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Performance Analysis of Alternator-Powered Fuelless Generator

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Abstract:

This paper presents the performance analysis of an alternator-powered fuelless generator. The target is to address the critical issue of energy dependence on fossil fuels. The novelty of this fuelless generator is the inventive application of a closed-loop system, where a 1.5HP DC motor of 3500 rpm is the prime mover and drives an AC generator of 220V for power generation. In this fuel-less generator, a DC source of 12V (Battery) is needed to initiate the process and to store the energy, which is fed back to the DC motor for its operation. The power generated is in the form of electricity, which is then fed back to the electric motor to sustain its operation, creating a power source without any fossil fuel. This will reduce the environmental impact by eliminating harmful emissions and also offer a cost-effective energy source through its self-sustaining nature. The materials used were sourced locally. The performance evaluation and environmental impact assessment quantify the reduction in greenhouse gas emissions and air pollution compared to traditional power sources. The practical operations were performed, data collected used in the computational analysis for efficiency. An output power rating of 1.2 KVA, a voltage of 220V was obtained, and the fuelless generator was analysed to have an efficiency of 87.1%. A further analysis indicates that the power of the generator increases as the speed increases, and the speed of the generator is maximum when no load is applied. The potential of this perpetual power source will revolutionize access to sustainable electricity.

Keywords — **Alternator, Motor, Powered, Fuelless, Generator.**

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I. INTRODUCTION

The fuelless generator is a self-sustained generator that produces electric energy for consumption. It powers itself and simultaneously supplies electricity. Hence, it is a form of renewable energy system. A fuelless generator does not require fossil fuels to generate electrical current. It's a sustainable method of generating electricity as these resources utilized for generation are renewable. The generator, just as the name implies, is a power-generating system that doesn't require any kind of fossil fuel for its operation, therefore, it is a zero-carbon energy system. This method of electricity generation will serve as an economic growth to the nation, for example, in Nigeria, where there is over-dependence on crude oil for energy production. In Nigeria, just like most developing countries in the world, with the challenges of light disruption, fuelless generators are promising an alternative to the power problem. By harnessing energy conversion and utilization, the fuelless generator has the potential to be environmentally sustainable, reduce emissions, and offer lower operational costs of operation. This technology could be particularly beneficial in remote locations where grid access or traditional fuel sources are limited.

This paper focused on the conversion of mechanical energy into electrical energy without the use of combustible fuels. It involves the assessment of its performance compared to a generator with a fossil fuel. It is of note that fossil fuel generator causes environmental pollution and produce smoke, which leads to degradation or depletion of the ozone layer, and the smoke affects human health when compared to this fuelless generator. This innovation led to the idea of generating electricity efficiently without noise and smoke, fuel-free, with high performance, and requiring less maintenance.

The main significance of the innovation is a portable generator that converts mechanical energy into electrical energy, without using any fossil fuel, which produces clean, renewable energy sources that will help reduce our reliance on fossil fuels and mitigate the effects of climate change. They are also affordable and accessible to people in both urban and rural areas, making them a viable solution for meeting the energy needs of developing countries and underserved communities. This type of generator can be used to power homes, businesses, and communities in remote areas where there is no access to the grid, and can be used to power electric vehicles and other transportation systems, as well as to generate electricity for industrial applications. This fuelless generator can also be used to provide backup power during power outages and generate electricity for disaster relief and emergencies. it has the potential to make a positive impact on the environment, society, and the economy, hence contributing to building a more sustainable future for all.

II. LITERATURE REVIEW

This section presents a review of related literature on the design, operation, and performance of a fuelless generator. The combination of AC generators using alternators with electric motors is a promising new technology that will help to meet the need for clean and sustainable energy. These generators work by using a DC motor to drive an alternator, which produces an AC voltage. The AC voltage is then rectified using an inverter to produce a DC voltage, which is used to power the DC motor, creating a self-sustaining system. Several studies have investigated the design and construction of generators. According to Adewumi (2016), the coupling design of power fuelless generating is better than the belt and pulley design of the generating set, with an efficiency range of 0% - 89.9% while 0%-73.23 % for the V-belt design. In Oyekola et.. al (2019) work, electrical energy was generated by coupling an alternator armature shaft directly with a DC motor powered by a rechargeable battery. The DC motor rotates the armature of the alternator in the field coil at high speed when activated from the starting switch, which results in alternating current output voltages of 220V. Adegoke et. al (2021), performance evaluation of the fuelless generator, which indicated that the efficiency of the system decreases with the load capacity, and validation was within the range of 0W to 1800W. The analysis has shown a decrease in the efficiency of the machine when there is a high increase in the load. Ajav and Adewumi (2014) undertook the design, construction, and Performance Evaluation of the fuel-less power generating set, with the result showing that the machine has an average efficiency of 56.43% at a load of 600W for continuous operation. And the peak efficiency of the constructed fuel-less power generating set was 89.1% at a load of 100W. According to Ramesh et. al (20220, since all electrical appliances like fans, drill motors, lights, among others are designed to operate at 220v ac at 50Hz same source is generated through inverter designed The drive stage is configured in push-pull mode of operation such that power losses can be minimized and inverter efficiency can be increased. Esom et. al (2020) show that the rotating DC motor (prime mover) turns the alternator to full speed, giving out the electrical energy. Part of the output power is recycled (feedback) to a battery charger to keep the battery on. The output result is as good as the conventional fuel generators, but is better because it is cost-effective, cheaper to run and maintain than the conventional types that use petrol or diesel and lubricants, and is again, pollution-free. Okhueleigbe et. al (2022), work discusses the use of a prime mover, shaft, gearbox that was connected directly with the alternator to generate electricity when the start button is turned on to generate an output supply of 220V. Abonyi et al. (2021) designed and constructed a fuelless AC generator using a 12 V, 10 A DC motor, a 230 V, 1 kW AC alternator, a 12 V, 100 Ah battery, and an inverter. The generator was found to be able to produce a stable output voltage of 230 V and a frequency of 50 Hz. It was also able to power a 100 W load without any problems. El-Ghazaly and El-Saadany (2010) designed and implemented an AC power generator using a DC motor. The generator was based on the principle of electromagnetic induction. David (1980) constructed a fuelless generator, incorporating a flywheel and bearings into a comprehensive energy storage system to demonstrate the feasibility of flywheel storage for home use

An exhaustive literature review has revealed that the project works on the fuel-less generator has been efficacious, and enough electrical power output has been obtained in every case, which can decipher a solution to electric power instability in the country. However, the past work has not laid much emphasis on the performance parameters to enhance the efficiency of the generator. The belt drive was widely adopted in prior works for the transmission of power from one shaft to the other, leading to power loss. This work addresses this gap by exploring the shaft-to-shaft arrangement of the DC motor and alternator. This work has addressed the issue as power loss is reduced and efficiency is improved.

III MATERIALS AND METHOD

This section presents the specific methods and materials used for the production of a typical model of a fuelless generator, as shown in Figure 3.1, which helps with performance analysis. Creativity techniques can also be used in power generation as shown in Ekong (2014).

In Figure 3.1, the circuit was built across electrical components, including the electric motor, alternator, and battery. The DC motor was 1.5 hp, with a speed of 3500 rpm.

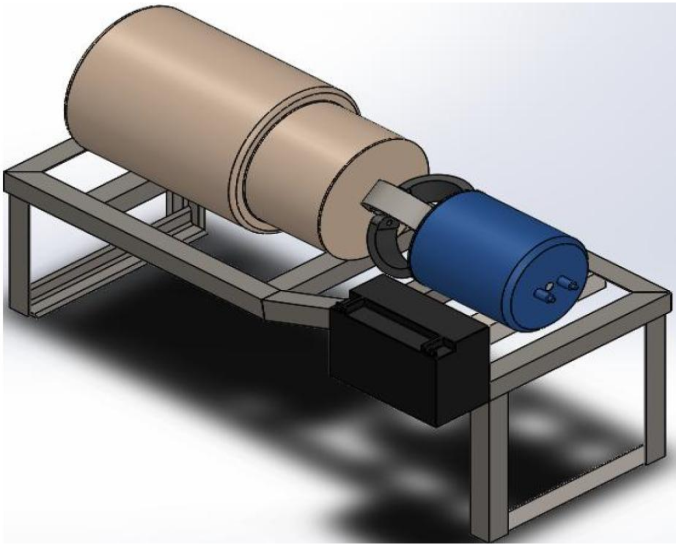

Figure 3.1: A typical Model of a Fuel-less Generator

3.1 Principles of Operation of the Fuel-less Generator

The fuelless generator uses an electric motor to transmit power to the alternator, which is in a shaft-to-shaft connection with the electric motor. The alternator produces voltage during this rotational motion of its rotor, which is then fed back to the electric motor to sustain its operation

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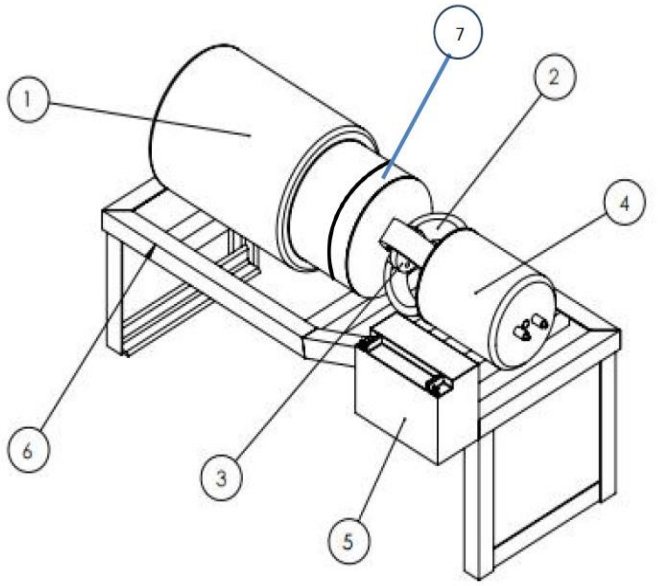

Figure 3.2: A CAD diagram of the Fuelless Generator

Table 3.1: Part list and quantity of the Fuelless Generator

PART NUMBER	PART NAME	QUANTITY
1	Alternator	1
2	Flexible coupling	3
3	Shaft	2
4	DC Motor	1
5	Battery	1
6	Frame	1
7	Flywheel	1

This process relies on the interaction between the electric motor and the alternator without the use of fuel, and is made possible by an alternating current supplied to the motor to initiate the process. The generator uses a DC motor to transmit power to the alternator, which is in a shaft-to-shaft connection with the DC motor. The alternator produces voltage during this rotational motion of its rotor, and the output power of the alternator is then fed back to the DC motor to sustain its 12 operation. This process relies on the interaction between the DC motor and the alternator without the use of fuel and is made possible by a 12V DC power source supplied to the motor by the battery to initiate the process. The fuel-less generator is made up of many components that are assembled. Table 3.1 describes these components and their ratings. Major Components/Parts are grouped into the Generating components and the Frame and casing and the manufactured fuelless generator is shown as Figure 3.3.

Figure 3.3: Manufactured Fuelless Generator

3.2.1 Generating components

These components are discussed as follows.

- **Electric Motor**

This is a device that converts energy into motion and can be connected to a power source to drive another device. This motor has positive and negative poles to which the polarity of the power source can be connected. The electric motor replaces the mechanical parts of a normal petrol generator, such as pistons, rings, spark plug, carburetor, combustion chamber, etc. All these parts synchronize to keep the coil in a desired and continuous motion. In this project, the rating of the electric motor used is 1 hp, 12 V, and it has a speed of 3500 rpm.

The electric motor was selected due to it's ability to transfer power to the rotor shaft of the alternator and speed it offers, which meets the requirements of the design.

Generally, it is known that the power transmitted by the electric motor is given by:

$P=IV$ (3.1)

Where P, is the power transmitted, I is the current, and V is the voltage.

Also, P $\frac{2\pi NT}{60}$ (3.2)

Where N, is the speed in rev/min, and T is the torque transmitted.

- **Alternator**

This is simply a device that generates an alternating current. It is quite different from the normal alternator that charges a car battery. This type of alternator, when receiving a constant motion from any device like an electric motor or belt drive, generates electricity. It comprises a starter, armature, and center rod. In this work, an alternator of 0.65 kVA rating was chosen because of its capability to produce 220 V. It is well known that the frequency of the generated voltage in an alternator is given by:

$$f = \frac{p}{2} \times \frac{n}{60} \quad (3.3)$$

Where f is the frequency and n is the speed in rpm

Similarly, the power output of the generator can be calculated using equation (3.1)

Also, the efficiency of a machine is given by the formula below:

$$Efficiency = \frac{Power\ Output}{Power\ input} \times 100 \quad (3.4)$$

- **The flywheel**

The flywheel is a rotating mechanical component that is used to store energy, which helps in controlling cyclic fluctuations in the system. It stores kinetic energy and then releases it when needed to help maintain a consistent speed and power output. It also helps to protect the motor from damage caused by sudden changes in the load or power input.

The kinetic energy of a moving particle is affected by its mass and is given by the equation:

$$E = \frac{1}{2}mv^2 \quad (3.5)$$

Where m is the mass of the flywheel, and v is the velocity of the particle.

However, the kinetic energy developed by a flywheel is given by:

$$K.E = \frac{1}{2} \times I \times \omega \quad (3.6)$$

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

The use of flywheel with mass concentrated at the rim contributes in improving the efficiency and performance of the system's efficiency. Hence, a 5kg flywheel with mass concentrated at the rim was used for this project to enhance the efficiency of the fuelless generator.

4. RESULTS AND DISCUSSION

4.1 Overview

The input and output data for the design are presented in this section. The results were obtained by evaluating the models presented in section three, and also by testing the fabricated design. The input and output data are tabulated for clarity. Additionally, graphs are used where necessary to demonstrate the relationship between certain parameters.

4.2 Parameters for Analysis

The fuelless parameters in Table 4.1 are based on the known values of the components used in the design. This involves the major components and their specifications, such as the electric motor, alternator, and others, which determine the voltage output of the generator. The Alternator has a rating of 0.65 kVA, which gives an output of 220 V. The DC motor is the driving mechanism and has a rating of 1 hp (horsepower) with a speed of 3500 r.p.m.

Table 4.1: Parameters of the Fuelless Generator

S/N	COMPONENTS	RATING	MATERIAL
1.	Alternator	0.65 kVA	Copper coil
2.	Electric motor	1 hp	Aluminium coil
3.	Flywheel	135 mm diameter	Aluminium
4.	Shaft	10 mm diameter	Steel

This test is intended to establish the ability of the generator to convert the DC input into AC output, which involves measuring the output power and comparing it to the input power. The generator's output is measured using a 60-W light bulb as a test load, and efficiency is then calculated using equation (3.4). This evaluation was done by loading the generator using 60W bulbs, which were connected to an extension wire. The output voltage and the current data were collected, and then the voltage and current results were computed. Thereafter, with the data for output voltages, power outputs are obtained as shown in Table 4.2, while the efficiency was computed respectively as shown in Table 4.3.

Table 4.2: Fuelless Generator Data

S/N	Generator Speed (rpm)	Output Voltage (V)	Power Output (W)
1.	0	0	0
2.	1000	70	210
3.	1500	105.5	316.5
4.	2000	150	450
5.	2500	200	600
6.	3000	220	660

The load capacity used for this evaluation ranges from 0 watts to 480 watts. Figures 4.1 to 4.5 illustrate the performance evaluation of the fuel-less generator. Figure 4.1 analyses the relationship between the rotational speed of the generator and the power output of the generator. The generator speed was adjusted, and the corresponding power output of the generator was recorded for five (5) different values. The computation and analysis carried out and was observed that the power output of the generator depends on its rotational speed. This indicates that as the speed of the rotor is increased, there is a corresponding increase in the power output.

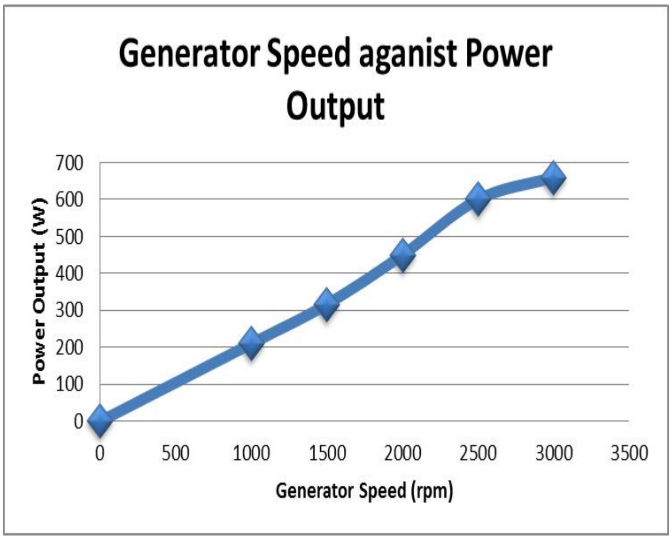

Figure 4.1: Graph of Generator Speed against Power output

Figure 4.2 examines the relationship between the rotational speed of the generator and the output voltage of the generator. The generator speed was adjusted, and the corresponding output voltage of the generator was recorded for five (5) different values. The computation and analysis carried out and was observed that the output voltage of the generator depends on its rotational speed. Indicating that as the speed of the rotor is increased, there is a corresponding increase in the output voltage until the maximum voltage of the generator (220 V) is produced, which is at the speed of 3000 rpm.

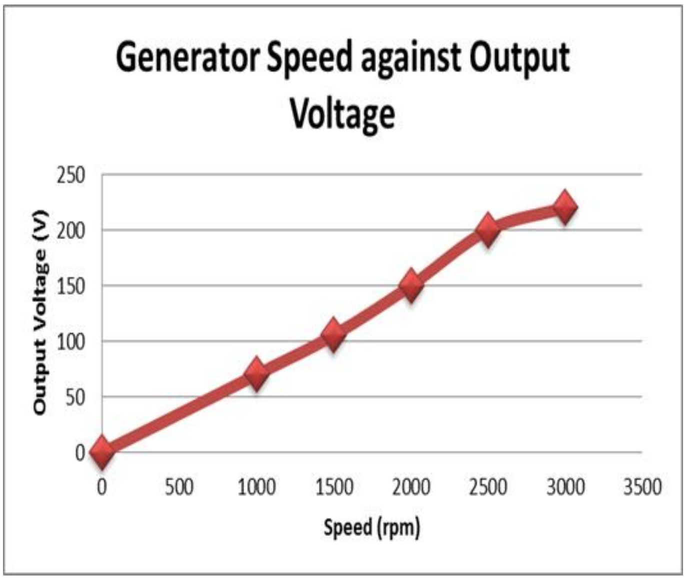

Figure 4.2: Graph of Generator Speed against Output voltage

Figure 4.3 evaluates the relationship between the generator loads against the rotational speed of the generator. As the load increases, there is a corresponding reduction in the speed of the generator, and five (5) different loads were applied. The analysis carried out and was observed that as the load was increased, there was a corresponding reduction in the speed. Hence, when more loads are continuously added to the system, it has a negative effect on the system by reducing its speed. At the point where the load was zero, the generator speed was maximum, and then reduced accordingly when the system was subjected to more loads.

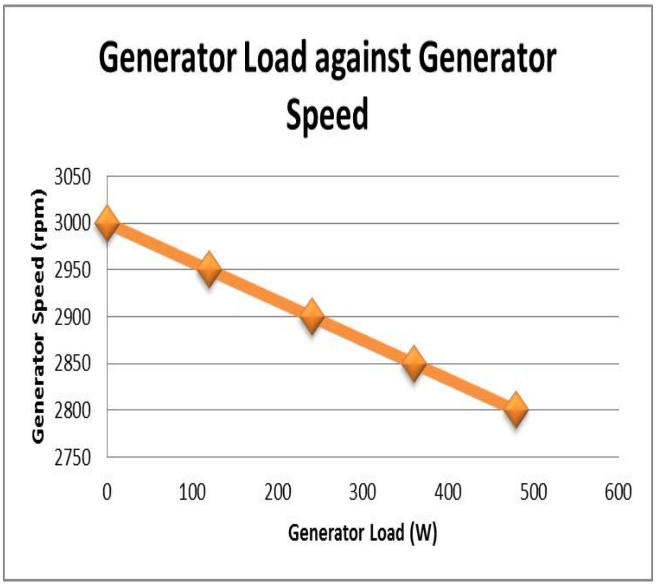

Figure 4.3: Graph of Generator load against Speed

Figure 4.4 evaluates the relationship between the generator loads against the efficiency of the generator. As the load increases, there is a corresponding reduction in the efficiency of the generator, and five (5) different loads were applied. The analysis carried out and was observed that as the load was increased, there was a corresponding reduction in the efficiency.

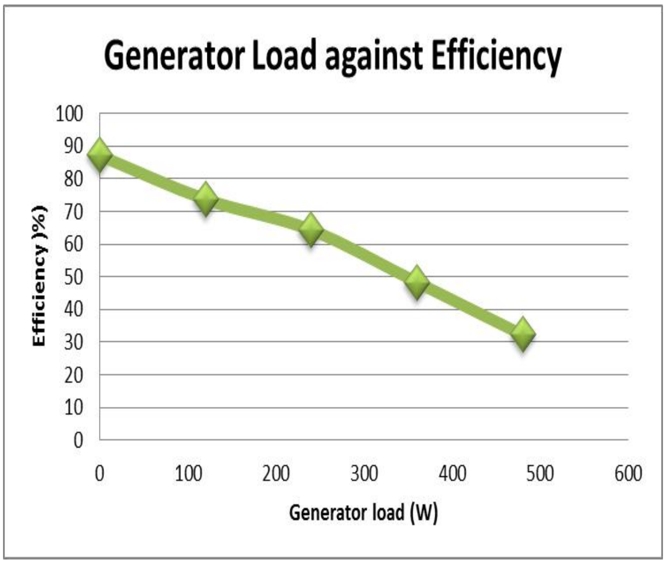

Figure 4.4: Graph of Generator load against Efficiency

Table 4.2: Load Capacity Ranges and Efficiency

S/N	**No of bulb used**	**Load (W)**	**Speed (rpm)**	**Efficiency (%)**
1.	0	0	3000	87.1
2.	2	120	2950	73.7
3.	4	240	2900	64.3
4.	6	360	2850	48.3
5.	8	480	2800	32.2

In Figure 4.5, it was observed that as the number of bulbs increases (load), the output power decreases, and the efficiency, which is in direct relationship with the power output, decreases.

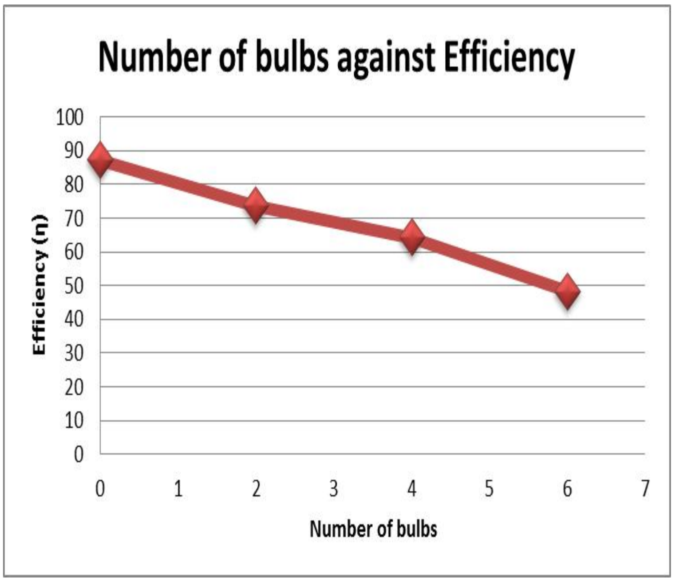

Figure 4.5: Graph of number of bulbs increases (load) against the efficiency

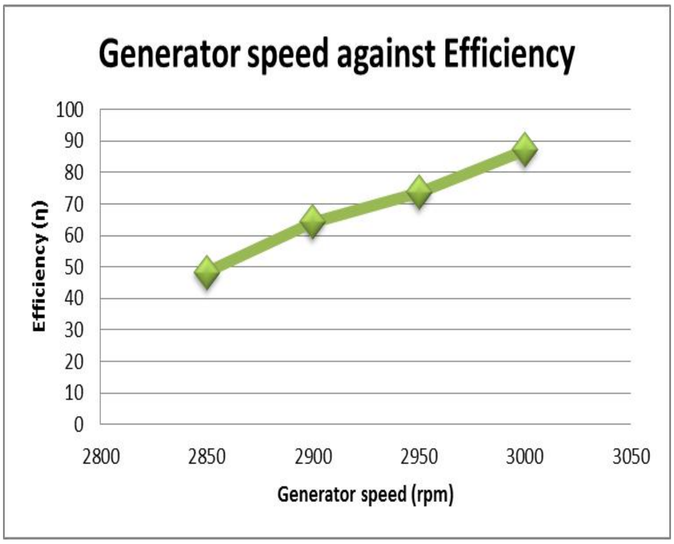

Figure 4.6: Graph of Generator speed against Efficiency

The analysis shows that the power of the generator is directly proportional to the speed, N, of the alternator and that the efficiency only increases with a corresponding increase in power output, as shown in Figure 4.6. Also, at the point where the load is zero, the generator speed is at maximum, but the speed reduces with respect to the load the system is being subjected to. Hence, overloading the generator will harm the generator.

V. CONCLUSIONS

The performance analysis of an alternator-powered fuelless generator was carried out, and the aim was achieved. The project explored the design and performance of a fuel-less generator, showing a closed-loop system where a DC motor drives an alternator for electricity generation, which then powers the same motor to sustain the operation. These construction parameters successfully yielded an accurate, effective, and efficient system. It not only significantly eliminates fuel consumption and maintenance requirements, but also boasts a compact design with fewer components requiring easy maintenance. This translates to simpler and more feasible maintenance compared to conventional internal combustion engines.The practical operations were performed, data collected used in the computational analysis for efficiency. An output power rating of 1.2 KVA, a voltage of 220V was obtained, and the fuelless generator was analysed to have an efficiency of 87.1%. A further analysis indicates that the power of the generator increases as the speed increases, and the speed of the generator is maximum when no load is applied. The potential of this perpetual power source will revolutionize access to sustainable electricity.

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