Energy Exchange Using Flywheel and Electrical Drives

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Abstract - ***In modern industries like paper mills, production of semiconductor, food processing industries use highly sensitive microprocessor and high frequency power electronic device, for that purpose reliability of power supply should be high. But due to unsymmetrical faults and unbalance load power quality issue occur, to counter this issues we can used flywheel energy storage system***

Flywheel store electrical energy into kinetic energy release out upon demand, FESS system can charge or discharge in quick time and give large amount of energy . This paper gives review on different type of FESS using different type of flywheel and motor abstract summarizes, in one paragraph (usually), the major aspects of the entire paper in the following prescribed sequence.

Key Words: flywheel energy storage system (FESS), electrical drives , flywheel,electrical and kinetic energy.

1.INTRODUCTION

Thε field of automation has had a notablε impact in a widε Flywheel storage system store electrical energy as kinetic energy in the rotational mass can gives in or out of flywheel with help of ac or dc electrical drives. It works in two modes generator and motor. In motoring mode electrical energy supply to the stator of motor which produced torque and rotate rotating mass with high speed and store kinetic energy and in generator mode this kinetic energy used to convert into electrical energy by faradays law electromagnetic induction, kinetic energy (K.E.) store in flywheel given by,

$$E_k = \frac{1}{2} J \omega^2$$

Where J– moment of inertia

w- angular velocity

so, K.E. is directly proportional to the product of moment of inertia and square of angular velocity, is given by

$$J = M r^2$$

Where, r- radius of flywheel

M- function of mass and velocity

1.1.BASIC BLOCK DIAGRAM OF FESS SYSTEM

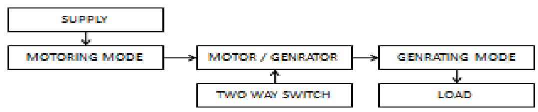

FIG I block diagram of FESS

2. STRUCTURE OF FESS –

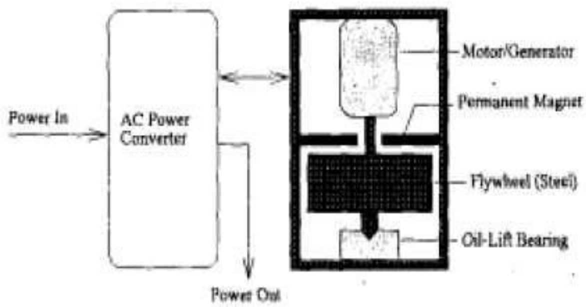

Fig II structure of FEES

The FESS system consist from electrical drive like motor /generator set, bearing, flywheel, supply, permanent magnet

3. COMPONANT USED IN FLYWHEEL STORAGE SYSTEM

The maximum spinning speed ω is determined by the capacity of the material to withstand the centrifugal forces affecting the Flywheel, which is the material tensile strength σ lighter material develops low inertia at given angular velocity (w) therefore composite material with low density and high tensile strength is excellent for storing kinetic energy. The maximum energy density with respect to volume and mass are,

$$eve = K \sigma \quad (3)$$

$$me = Co/\rho \quad (4)$$

$$\sigma = r2\ \omega \quad (5)$$

Where 'eve' is the kinetic energy per unit volume me‟ is the kinetic energy per unit mass ,*K*‟ is the shape factor

TABLE-I

KINETIC ENEERGY FOR DIFFERENT MATERIAL OF FLYWHEELS

Material	M (kg)	σ (Pascal)	ρ (kg/m³)	E_{kmax} (joules)	E_{kmax} (kWh)	E_{kmax}/M
Carbon Fiber	450	4×10^9	1799	5×10^8	139	1.1×10^6
Steel	450	6.9×10^8	8050	1.9×10^7	5	4.3×10^4
Aluminium	450	5×10^8	2700	4.2×10^7	12	9.2×10^4

carbon fibre-

$$E_{kmax} = \frac{1}{2}\frac{M\sigma}{\rho}$$

$$Ekmax = \frac{450*4*10^9}{1799*2}$$

= 500277932.2 joules

$$Ekmax = \frac{500277932.2}{3600000} = 138.88 \text{ Kwhr}$$

Similarly

For steel-

Ekmax= 19285714.29 joules

Ekmax= 5.3Kwhr

Similarly

For aluminium-

Ekmax= 4666666.67 joules

Ekmax= 11.57Kwhr

From above table shows that composite material is best suitable for FESS system

TABALE II

DIFFERENT FLYWHEEL MATERIAL CHARECTERSTICS

Material	ρ [kg/m3]	σ [Mpa]	e_v[mj/m3]	e_m [kj/kg]
Aluminium	2700	500	251	93
Steel	7800	800	399	51
Carbon fibre	1600	1500	752	470

In order to obtained high kinetic energy from flywheel system, flywheel material must have high tensile strength and low mass density result into high angular velocity like modern composite material. In comparisons with composite material metals are heavy and less in cost

4. Different shapes and shape factor of flywheel

Fig II shows the different shapes and shape factor (K) for the metals and composite materials. K can be describe as measurement of the flywheel material utilization the equation [3] & [4] valid assuming axial symmetry and planner stress

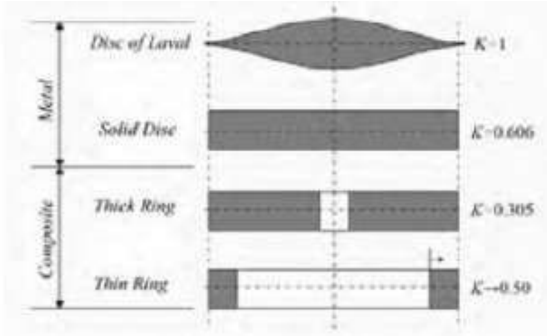

Fig III. flywheel shapes

5. ELECTRICL MACHINE

The design, construction, and test of an integrated flywheel energy storage system with a homo-polar inductor motor / generator and high-frequency drive is shown in this paper.
The motor design features low rotor losses, a slot-less stator, construction from robust and low cost materials, and a rotor that also serves as the energy storage rotor for the flywheel system, was implemented by Perry Tsao et.al. This paper contributes four main areas i..e integrated flywheel design, flywheel motor design high frequency drive design and sensor less control design, fig IV shows the rotor for homopolar induction motor

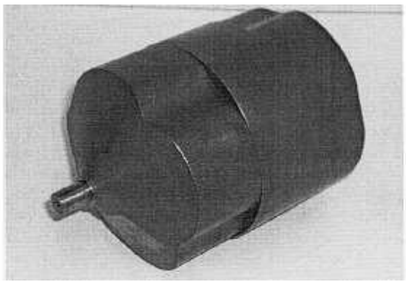

Fig IV homopolar induction motor rotor

Tomasz siostrzonek et al present the result of research of the rotating energy accumulator. In the study brushless motor with permanent magnet used as motor generator set, this FESS system stored about 4 MJ of energy and the rotational speed was 6000rpm
Fig V shows the setup for flywheel energy storage system
Various machine used for high speed application like permanent magnet synchronous motor, switch reluctance motor.
Permanent magnet motor widely used motor to develop flywheel energy storage system. Permanent magnet synchronus

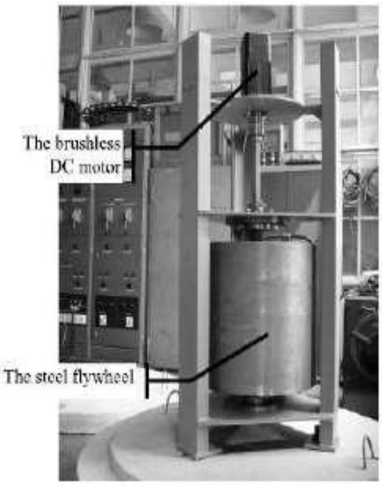

Fig V Flywheel energy storage setup

motor having two part like every motor stator and rotor .stator is like ordinary motor having 3 phase or single phase winding and having armature winding on it and rotor is made with permanent magnet like alnico, neodymium iron-boron NdFeB magnets or samarium-cobalt alloys SmCo. , when PMSM run as generator then there is no need to give field excitation and also not require slip ring due to use of permanent magnet S, Due to that PMSM motor is highly efficient compare to other motors, this motor does not have brush losses
all three phase surface mounted axial flux brushless dc machine main advantageous simple control strategy and highly efficient

TABLE III
COMPARISION OF ELECTRICAL MACHINE SUITABLE FOR FEES SYSTEM

Machine	Asynchronous motor	Permanent magnet synchronous motor
Power	high	Medium and low
Rotor losses	Copper and Iron	none
Efficiency	Less than pmsm	more
Tensile strength	High	low
Cost	low	High

6. Bearing- Two type of bearing

Active bearing
An active magnetic bearing (AMB) works on the principle of electromagnetic suspension and consists of an electromagnet assembly, a set of power amplifiers which supply current to the electromagnets, a controller, and gap sensors with associated electronics to provide the feedback required to control the position of the rotor within the gap.

Passive bearing

A type of magnetic bearing that does not require an external controlling system. Passive magnetic bearings are not capable of operating under as high of temperatures or sustain as high of a load as active magnetic bearings. Passive magnetic bearings (PMB) achieve contact-free levitation of an object by permanent magnetic attractive or repulsive forces.

7. Conclusion

In this paper gives the calculation for kinetic energy from that we can conclude that composite material is best suitable for flywheel based energy storage system due to high tensile strength and high angular velocity. This paper also review some influence paper in the design of flywheel energy storage system, FESS system is a basically energy converting system which convert kinetic energy into electrical and vise-versa

Yu li et al design a high efficient FESS system with the help of brushless dc motor and calculate the losses. Tomasz siostrzonek perform study of FEES with trapezoidal back emf brushless dc motor. The flywheel energy storage system classified into two type low speed in which conventional material like metals are used for making flywheel and high speed used composite material and having high tensile strength and high angular speed explain by R. Peña-Alzola.

8. References

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