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Research Paper

Design and Implementation of a 5 kVA Fuel-Less Generator

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ABSTRACT
There is the need for alternative power supplies due to incessant power issues such as power sag, surge, frequency instability, interruption and outages in this part of the world. However, the use of generators comes with its attendant high cost of fuel, air and noise pollution.Despite the fact that a number of research models and prototypes have shown some characteristics of fuel-less energy generation, no fully self-sustaining, high-output system has been verified commercially because of energy storage restrictions and efficiency losses. New designs are still required in order to reduce energy losses, increase operating duration without outside assistance, and scale beyond household loads.Therefore, this paper successfully designed and implemented a 5 kVA fuel-less generator using a d.c motor and a 50 kg flywheel as its energy storage unit. The design produces an output voltage of 185V, power of 4 kW given an efficiency of 80%. However, improvements can be made by working on the motor, pulleys, bearings and the flywheels. Flywheel is one of the most promising technologies that can efficiently replace the conventional lead acid batteries as energy storage systems for a variety of applications, including automobiles, economical rural electrification systems, and stand-alone, remote power units commonly used in the telecommunications industry. Thus, if these parameters are carefully implemented on the subsequent related work, we can tend towards achieving the self-sustainability and greater efficiency of the fuel-less generator using flywheel.

KEYWORDS: *Air Pollution, Electricity Supply, Energy Storage, Flywheel and Fuel-Less Generator.*

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I. INTRODUCTION

Power generation and distribution have played a crucial role in developing economies in various sectors, including industry, finance, media, health care, and aviation. One of the main issues resulting from the usage of generators with fossil fuels is environmental pollution, which causes the ozone layer to deteriorate or thin out. Air and noise pollution, and the shifting price of fossil fuels are other issues. The only solution to these issues is the fuel-less generator.The fuel-less engine typically works very quietly and smoothly, and the finest feature of the design is that there is no air pollution because no harmful gases such as carbon monoxide (CO) is released (Cibulka, 2009). In some fringe research, fuel-less generators are referred to as self-sustaining or over-unity generators. They are made to function without the use of conventional fossil fuels. According to Rahman et al. (2019), practical applications incorporating renewable energy technologies have proven to be viable alternatives to conventional fuel-based systems, despite the fact that they are frequently viewed with suspicion in mainstream research since they are thought to violate the rules of thermodynamics. Many "fuel-less" systems really work by using energy sources like solar panels, batteries, or permanent magnets to generate rotational motion that powers a generator.The development of fuel-less generators has relied heavily on technologies based on magnetic energy. The development of a low-voltage, fuel-less generator using permanent magnets and electromagnetic coils was examined by Nwosu and Okoro (2018). Although the system's effectiveness is still constrained by load capacity and energy storage capabilities, the study showed that magnetic fields can be efficiently used to create continuous motion with little input energy.Likewise, Adeoye et al. (2020) investigated the creation of an electromagnetic generator that was driven by a battery bank and a brushless DC motor. To establish a semi-sustainable loop, their system depended on sporadic recharging from the generator output. Even though the system could produce up to 3 kVA of useful power, its complete autonomy was limited by the need for frequent external recharge.There has also been much research done on the integration of renewable energy sources like wind and solar power with generating systems. According to Akorede et al. (2017), a hybrid solar-powered generator that combines an inverter, solar charge controller, and battery storage may produce up to 5 kVA. In addition to offering a dependable power source for rural applications, this method greatly decreased reliance on fossil fuels.Hybrid systems, however, are still sporadic since they depend on the availability of sunshine or wind. Ibrahim and Yusuf (2021) highlighted the necessity of integrating mechanical and electrical energy recovery technologies, like flywheel energy storage or regenerative braking, in order to improve autonomy and dependability.In order to design an effective 5 kVA generator, the mechanical-to-electrical conversion process must be optimized in addition to selecting appropriate energy sources. As stated by Osakwe and Eze (2022), inefficiencies in battery charging and discharging cycles, frictional losses in the shaft, and core losses in the generator frequently restrict system operation. Their research emphasizes the need of putting intelligent energy management systems in place and choosing high-efficiency alternators.Furthermore, maintaining system stability is largely dependent on the control circuitry. To achieve consistent output voltage and frequency, inverter design, pulse-width modulation (PWM) management, and battery protection circuits are required (Oladipo and Adebayo, 2020). Their study backs up the application of microcontroller-based technologies to improve off-grid power systems' automation and load management.Abatan (2013) and Dipali (2017) worked on a self-charging inverter alternative that produces constant electricity while being affordable, quiet, and emission-free. The batteries in the system are recharged at the same rate at which the batteries are discharged by the D.C when the system is drawing battery current. Based on the capacity of the anticipated load, their study showed that the system could be developed to any limit without the need for maintenance. As a result, buying a fuel-free generator costs less money. With the aid of the Matlab/Simulink programming language, Subramanian (2010) simulated the load controller of a self-energized asynchronous generator with a stable power generation. Additionally, the research by Sreenivasula (2014) and Rajendra (2012)demonstrated the modelling and simulation of an isolated power generation system using an asynchronous generator and an A.C/D.C/A.C converter feeding an RLC series circuit. Their goal was to replicate an A.C/D.C/A.C converter feeding an RL load and a self-excited asynchronous generator (SEASG) feeding an RLC series circuit coupled at the same point. Due to the affordability, dependability, and low maintenance requirements, Adewumi (2016) designed a 2.5kVA self-induced power generator as a workable alternative for isolated power generation from renewable energy sources.

II. MATERIALS AND METHODS

The design comprises of a D.C motor, Flywheel, Belts, A.C Generator (Alternator), Charging and the Batteries Units (Figure 1). These components were carefully mountedon the constructed frame and carefully connected.

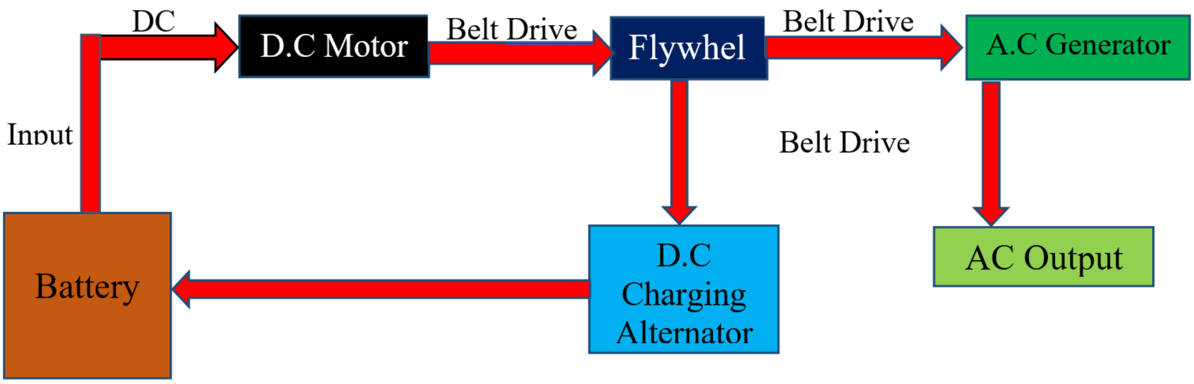

Figure 1: Block Diagram of the Fuel-less Generator

1. D.C Motor

The 12Vd.c motor (Figure 2) converts electrical power into rotating mechanical energy thereby turning the flywheel.

Figure 2: D.C Motor

2. Flywheel(Figure 3)

It is known that kinetic energy of a moving particle is affected by it mass of the flywheel,as shownin equation (1).

K.E $=\frac{1}{2}I\omega^2$(1)

Where, I is the moment of inertia and ω is the angular velocity.

The moment of inertia for a solid cylinder (flywheel) rotating about its central axis is

$$I=\frac{1}{2}mr^2 \quad (2)$$

Where, m is the mass and r is the radius. Hence, if a flywheel of a greater mass that the frame can withstand is used, the kinetic energy it produces increases which in turn rotates the generator to produce a great electrical output. Also, a flywheel with mass concentrated at the rim enhances the system's efficiency. Hence, a flywheel of mass 50kg concentrated at the rim was used for the project. However, the 50kg flywheel is shown in Figure 3.6.

Figure 3: 50kg Flywheel

The radius (r) of the flywheel used is 0.25 m.Therefore, the moment of inertia,

$$I=\frac{1}{2}mr^2 \quad (3)$$

$$I=\frac{1}{2}50\ (0.25)^2 \quad (4)$$

$$I=\ 1.5625kgm^2 \quad (5)$$

A desired angular velocity (ω);

$$\omega=\frac{1500}{60}=25\ rps \qquad (6)$$

$$\omega=\ 25(2\pi)=50\pi=157.14rad/s$$

The kinetic energy (K.E),

$$\text{K.E}=\frac{1}{2}I\omega^2 \quad (7)$$

$$\text{K.E}=\frac{1}{2}1.5625(157.14)^2=19{,}291.39\ \text{J.}$$

The Power required to reach that kinetic energy in a given time (t = 5s),

$$P=\frac{dE}{dt}=\frac{19{,}291.39}{5}=3858.28W$$

Since 1hp = 746 W therefore,

$3858.28\text{W}=\frac{3858.28}{746}=5.17hp$

Therefore, the D.C motor should have a minimum power of approximately 5.0 hp to drive the alternator and flywheel.

3. A.C Generator

A 5 kVA alternator is used because of the a.c output required (Figure 4).

Figure 4: A.C Generator (Perry, 2008)

4. Charging Alternator and Battery

A 12V, 75Ah is used. The charging alternator used converts mechanical energy received from the flywheel into electrical energy at its terminals to charge the battery. The value of the charging alternator used is determined as follows;

$$\text{Charging Current} = Ah\ (C)\ A \qquad (8)$$

Where, Ah is the battery capacity, and C is the charging Rate (20% = 0.2). Therefore,

$$\text{Charging Current} = 75\ (0.2)A = 15A$$

Therefore, a 15A charging alternator was selected.

5. Other Materials Used

The following items and materials are carefully selected for better efficiency namely;
Circuitbreaker, power switch, bearings, chassis, belt drives, cables etc. (Table 1).

Table 1: Major Components/Materials Used

S/N	DESCRIPTION
1.	5 hp D.C Motor
2.	50 kVA A.C Alternator
3.	50 kg Flywheel
4.	Bearings
5.	Chassis Fabrication
6.	Belt Drives
7.	Change Over Switch
8.	Terminal Box (A.C Alternator)
9.	Pulley
10.	Bolts& Nuts
11.	Dampers
12.	15 A Charging Alternator
13.	12 V Battery

III. IMPLEMENTATION

In the implementation phase, the step-by-step process for couplingthe fuel-less generator is as follows;

- Assembling the components: All of the components including the dampers were carefully placed and bolted on the chassis/frame constructed (Figure 5).
- These components were carefully connected (Figure 6).

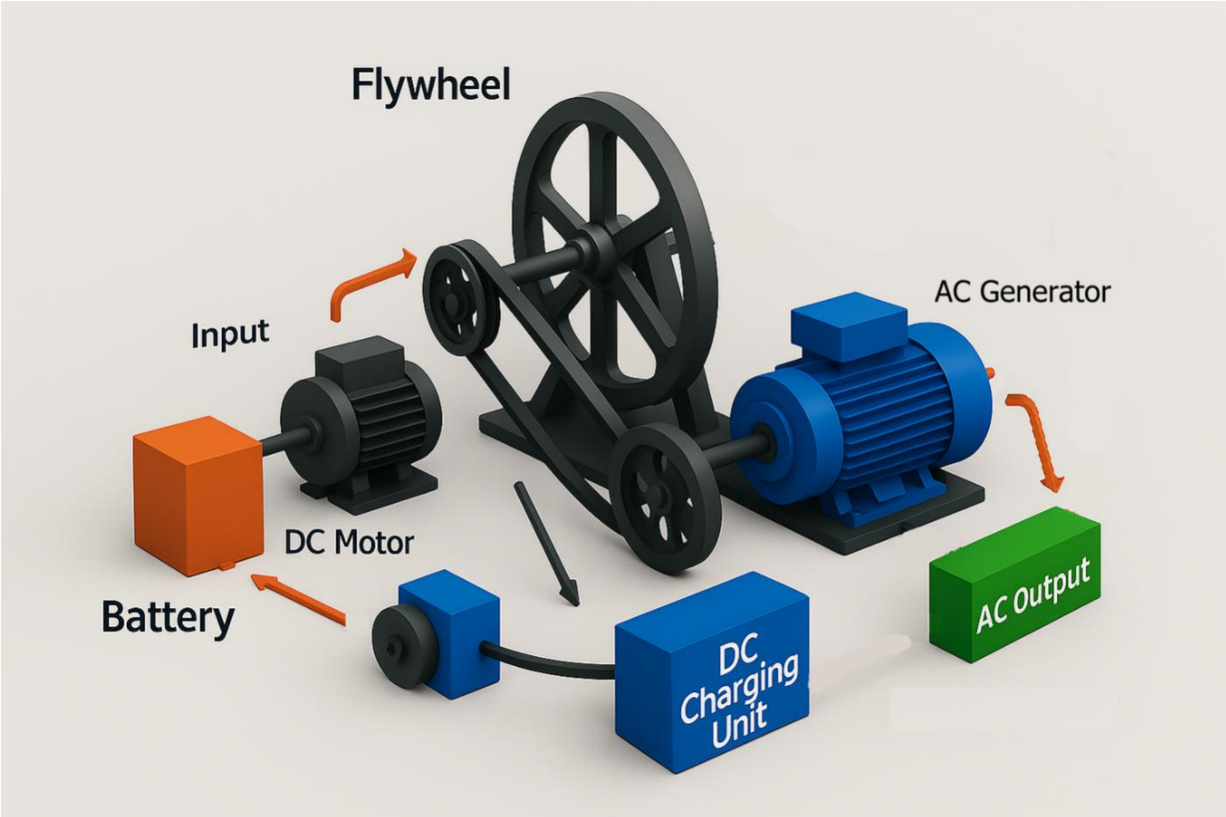

Figure 5: Coupling Process of the Fuel-Less Generator Components

IV. RESULTS AND DISCUSSION

Results

After a successful completion of coupling the 5kVA fuel-less generator, , it was tested to evaluate its performance. The following data in Table 2 were taken using suitable Multimeters for the purpose of analyzing the characteristics of the generator.

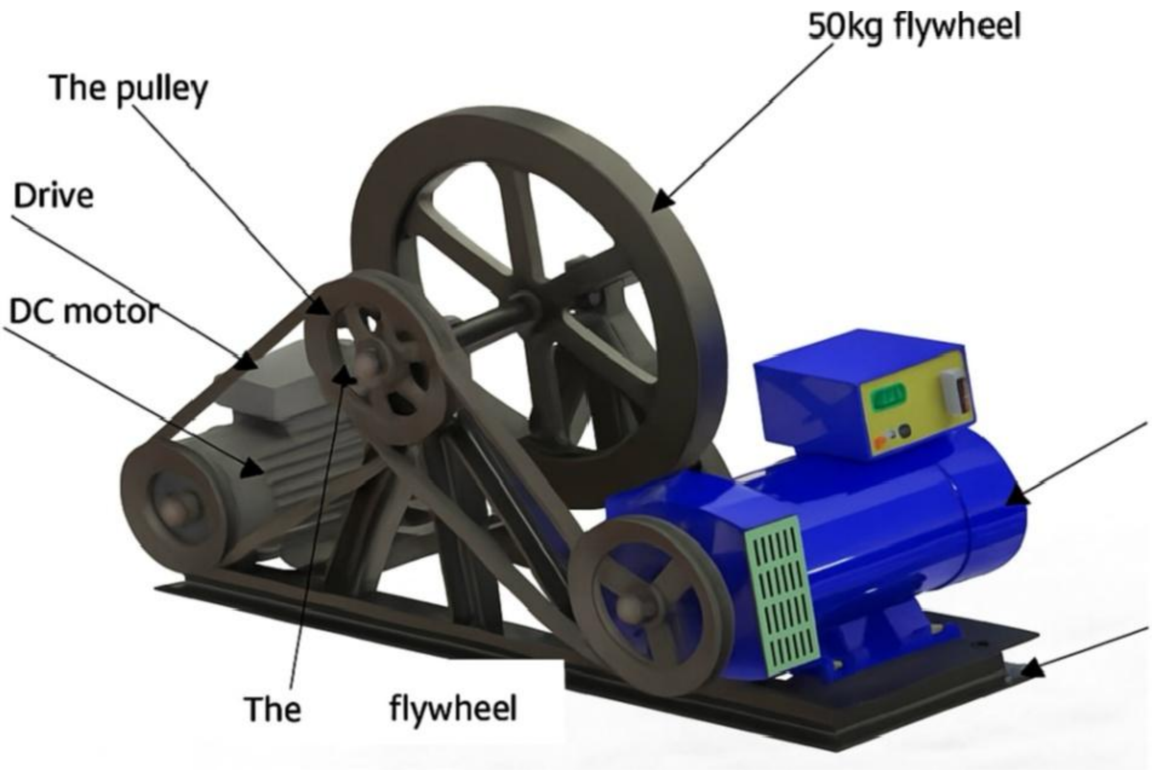

Figure 6: Complete Coupling o the Fuel-Less Generator

Table 2: Major Components/Materials Used

Parameters	Input Parameters	Output Parameters
Battery Capacity	12V	
D.C Motor	5Hp	
Flywheel	50 Kg	
A.C Alternator	5 kVA	
D.C Charging Alternator	15 A	13.5 V
A.C Generator Output Voltage	-	185 V
A.C Generator Output Current	-	21.62 A
A.C Generator Output Power	-	4 kW
Efficiency	-	80%

Discussion

Considering Figures 1 and 5, a 5 kVA fuel-less generator was designed, and implemented. Figure 6 shows the coupled generator. When the incorporated power switch is switched ON, current flows from the battery through the circuit breaker to power the d.c motor. The d.c motor converts itselectrical energy to rotating mechanical energy at the motor's shaft pulley. The motor shaft pulley is connected to the shaft pulley of the flywheel using belt coupling. The flywheel subsequently drives the a.c generator to produce an a.c output at its terminals. The rotational mechanical energy at the shaft of the flywheel is also connected to the d.c charging alternator that produces 13.5Vd.c energy at its terminalsto charge the battery connected to it.Using a multimeters, and tachometer to measure the voltage produced and the speed at which the generator is producing that voltage respectively. It was found to produce a voltage of 185V and 21.62A at a speed of 1200 rpm. It was from this basis the output power was calculated at 4.0 kW (at a power factor of 0.8), and hence the overall efficiency of the system estimated 80.0%.It was observed that the speed of the flywheel and generator pulley have a linear relationship. Varying the size of either of the motor wheel or the flywheel that is connected to the generator will have an effect on the amount of voltage produced, and the amount of work done on the system. Thus increasing either of them will result to an increase in the speed of the generator and thus increase in the voltage produced.

V. CONCLUSIONN

Due to incessant power interruption and outages in this part of the world, the need for alternative power supplies (such as solar systems, electric generators etc), cannot be over emphasized. However,the attendant high cost of fuel, air and noise pollution connected with electric generators cannot be ignored. Therefore, this paper successfully designed and implemented a 5 kVA fuel-less generator using a 50 kg flywheel and a 5 hp d.c motor. The design produces an output voltage of 185V, power of 4 kW given an efficiency of 80%. However, improvements can be made by working on the motor, pulleys, bearings and the flywheels. Flywheel is one of the most promising technologies that canefficiently replace the conventional lead acid batteries as energy storage systems for a variety of applications, including automobiles, economical rural electrification systems, and stand-alone, remote power units commonly used in the telecommunications industry.

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