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Flywheel Based Battery Charger

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Abstract: ***Present paper demonstrate the conceptdesign, setup and testing of flywheel based battery charger. Improvement in efficiency is achieved by replacing electrically powered flywheel based battery charger with human powered flywheel based battery charger.***

Keywords: flywheel, kinetic energy, transmission, energy storage

1. Background of Flywheel Concept

Energy storage can take several forms; fuels, batteries, and flywheels (kinetic energy) [4]. Flywheels have been in existence since time immemorial serving as devices for mechanical energy storage. Flywheel energy storage functions through high-speed acceleration of the flywheel (a rotor) while maintaining the rotational energy in the entire system [2]. The subsequent extraction of energy from the system decreases the rotational speed of the rotor as a consequential outcome of the energy conservation principle. Correspondingly, increasing the speed of the rotor requires addition of energy to the framework.Potter's wheel, the first version of flywheel, exemplifies the functioning of, and illustrates the basic structure of a flywheel. In this case, the potter proffers the requisite force for rotation of the wheel. Subsequently, while the potter molds the wheels using her hands, she repeatedly kicks the wheel to normalize the rotation speed vis-à-vis the frictional forces that work against the acceleration of the wheel. Friction in the potter's wheel come from both the wheel bearings and working the clay. To this end, it is noteworthy that the weight of the wheel determines the uniformity of the rotational velocity and the ultimate outcome.

The modern flywheel features tiny, but entirely significant, modifications depending on the specific application of the flywheel system. Essentially, the contemporary flywheel for electrical energy storage comes complete with a rotating mass whose function is to regulate the voltage of the lines attached to the flywheel. The rotating mass is often made of metal but can encompass other suitable materials in accordance with the features of the entire system and the general use. Since the rotating mass forms part of an electrical motor [4], it draws its spinning force from the electric motor. However, due to the such forces as friction, the flywheel occasionally losses energy, thus, necessitating the existence of a mode of charging for increased energy. On that note, charging the flywheel entails sequential injection of electrical current pulses[3] to the fixed coils (the stator). The electric currents generate magnetic fields that exert force on the flywheel setting it in a rotational motion. Speeding up the rotor stores energy while slowing it down provides energy- this sums up the operation principle of the flywheel. The control system couples with the voltage system of the setup to control the entire operation of the flywheel.

On the same vein, it would be erratic to assume that the flywheel only has two states (speeding up or slowing down), it remains idle in the absence of the former state. At this point, the flywheel rotates at a constant speed given that the friction losses in the bearings are negligible [4]. As such, it can take a relatively longer time to slow down.The improved or contemporary flywheel's primary parts include a power converter, stator, rotor, controller and bearings. The rotor is a combination of the rotating sections of the power generator and the bearings. Below is a schematic diagram for flywheel subsystems.

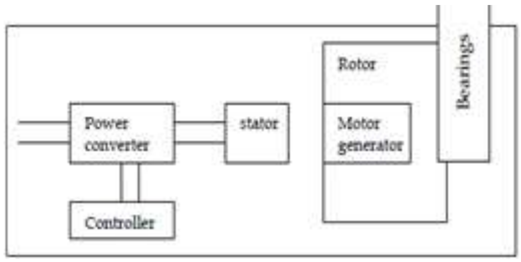

Figure 1: Flywheel subsystem

The power converter attaches to a Direct Current (DC) source. According to Castelvecchi (2007), it generates the pulses of current whose cumulative force speeds up the flywheel (rotor). The resulting current has both varying voltage and frequency.The function of the controller is to determine and regulate the frequency in a manner that the rotor receives the push just in time. Permanent magnets form an inalienable parts of the rotor.The bearings provide a minimal-drag support [3] for the rotor with a net effect of less energy loss. The entire system operates alongside the necessary cooling fans, fuses and contractors to improve safety and efficiency. On the overall, the flywheel system is useful in supplying the required energy when the need arises or dissipating the excess energy when necessary. Such mode of operation can be critical for a flywheel based battery charger.

2. Flywheel Based Battery Charger

Essentially, a flywheel system is a simple mechanical battery. As such, with the earlier mentioned components, one can easily modify the basic structure of a flywheel for such applications as a flywheel-based battery charger. The following figure is an illustration of a possible flywheel design for such a battery charging flywheel system.

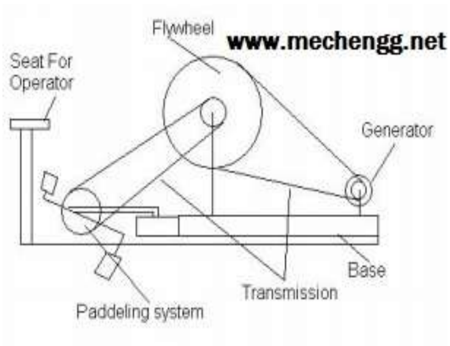

Figure 2: Setup of Flywheel Based Battery Charger

2.1 System Description

The Figure 2 offers a pictorial outlook of a battery charger that incorporates a flywheel and its operation principle. The basic design of this battery charger model comprisesa flywheel that consist of a medium-density fireboard, steel, and iron among other materials. In most cases, the flywheel is forms from any two of the components to cater for issues of cost saving and durability. While the flywheel model described in the introductory section of this paper uses electrical currents to acquire a rotational force, this design is unique in the sense that it will use human power just like the potter's wheel. Using the human power in this case is aimed at making the system more energy-saving in the sense that it will not require any electricity or whatever form of energy to run. Besides, then, it means that the system will hardly experience downtimes given that the minimal human power required will always be present. The human power finds its way through the mechanical framework with the help of paddles, chain, sprocket, and the freewheel structure.The mechanical human power from the flywheel system then propagates to the electricity generator. The process uses the mode of energy transmission that multiplies the velocity of the rotor (flywheel) before its transmission to the electricity generator.

Figure 3: Internal construction of flywheel assembly includes the housing, stator, rotor, hub, and magnetic bearings

The flywheel, thus, generates mechanical power that converts into electrical power. The electrical power is stored in a secondary battery through an electrical charging circuit. Caution is necessary to ensure that the charging circuit has such features as low discharge cut-off, current backflow proofing, overcharging protection, and high voltage cut off in case any anomalies occur in the course of charge storage. Following a successful assembly of the entire system, it is put into an iron-cabinet which should also be portable and not prone to disintegration. The above flywheel based battery charger system is projected to vary between 1.5 to 12-voltbattery charging. In a commercial sense, this design is highly promising. The commercial potential of this design is particularly perspicuous given the fact that load sheddinghas, in the recent past, been a weighty issue [1] in both remote urban and rural areas. The system has the ability to give massive positive returns for home use and small scale agricultural use. In an urban set up, this flywheel based battery charging system can find application in the exercise machines. To this end, the dynamic device is multifaceted in the sense that it can perform several roles both in and out of the home. Another advantage of this design is that it can be modified to serve both large and small scale operations. In addition, in a world that is constantly looking for means to save energy, this system seems to be the right choice given its mechanical nature. Finally, just like the normal generators, this system proffers the ability to incorporate stationary driving machines. In this manner, a simple step-up of the engine capacity through multiplication of the available power enables the system to charge larger batteries.Even with such high levels of efficiency and effectiveness, the system still uses bearings whose complexity may increase energy loss. Besides, the limits of mechanical fatigue and stress of the components may prevent the system from superseding the sensible levels of efficiency and performance in large scale operations. Samineni (2003) approximates the speed limit of the materials at 700M/sec which is relatively low for larger batteries. Even then, the possibility of adjustments makes a case for this system.

3. System Testing

In as much as the design of the system looks simple superficially, testing is still critical and plays a central role in determining the feasibility of the system and its plausibility in various application settings. The degree of interdependence and integration of the various components of the flywheel seemed relatively high. However, the actual performance of the various components, especially the external subsystems, can only be ascertained when they are part of the flywheel framework [5]. For instance, the characterization of a bearing is only possible when it is used in a flywheel that is rotating at its maximum speed and power. Among the attributes that notable during the system testing include output voltage, step load transient response, start-up and charging time, power versus time, standby power consumption, energy recovery efficiency, and duty factor.

4. Conclusion and Recommendations

This particular design of the flywheel based battery charger has not yet been rolled out for commercial use. The stated commercial applications are mere projections of it potentiality. However, while this design can be used for further research that would see pivotal improvements incorporated into this design, it could also be adopted gradually. Scalability is one major concern of this design. Here, size matters. As a matter of fact, large scale adoption of this design requires a relatively larger system with numerous modifications and adjustments. Such an endeavor comes with equally numerous iterations before the system meets the scale requirements. It is also noteworthy that the battery charger will, at some point, cease to be portable in large scale application. Apart from scalability, system efficiencyis an issue of concern. Even then, the issue of efficiency grows more critical with increase in scalability. Thus, in large scale applications, the flywheel based battery charger must be highly efficient. It is, therefore, fortunate that this design is highly flexible and can be tweaked depending on the nature of application and the needs of the consumers. Since this design is not yet commercialized, it is recommended that business incubators work in close co-operation with the developers to oversee the success of this device.Besides, several field experiments are necessary in determining the actual, rather than theoretical, feasibility of this design. Finally, the fact that this design uses human power limits its scalability and performance, thus, electrically powered flywheel based battery chargers would be more suitable at such high scales. The design in this discussion remains highly suitable for small scale operations, but with room for modification to meet the high-scale thresholds.

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