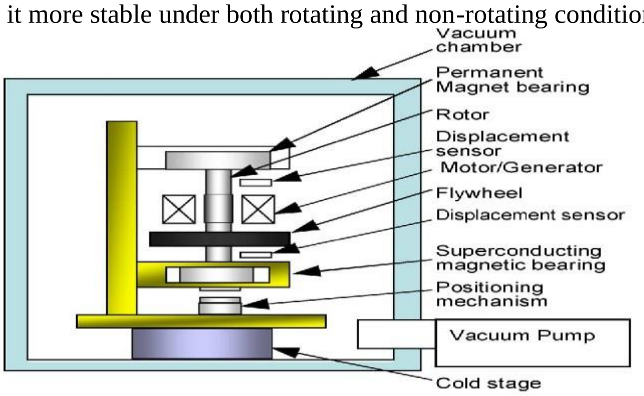

Fig. 2 Description of the flywheel energy storage system using a SMB and a PMB

CONCLUSION

Flywheel storage energy system is not a new technology; though, the bottomless interest in applying its principle in power system applications has been really increasing in the recent decades. in addition, research has been applied to develop the great feature the FES can offer, which primarily exposed in power excellence improvement and improvement of the network dependability and stability. in addition, advancements in the design of the flywheel energy units, composite materials, and power electronics devices have powerfully presented the FES technology as vulnerable option to the electromechanical batteries, especially that FES system have the description of storing and releasing energy in very fast time with very high operational efficiency. Besides, Flywheels are now used intensively in many applications related to power system such as telecommunications, utilities load levelling, and even in some additional applications in satellite engineering as well. In addition, it has been concentrated lately in distribution sectors of electrical power. Most of the distribution networks are exposed to voltage dips problems, and FES system, associated with its power electronics converters, offer effective compensation for the network Moreover, many researchers have started conducting studies to evaluate the high possibility of having FES systems with intermittent power system sources such as wind and solar systems. This paper tried to demonstrate the concept of many technical papers on FES system. After illustrating the basic functioning design and way of work, this paper described the position of the FES systems in the control of reactive power and power quality in distribution network. behind that, a brief basic design and lately design of flywheels using SMB and PMB have been illustrated in some feature. The paper concluded with the recent developments in flywheels industry that can offer the FES systems in the future to be great solution to solve the power system reliability problems in the low voltage distribution network.

REFERENCES

[1] T. Aanstoos, J. P. Kajs, W. Brinkman, H. P. Liu, A. Ouroua, and R. J. Hayes, "High voltage stator for a flywheel energy storage system," IEEE Trans. Magazine

[2] I. Vajed, Z. Kohari, L. Benko, V. Meerovich, and W. Gawalek, "Investigation of joint operation of a superconducting kinetic energy storage (Flywheel) and solar cells," IEEE Transactions on Applied Superconductivity

[3] B. Bolund, H. Bernhoff, and M. Leijon, "Flywheel energy and power storage System," Renewable and Sustainable Energy Reviews

[4] J. C. Zhang, L. P. Huang, Z. Y. Chen, and S. Wu, "Research on flywheel energy storage system for power quality," in Proc. International Conference on Power System Technology

[5] J. C. Zhang, Z. Y. Chen, L. J. Cai, and Y. H. Zhao, "Flywheel energy storage system design for distribution network," in Proc. IEEE Power Engineering Society Winter Meeting