Published by The College of Science & Information Technology (COSIT), TASUED, Vol. 18, No. 2, pp. 95-103.

COSIT, TASUED
Journal of Science and Information Technology (JOSIT)

Design and Implementation of a Fuelless Electricity Generator using Readily Available and Recycled Materials

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Abstract

This paper presents the design and implementation of a fuelless generator using readily available and recycled materials. The fuelless generator is a device that generates energy without consuming traditional fuel sources like gasoline, coal or natural gas. This research was designed to provide a sustainable and affordable energy solution for off-grid communities, especially in rural areas with limited access to electricity. The generator harnesses the power of renewable and electromechanical energy sources combined with innovative engineering techniques, to generate electricity without the need for conventional fuels. The design process compared coupling of alternator, Dc motor with battery charged and without charge circuit. The result shows that the machine had a peak efficiency of 89.8% at a load of 100 watts and the lowest efficiency of 20.6% at a load of 1600 watts without charging system compared to peak efficiency of 91.2% at a load of 100 watts and the lowest efficiency of 28.1% at a load of 1600 watts with charging system. The performance evaluation demonstrated that the fuelless generator was capable of reliably generating electricity from renewable energy sources, providing a sustainable and affordable energy solution for off-grid communities.

Keywords: Fuelless generator, renewable energy, recycled materials, off-grid electrification, sustainable energy

INTRODUCTION

Access to reliable electricity is crucial for economic development, education, healthcare, and overall quality of life. However, many communities worldwide, particularly in rural and remote areas, lack access to electricity due to various challenges, including geographical barriers, high costs of infrastructure development, and dependence on fossil fuels (Oyedepo 2012). The global energy landscape is dominated by fossil fuels, which pose significant environmental challenge (Bahman Zohuri (2023) Most of the electricity generated from fossil fuels remains one of the biggest polluters of our environment. Research has shown that estimated CO_2 emission from the global electrical power industries all over the globe is about 333 billion tonnes yearly (Ed, *et al*, 2013). Due to this effect, environmental health has been depleted and increased atmospheric carbon dioxide levels increase the greenhouse effect that causes global warming (Ed, *et al*, 2013).

Apart from pollution, (Ajav and Adewumi 2014) in their paper, as reviewed by the Occupational Safety and Health Administratio said that noise as an unwanted sound from most generators, is uncomfortable to the human ears because unwanted noise causes variation in air pressure near the ear with corresponding high amplitude. The maximum noise levels permitted is in the range of 52 dB to 72 dB, depending on location and distance from the source but the conventional generator raised the noise level to 100 dB or more which is dangerous to the ear (Otulana *et al*. 2015). Therefore it becomes imperative to seek means to reduce this effect.

Renewable energy sources such as solar, wind, and hydroelectric power have made substantial inroads but face limitations like intermittency and resource dependency. In response to these challenges, there is a growing interest in developing alternative energy solutions that are sustainable, affordable, and environmentally friendly (Oyedepo 2012).

One promising approach is the development of fuelless generators that harness renewable energy sources such as solar, wind, and kinetic energy to generate electricity without relying on traditional fuels. These generators have the potential to provide clean and reliable power to off-grid communities while reducing dependence on fossil fuels and mitigating environmental impacts.

Research into developing fuelless electricity generators is necessary at this time because automobiles has likewise shifted from fossil fuel to electric vehicles. Why is this so? This is because conventional fossil fuel is a depleting resource, apart from the environmental and health challenges gasoline engines raise. A fuelless generator - a device that can produce electricity without the consumption of conventional fuels, offers a potential solution to these challenges.

In this work, the design and implementation of a fuelless electricity generator using readily available and recycled materials is presented. The generator utilizes a combination of solar panels and innovative mechanical techniques to convert natural energy sources into electrical power. The design process, materials selection, construction, and performance evaluation are discussed in detail, demonstrating the feasibility and effectiveness of the fuelless electricity generator concept.

RELATED WORKS

Traditional generators rely on fuel combustion and nuclear reactions to produce energy, which have inherent environmental and economic drawbacks (Oyinkanola *et al.,* 2019). Non-conventional power-generation technologies are gaining more grounds because most of them are renewable in form, having little environmental effects, and are reliable and long-lasting (Erinle, *et a*l, 2023). However, renewable energy technologies, while cleaner, often depend on weather conditions and geographical factors (Oyinkanola *et al.,* 2018).

In 1902, Nikola Tesla worked on free energy generators. A device that works and generates electricity without using gasoline or liquefied natural gas such as conventional generators,

Cite as:

Oyinkanola; L.O.A; Adejuwon, S.O., Fajemiroye, J.A.; Ajibola, S.O.; Abdfatai, Y. (2024). Design and Implementation of a Fuelless Electricity Generator using Readily Available and Recycled Materials. *Journal of Science and Information Technology (JOSIT),* Vol. 18 No. 2, pp. 95-103.

would be its prime mover and was developed in 1933 by Nichelson (Oliver, 2004). Zero-point energy, a concept from quantum mechanics, suggests that even in a vacuum, space is not entirely empty, but rather filled with fluctuations in energy at the quantum level, as suggested by R. Home and his partner (2009).

Many researchers have worked on fuelless generators using several methods and materials (Ngozi et al. 2024) (Otulana et al. 2015) (Kasim and Baba 2021) (Esom and Aneke 2020). DC electric motors powered by rechargeable 24 V/75 Ah batteries, rotation made by the motor provides energy to the alternator, resulting in the generation of AC voltage. The output of the AC generated was Used to recharge the battery using a rectification circuit, and the connected converter will use remaining available energy to power the appliances attached (Sylvester et al. 2021).

DC Motor

A DC electric motor converts mechanical energy in the form of rotational motion, through the effect of electromagnetism to current. It is also an electrical machine that transforms electrical energy into mechanical energy by creating a magnetic field that is powered by direct current The DC motor relies on a battery for power supply, unlike other types of electric motors that can receive charges from an electric generator (Iyappa et al. 2014).

DC motor basically consists of two main parts, the rotating part is called the rotor, and the stationary part is called the stator (figure 1). The rotor rotates with respect to the stator. The rotor consists of windings, the windings being electrically associated with the commutator containing brushes. When a DC motor is powered, a magnetic field is created in its stator. The field attracts and repels magnets on the rotor; this causes the rotor to rotate. To keep the rotor continually rotating, the commutator that is attached to brushes is connected to the power supply current that is also connected to the motor’s wire windings. The commutator regulates the flow of current among the coils (Esom and Aneke, 2020).

Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic, to periodically change the direction of current in part of the motor. DC motors were the first form of motors widely used, as they could be powered from existing direct-current lighting power distribution systems. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings. Small DC motors are used in tools, toys, and appliances. The universal motor, a lightweight motor used for portable power tools and appliances, can operate on direct current and alternating current. Larger DC motors are used in propulsion of electric vehicles, elevators and hoists as well as in drives for steel rolling mills (Wikipedia, 2023).

The first commutator DC electric motor capable of turning machinery was invented by English scientist William Sturgeon in 1832. Following Sturgeon's work, a commutator-type direct-current electric motor was built by American inventors Thomas Davenport and Emily Davenport, which they are patented in 1837. The motors ran at up to 600 revolutions per minute and powered machine tools and a printing press (Garrison, 1998).

Due to the high cost of primary battery power, the motors were commercially unsuccessful and bankrupted Davenport. Several inventors followed Sturgeon in the development of DC motors, but they all encountered the same battery cost issues (Jonah et al. 2023). As no electricity distribution system was available at the time, as such no practical commercial market emerged for these motors.

After many other more or less successful attempts with relatively weak rotating and reciprocating apparatus Prussian/Russian Moritz von Jacobi created the first real rotating electric motor in May 1834. It generated remarkable mechanical output power. His motor set a world record, which Jacobi improved four years later in September 1838 (Richter, 2013). His second motor was powerful enough to drive a boat with 14 people across a wide river. It was also in 1839/40 that other developers managed to build motors with similar and then higher performance (Wikipedia, 2024).

In 1855, Jedlik built a device using similar principles to those used in his electromagnetic self-rotors that was capable of useful work (Guillemin, 1891). He built a model electric vehicle that same year.

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A benefit to DC machines came from the discovery of the reversibility of the electric machine, which was announced by Siemens in 1867 and observed by Pacinotti in 1869. Gramme accidentally demonstrated it on the occasion of the 1873 Vienna World's Fair when he connected two such DC devices up to 2 km from each other, using one of them as a generator and the other as motor (Zenobe, 2012)

One of the reasons DC motors are preferred over other types of motors is their ability to precisely control their speed, which is a necessity for industrial machinery. DC motors are able to immediately start, stop, and reverse - an essential factor for controlling the operation of production equipment.

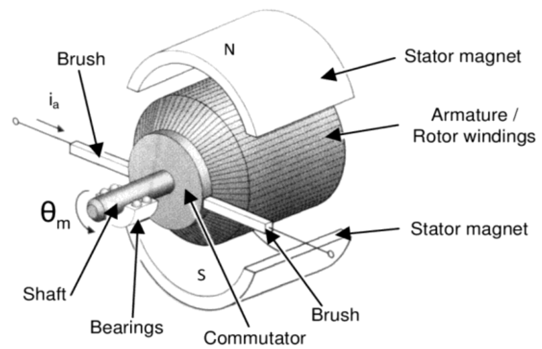

Figure 1. A diagram of brush DC motor.

Alternator

An Alternator, utilizes the electromagnetic induction principle to convert mechanical energy into electrical energy. A permanent magnet alternator which is a power-generating device produces a sinusoidal output when mechanical input (motor) is connected to it through a shaft or hub. It is made of stationary and moving parts enclosed in housing. Power is generated when there is relative movement between magnet and electric fields. The alternator consists of a stator, armature, or rotor.

Alternators are of two forms: one working by induction and the other by permanent magnets. Alternators are used for large generators and small generators respectively.

The stator in the alternator consists of a cast-iron frame, which supports the armature core and has slots on its inner periphery to house the armature conductors (figure 2). The rotor is like a flywheel having alternate N and S poles fixed to its outer rim. The magnetic poles are exited from direct current supplied by a d.c source at 125 to 600 volts. In most cases, the necessary exiting current is obtained from a small d.c shunt generator which is belted or mounted on the alternator's shaft. Because the field magnets rotate, this current is supplied through two slip rings. When the rotor rotates, the stator conductors being stationary are cut by the magnetic flux, hence they have induced e.m.f produced in them. Because the magnetic pole is alternatively N and S, they induce an e.m.f and hence current in the armature conductors, which first flow in one direction and then another. Thus, an alternating e.m.f and current is produced in the stator conductors whose frequency depends on the number of N and S poles moving past a conductor in one second, and the direction is given by Fleming's Right-hand rule (Theraja, B.L.and Theraja, A.K. 1967).

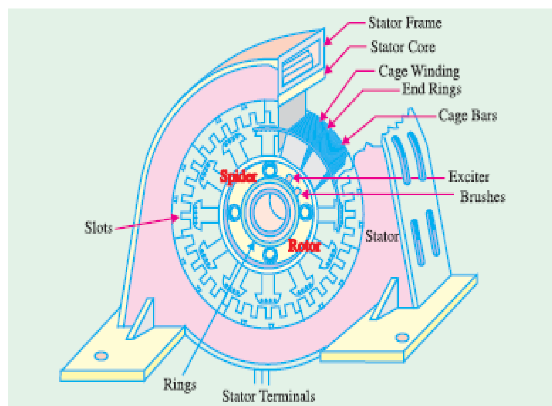

Figure 2. Alternator assembly (*Theraja*).

METHODOLOGY

The selection of materials for the fuelless generator was guided by principles of sustainability, availability, and durability. The design of the fuelless generator began with a thorough analysis of available renewable energy sources in the target area, including solar radiation levels and kinetic energy sources. Based on the prevaling analysis of the level of renewable energy in the Southwest of Nigeria, a hybrid system consisting of solar panels was chosen to maximize energy generation efficiency and reliability.

The fuelless generator's design incorporates recycled materials such as old car alternator, motors that are affordable in the market, car parts, and scrap metal, making it cost-effective and environmentally friendly. The mechanical components were designed to withstand harsh weather conditions and operate efficiently with minimal maintenance requirements.

The electrical system includes a battery bank for energy storage, a charge controller to regulate charging from solar panels, and an inverter to convert DC power to AC power. The system is designed to be modular and scalable, allowing for easy expansion and customization based on specific energy needs.

Materials

The input sources of the three modes include a battery, motor (AC or DC), or mechanical means (e.g use of spring). A Motor is used instead of battery or mechanical means because the battery life span is not encouraging due to the continuous drawing of energy from the battery which is not recharged in the same rate as it is discharged. Also, the Mechanical mean of using a spring is fraught with expansion and contraction process which, with time, depreciates the effectiveness of the spring.

Figure 3. Alternator used.

Body and Structure

1. Framing

Anguler rods and frames were adapted to support mechanical rotation (figure 4), while scrap metal was used to construct sturdy frames and mounts. The construction process involved a combination of welding, cutting, and assembling various components to form the generator's structure. Electrical wiring and connections were carefully installed (figure 5) to ensure safety and efficiency, following standard practices for renewable energy systems.

Figure 4. Metal base frame.

2. Crank Shaft

The weight of a disk flywheel is thought to be concentrated on the flywheel's rim. In order to calculate the kinetic energy of the flywheel the disk's weight is disregarded. Therefore, it is assumed that the weight of a circular rim is concentrated at the horizontal centerline to compute the kinetic energy of the flywheel (Tyler, 2006). See equation (1):

$$The\ kinetic\ energy\ = {Wv^2}/{2g} \quad (1)$$

where *W* is the flywheel weight, of the flywheel rim, and *v* is the velocity of flywheel at the horizontalal centerline of the rim.

The velocity of a rotating rim v is from equation (2):

$$v = 2\,\pi\, RD/\,60 \quad (2)$$

where π is 3.1416, *R* is the rotational speed, and *D* is the distance of the rim horizontal centerline from the center of rotation.

But, here instead of using flywheel we use crankshaft as link between the DC motor and the alternator to transfer mecanical energy from DC motor into the alternator to prroducce desired electricity.

Design

Control Unit

The control unit performs rectification and smoothing of the alternator's output using necessary electronics circuitry. Capacitor and Automatic Voltage Regulator (AVR) was used in this work. The capacity of thalternator can be determined by the formula as given in equation (3).

$$P = IV \cos \phi \quad (3)$$

where P is power output, V is voltage (Volt), I is current (Ampere) and ϕ is the phase angle.

Charging Unit

The charging unit comes from the output of the alternator which comprises of diode and (AVR). As the generator generates electricity, at the same time it returns (or recharges) current back to the battery through a diode.

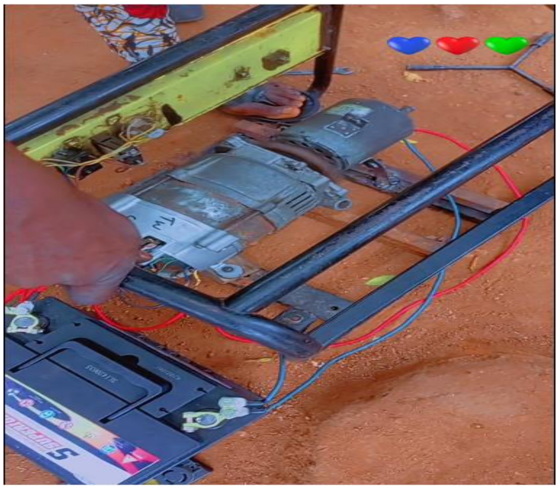

Figure 5. Mounting of components in metal iron frame.

Efffiieny of the Machine

The effiiency of the machine was calculated using the formula in equation (4):

$$Efficiency = \frac{\text{Output power}}{\text{Input power}} \times 100\ \% \quad (4)$$

RESULTS AND DISCUSSION

The performance of the fuelless generator was evaluated through field testing in an office within The Polytechnic, Ibadan with limited access to electricity. Data on energy production and system reliability were collected from 8:00 am to 4: 00 pm for five weeks to assess the generator's effectiveness in meeting the office energy needs. The results were obtained using a multi-meter to read the input and output voltage at different load conditions. The load used ranged from 0 - 1600 W. The testing was first carried out without a charging system as shown in Table 1 and then with a charging system as shown in Table 2. The system's output efficiency was calculated using the output data obtained during the testing process with varied load capacities as presented in Table 1 and Table 2 and shown in the Figure 6 below.

Figure 6. Constructed generator when tested and operational.

Table 1. Generator testing analysis without recharging the battery.

Test	Load (W)	Input Voltage (V)	Output Voltage (V)	Input Current (A)	Output Current (A)	Input Power (W)	Output Power (W)	Efficiency (%)
1	0	12.00	220	0	0	0	0	0
2	100	11.80	217	8.19	0.40	96.64	86.80	89.8
3	200	11.70	198	8.38	0.43	98.05	85.14	86.8
4	300	11.50	192	7.95	0.39	91.43	74.88	81.9
5	400	11.30	187	7.41	0.34	83.73	63.58	75.9
6	500	11.20	180	7.81	0.33	87.47	59.40	67.9
7	600	11.00	175	6.77	0.25	74.47	43.75	58.7
8	700	10.90	170	6.62	0.21	72.82	35.70	49.0
9	800	10.80	163	5.81	0.17	62.75	27.71	44.2
10	900	10.60	156	4.94	0.12	52.36	18.72	35.8
11	1000	10.40	150	4.25	0.10	44.20	15.00	33.9
12	1100	10.35	148	4.24	0.10	43.88	14.80	33.7
13	1200	10.32	146	4.22	0.09	43.55	13.14	30.2
14	1300	10.21	142	4.10	0.08	41.86	11.36	27.1
15	1400	10.00	141	4.08	0.07	40.80	9.87	24.2
16	1500	9.98	141	4.04	0.06	40.32	8.46	21.0
17	1600	9.97	138	4.03	0.06	40.18	8.28	20.6

Table 2. Generator testing analysis with recharging the battery.

Test	Load (W)	Input Voltage (V)	Output Voltage (V)	Input Current (A)	Output Current (A)	Input Power (W)	Output Power (W)	Efficiency (%)
1	0	12.00	220.0	0	0	0	0	0
2	100	11.95	218.2	8.21	0.41	98.11	89.46	91.2
3	200	11.91	217.0	8.42	0.40	100.28	91.14	86.6
4	300	11.88	215.1	8.15	0.38	96.82	81.74	84.4
5	400	11.83	212.6	7.95	0.36	94.05	76.54	81.0
6	500	11.87	209.5	8.38	0.37	99.47	77.52	77.9
7	600	11.78	205.5	7.84	0.31	92.36	63.71	69.0
8	700	11.75	202.4	7.65	0.27	89.89	54.65	60.8
9	800	11.69	200.2	7.54	0.25	88.14	50.05	56.8
10	900	11.62	197.8	7.40	0.20	85.99	39.56	46.0
11	1000	11.58	195.0	7.22	0.18	83.61	35.10	42.0
12	1100	11.57	195.8	7.29	0.18	84.35	35.24	41.7
13	1200	11.56	195.2	7.21	0.17	83.35	33.18	39.8
14	1300	11.55	194.6	7.20	0.16	83.16	31.14	37.4
15	1400	11.54	194.2	7.23	0.15	83.43	29.13	34.9
16	1500	11.53	193.8	7.19	0.14	82.90	27.13	32.7
17	1600	11.51	193.5	7.18	0.12	82.64	23.22	28.1

DISCUSSION

The input voltage which is supplied by the battery ranges from 9.97V at a load of 1600W to 12V at 0W for fuelless power generating set without a charging system compared to 11.51V at a load of 1600W to 12V at 0W with a charging system.

The result shows hat the machine had a peak efficiency of 89.8% at a load of 100 watts and the lowest efficiency of 20.6% at a load of 1600 watts without a charging system compared to peak efficiency of 91.2% at a load of 100 watts and the lowest efficiency of 28.1% at a load of 1600 watts with charging system. Also, the duration of operation of the generator with a charging circuit was more than that of one without a charging ciruit.

The performance evaluation demonstrated that the fuelless generator was capable of reliably generating electricity from renewable energy sources, providing a sustainable and affordable energy solution for off-grid communities. The generator's modular design and use of recycled materials make it suitable for replication and adaptation in similar settings around the world.

CONCLUSION

The design and implementation of a fuelless generator using available and recycled material had been carried out, the duration of operation of generator with charging circuit was moe than that of one without charging circuit and incresrsa in efficience make it offer a promising solution to the challenge of off-grid electrification in rural communities. By harnessing renewable energy sources and incorporating innovative engineering techniques, the generator provides a sustainable and environmentally friendly alternative to conventional fuel-based generators.

Future work could focus on further optimizing the generator's design and performance, exploring additional renewable energy sources to increase and stabilizing the efficiency. Conducting outreach and education efforts to promote the adoption of fuelless generators in off-grid communities. With continued innovation and collaboration, fuelless generators have the potential to transform energy access and improve the lives of millions of people worldwide.

ACKNOWLEDGEMENT

The authors are grateful to TETfund for the sponsorship of the project through the IBR program of the organization and the authorities of The Polytechnic, Ibadan for providing the platform to showcase the research work.

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