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A REVIEW ON FLYWHEEL ENERGY STORAGE SYSTEM (FWESS)

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Abstract: ***This Review focuses on the design and implementation technooooooFly Wheel Generating system of Electrical Energy. This design can be eliminate sudden interruption of delivering of Electricity to Load. Fly Wheel energy storage generator provide contribution to maintain the reliability of the supply. It also improves the stability of the supply system and also improves the quality of the supply. of of many technologies have been attempted to storage energy but Flywheel energy storage system (FWESS) has proved as one of the best energy storage system. This paper focus on the concept of Fly Wheel Generator (Fly Wheel Energy Storage System, FWESS), different components of FWESS, operation of FWESS, different protections needed for FWESS and maintenance of FEWSS.***

Keywords: FWESS (Flywheel Energy Storage System), Synchronization, Fault Annunciator, CTR(Current Transformation Ratio), PTR (Potential Transformation Ratio), Non salient pole, Flywheel.

I. INTRODUCTION

To cater a need of A.C. Control supply, Flywheel Energy Storage System (FWESS) has been used in various industries. Foremost requirement of any control supply system is to cater the constant output control supply without reflecting the disturbance at its input supply. FWESS meets this requirement as flywheel having heavy inertia. Because of heavy inertia of flywheel, the generator will produce the rated voltage at the rated load for the duration up to 8 to 10 seconds in case of disturbance or interruption of main input supply.

II. MAJOR COMPONENTS OF FWESS (FLY WHEEL ENERGY STORAGE SYSTEM)

The following are the major components of Fly Wheel Energy Storage System (FWESS)

1. A.C. Squirrel cage induction Motor.
2. Brushless Non- salient pole synchronous generator.
3. Flywheel mass
4. Control Panel.

A.C. Squirrel cage induction motor

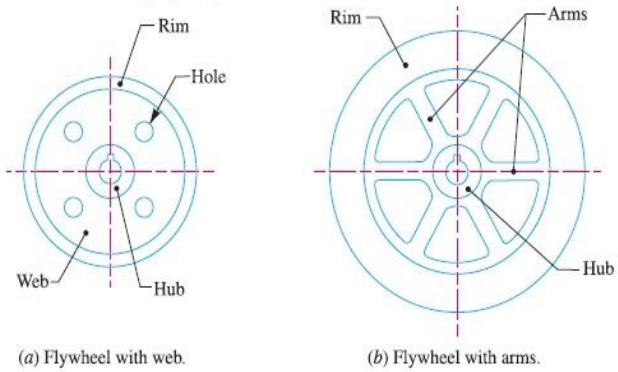
In Flywheel Energy Storage system A.C. Squirrel cage induction motor acts as a prime mover to drive the generator. This A.C. Squirrel cage induction motor is specially designed motor as compared to ordinary motor. It has to rotate a heavy inertia mass hence it is designed to withstand long starting current for at least 18 to 20 seconds, whereas an ordinary motor has starting current time of about 5 to 7 seconds.

Brushless Non – salient pole synchronous generator

Brushless Non- salient pole synchronous generator as a exciter mounted on the same shaft as that of the generator in the generator housing itself. Supply to the field of exciter is given externally and voltage produced on the rotor is specified by rotating rectifier. This voltage is then being fed to the field winding of main generator. This is leads to elimination of brush and commutator and associated maintenance problem. However now a days static exciter is the better substitute to eliminate the maintenance problem.

Flywheel mass

Flywheel generator system is not like generator coupled with prime mover. This is coupled with heavy fly wheel which having heavy mass. This fly wheel stored kinetic energy during normal running of set. In the event of non availability of motive power or interruption in the motive power, fly wheel will feed the input energy which has been stored in the form of kinetic energy. Rating of the set is worked out based on the mass of fly wheel. Figure (a) shows Fly wheel with web. And figure (b) shows Fly wheel with arms.



(*a*) Flywheel with web. (*b*) Flywheel with arms.

III. OPERATION OF FWESS

When the motor start-stop switch and generator load switch is closed, the units starts automatically and supplies power to the consumer. The same is valid for main supply interruptions and mains recovery.

There are three operating modes for FWESS Set.

1. Single operation
2. Parallel operation with manual synchronization
3. Parallel operation with automatic synchronization

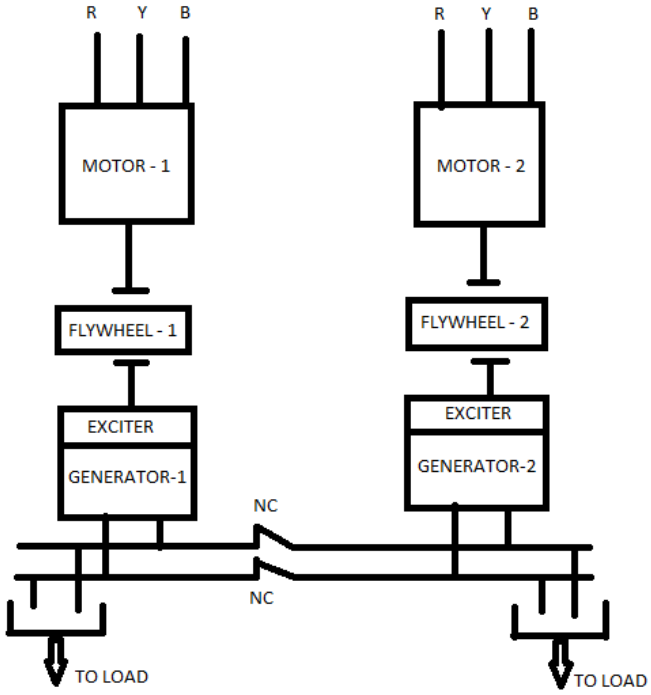
Single operation

If the supply voltage monitored by main voltage monitor the control system will be released and FEWSS system can be started switching the switch. The air contactor closes and motor starts running. When the adjusted time is over the contactor closed and automatic voltage regulator (AVR) is

connected to the mains. Upon the generator voltage activator generated voltage monitor, the relay operates the auxiliary contactors. Now onwards the control supply and the AVR will be supplied by Generator. Closing the switch and air contactor operates and consumer will be supplied stabilized voltage from FWESS set. The unit will be switched off on mains interruption once the buffer period set on the timer relay is over. At mains recovery the FWESS supplied the consumer automatically.

Parallel Operation with manual synchronization
This requires synchronization switch is in manual position and the coupling switch is closed. The load contactor of the incoming machine will be blocked by the relay and can be switched on by pressing synchronization button. The synchronization voltmeter indicates the voltage difference between both FWESS set. On the passing through zero, press the synchronization button, hence the air contactor energizes and both the FWESS runs in parallel. Figure (c) shows the schematic diagram of two FWESS set in parallel.

Parallel Operation with automatic synchronization
This requires synchronization switch is in automatic position and coupling switch is closed. The FWESS are started successively as in the manual mode. The FWESS started at first, switches automatically to the outgoing bus, while the load contactor of incoming machine will be blocked by the relay. The synchronization relay compares the difference in voltage automatically. It will switch on the load contactor while passing though zero. The automatic synchronization scheme operates only at no load or small partial load.



(c) Schematic diagram showing two FWESS set in Parallel

IV. PROTECTION OF FWESS

The following protections are provided for the FWESS.

(A) Motor Protection :
1. Motor Overload Protection by Thermal Overload Relay (Bi-metallic relay – BMR)
2. Motor under voltage protection

(B) Generator Protection :
1. Generator overload protection
2. Over voltage and under voltage protection
3. Under frequency protection

V. SETTTING AND ADJUSTMENT OF FWESS

(A) Generator voltage adjustment :
Generator voltage adjustment is done by turning the potentiometer. The generator output voltage is adjusted within +/- 5 % of its rated value. At the same time the load splitting can be adjusted for parallel operation.

(B) Setting of Automatic voltage Regulator (AVR) :
AVR panel consists of
1. Voltage regulator card.
2. Over voltage and under voltage card.
3. Over frequency and under frequency protection.

Regulator card regulates the generator output voltage respective of the set value. It supplies excitation voltage to the exciter. Excitation voltage range from 08 volts to 80 volts D.C. In normal condition excitation voltage is 18 volts D.C.

Under frequency setting is done for 43 Hz.
Over voltage and under voltage setting is done for
+/- 17%.

(C) Setting of Under voltage protection unit :
This unit is used to provide under voltage protection to generator of FWESS.
It has two settings V_{ON} (Pick-up setting) and V_{OFF} (Drop-off setting). If setting of V_{ON} is -5% and the setting of V_{OFF} is 0.75 than it can be interpreted as below.

Under voltage protection unit will be activated when the generator will attain 240 – 0.05 X 240 = 228 Volts (Response Value) at its terminal and under voltage protection unit will drop off when the generator terminal voltage will fall 0.75 X V_{ON} (0.75 X 228) = 171 Volts. (Release Value).

(D) Reverse Power relay setting for FWESS :
It is set for amount of reverse power and time duration for reverse power. The setting of reverse power relay is done with the help of following formula.

$$\text{Setting} = \frac{\text{(Rated Gen. Power, Watt X \% Reverse Power)}}{\text{(Relay name plate data X CTR X PTR X 3)}}$$

Relay name plate data = 0.1 X Rated voltage X Rated current of CT used
= 0.1 X 240 X 5
= 120 Watts.

Relay setting for 10 % reverse power can be done by

(7500 X 0.1) / (120 X 8 X 1 X 3) = 26 %

and if time duration is for 2 seconds than with above setting of 26 %, if 3.1 ampere current will pass for 2 seconds in reverse direction than the generator will isolate from the load.

VI. MAINTENANCE OF FWESS

In the FWESS system the Motor – Generator set is of the brushless type maintenance is limited to ball bearings. The ball bearings used for the machines are greased for life and must be replaced after every 20000 operating hours.

The flywheel pedestal baring must be greased regularly after every 3000 operating hours.

VII. ADVANTAGES OF FWESS

- Flywheel energy storage system can be easily and inexpensively maintained.
- In FWESS the life time of the flywheel is almost independent of the depth of the charge and discharge cycle.
- FWESS does not require periodic maintenance.
- FWESS has short recharge time.
- FWESS system are not sensitive to temperature so they are operating in a vacuum containment.
- The fly wheel operates at upwards of 85 to 90 % efficiency.
- FWESS has high power output.
- FWESS has large storage capacity.
- FWESS has less overall cost.
- FWESS has effective power compensation.

VIII. DISADVANTAGES OF FWESS

1. FWESS has mechanical stress and fatigue limits.
2. FWESS has short discharge time.
3. FWESS has complexity of durable and low loss bearings.
4. There are safety concerns associated with fly wheels due to their high speed rotor and possibility of it breaking loose and releasing all of its energy in an uncontrolled manner.
5. Material limits at around 700 M/Sec tip speed.

IX. APPLICATIONS OF FWESS

1. Flywheel energy storage system enhances the transient stability of power system.
2. To alleviate the damaging and costly effects of electrical sags and momentary power interruptions.
3. FWESS is a new tool that can be employed to add security to the process through the use of kinetic energy stored in a flywheel.
4. Direct current (DC) system flywheel energy storage technology can be used as a substitute for batteries to provide backup power to an uninterruptible power supply (UPS) system.
5. Flywheels intended for UPS application are typically designed to provide power at their maximum rate for a period of about 15 seconds.

X. CONCLUSION

Flywheel energy storage system can be used to improve power quality and enhance the transient stability of power system. Fly wheel energy storage system is not a new technology but it is a new tool for industry to add security to the process through the use of stored kinetic energy in a flywheel. There are several energy storage system but FWESS has proven that it is a best kinetic energy storage system. Flywheel energy storage system is an alternative to the electro chemical batteries.

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