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Development Of Self-Induced Fuel-Less Generating Set For Sustainable Power Supply In Nigeria Using Local Available Materials

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ABSTRACT: *The incessant power outage in Nigeria power system industry has brought about the frequent use and proliferation of internal combustion engine generating sets in almost every home and industries in Nigeria today. This is not a healthy development looking at the quantity of emission of poisonous gas (carbon IV oxide), particulates and volatile harmful substances released on human population. This has provoked the new innovations – fuel less generator in Nigeria into being, using available material. Presented is a 5KVA fuel less generating set designed to serve as a standby generator against the incessant power outage in Nigeria. In its features, it consists of a d.c battery, d.c motor, alternator, connecting shaft, charging panel (transformer, diode and capacitor), and a frame. A12V, 100Ah battery (power source) was connected to a 12V d.c motor which in turn rotated to give the mechanical power through the shaft. The rotating d.c motor (prime mover) turns the alternator to a full speed and this gives 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 is cost effective, cheaper to run and maintain than the conventional types that use petrol or diesel and lubricants and is again, pollution free.*

KEYWORDS*: Fuel less generator, Nigerian power system, pollution free, no lubricants, poor power quality, power outage, standby generator.*

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I.INTRODUCTION

The Nigerian power system is characterized by series of constant power failures and outage, most of which are either technical or non-technical in nature. These problems range from tripping of lines on account of faulty equipment to constant increase in load more than the available power supply. Others may be natural or weather related problems like wind, flood, earthquakes and such likes. The proliferation of generating sets and the consequent, air pollution/noise is on increase on daily basis because of these problems, and this calls for a change in direction through the use of fuel less generators.

II. EMPIRICAL REVIEW

The exact nature of electricity is not known but thorough investigation revealed that it consists of small negative charge called electron. When these electrons are standing still, it is said to be static electricity, but when they are forced to move, it is said to be dynamic electricity [1]. Power generation and distribution have been the major economic hub in the development of the national economy - be it manufacturing, banking, media, healthcare, aviation and a lot more [2]. Power is defined as the rate of doing work and the productivity of any nation depends on the availability of power at all times.

It is an axiomatic fact that majority of Nigerian problems are traceable to erratic power supply where many activities are paralyzed due to the incessant power outage [2]. Analysis have revealed that Nigeria loose about ₦220 billion annually due to unstable nature of the country's power supply [3]. Moreover, environmental

pollution which leads to degradation or depletion of ozone layer is one of the major problems caused by the use of fossil fuelled generators. Again, other problems include, land and water pollution, noise pollution, increase in the price of fossil fuel year in year out, among others.

The fuel less engine usually runs very smooth and quiet and the best part of the design is that it is free from air pollution since there is no emission of dangerous gas like carbon monoxide (CO) and carbon dioxide (CO_2).

III. FEATURES OF THE FUELLESS GENERATOR

The fuel less generator in its features consist of a d.c battery, d.c motor, alternator, connecting shaft, charging panel (transformer, diodes and capacitor), and a frame[4].

In its principle, a 12V 100 Ah battery (power source) was connected to 1hp, 12V d.c motor which in turn rotated to give the mechanical power through the shaft. The rotating d.c motor (prime mover) turns the alternator to a full speed and this gives out the electrical energy. Part of the output power is recycled (feedback) to a battery charger to keep the battery on. It is worthy to note that the output of the fuel less generator remains constant irrespective of the number of batteries (power source) used. For instance, using a 2-number, 24V, 200AH deep cycle batteries can only drive the d.c motor faster than using a 2-number of 100AH deep cycle batteries [4]. To sustain the output voltage: once the rate of discharging the batteries is equal to the rate of charging the batteries then the output voltage remains constant and the fuel less engine can operate for 365 days without any interruption[5]. This is an ideal renewable energy source.

The concept here is to replace the internal combustion engine of the conventional generator, which depends on fuel, with electromechanical device (motor/prime mover) that converts the electric current into mechanical energy. This mechanical energy will be used to drive the alternator while the current produced by the alternator is recycled (feedback) by a battery charger to charge the battery and power again the electromechanical device (d.c motor) and the cycle repeats itself all over again.

IV. THE DESIGN CONCEPTS OF FUEL LESS GENERATOR

The electromechanical device (d.c motor) used to replace the internal combustion engine of the conventional generator is designed in such a way that it uses less power than the alternator power output, so that one can still be able to power gargets at home e.g. television, refrigerators etc after recycling chunk of the output power in battery charging. This is the secret behind the development of fuel less generator [5].

SYSTEM DESIGN

Design specifications:

Assumed capacity of the fuel less generator – 5KVA

Battery capacity – 12VDC, 100AH

d.c motor

- Input voltage – 12VDC (from the battery)
- Input current – 62.17A
- Output power – 1hp or 746 watts

Alternator

- Capacity in KVA – 800Va or 0.8KVA
- Proposed KVA output rating of the alternator when fully spun with the d.c motor – 5KVA
- Power factor (p.f) – 0.85
- Output voltage of alternator – 220V

To calculate the output power of the proposed generator:

5×10^3 VA x p.f = output power

$\Rightarrow$ 5×10^3 VA x 0.85 = 4250 watts or 4.25KW

$\therefore$ 4250W – 746W = 3504 watts or 3.504KW

This is what remained in the output power after the motor has expended 746 watts to spin the alternator and recycling to charge the battery has taken place.

Therefore, the 3504W or 3.504KW remaining is what we use to power devices at home such as television, fridge, laptops or lighting points.

Check:

Convert to KVA rating and compare

$\frac{3.504}{0.85}$ = 4.117KVA < 5KVA assumed

$\therefore$ OK

Transformer design:

The specifications for transformer are as follows:

KVA rating = 5KVA
Power rating = 4250 watts
Power factor = 0.85
Primary voltage = 12 volts
Secondary voltage = 220 volts
Frequency = 50Hz

If real power (Re) = apparent power x power factor

$\therefore$ Re = 5 x 10^3 x 0.85 = 4250 watts

For primary current:

Re = I_1V_1
4250w = 12I

Therefore, the primary current rating $I_1 = \frac{4250}{12}$= 354.17A

For secondary current:

Re = I_2V_2
4250w = $220I_2$

Therefore, the secondary current rating $I_2 = \frac{4250}{220}$= 19.32A

The approximate standard wire gauge (SWG) for the primary and secondary currents were obtained from a chart thus, I_1= 6SWG (5.38mm); I_2 = 14SWG (3.25mm).

Calculating the Number of Turns

The number of secondary windings N2 was obtained from the approximate design equation for 50Hz transformer and gotten to be 290 turns. The primary winding was obtained by using the transformer equation:

$\frac{V_1}{V_2} = \frac{N_1}{N_2}$ - - - - - 3.1

Where

V_1 = voltage in the primary winding
V_2 = voltage in the secondary winding
N_1 = number of turns in the primary winding
N_2 = number of turns in the secondary winding

Hence, from equation (3.1),

$N_1 = \frac{V_1}{V_2} N_2$

$N_1 = \frac{24 \text{ x } 290}{220} = 32$ turns

To obtain the transformation ratio or turn ratio of the transformer, we apply;

$\frac{N_1}{V_1}$ or $\frac{N_2}{V_2}$

Therefore, $\frac{32}{24}$ or $\frac{290}{220}$ = 1.33 or 1.32

So, the transformer winding ratio is 1.3 turns: 1 i.e (1.3: 1)

V. IMPLEMENTATION OR INTEGRATION OF DESIGNED OUTPUTS TO PROMOTE STEADY POWER SUPPLY

In this section, the actual integration of the designed outputs to produce a fuel less generator was done with highlights on its significance in the life of Nigerians. In its construction, the designed apparatus were set up as shown in the block diagram. A 12V d.c, 100Ah battery was connected to a 1hp, 12V d.c motor using selected cables and the motor shaft connected to 800VA (0.8KVA) alternator shaft just as shown in figure 4.1.

Coupling: To transmit torque between the two shafts (alternator and motor shafts), a coupling using elastomeric flexible or adjustable material was used. This greatly mitigates vibration and shock effects between the two machines to reduce maintenance time to the barest minimum during operation.

Charging Unit: The d.c motor consumes energy from the battery during operation and so a diode-rectifier-system was incorporated in the design to recharge the battery while an installed suitable controller helped to regulate the voltage due to consumer load variations.

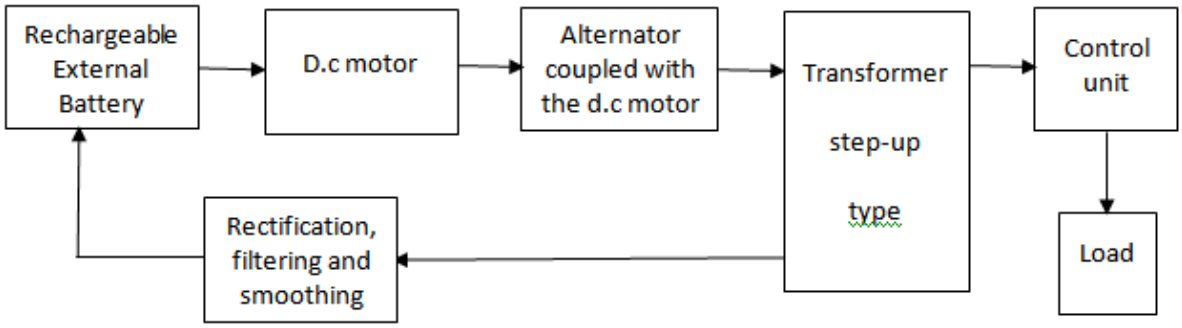

Figure 1: Block diagram of the fuel less generator

The fuel less generators plays great role and significance in life of the citizenry. The frequent power outage which results in proliferation of fossil-fuelled internal combustion engine generators everywhere in the country will reduce when people resort to the use of fuel less generators. The problem of environmental pollution and climate change will become things of the past and can be laid to rest. This piece is a new innovation in Nigeria; it is eco-friendly, low noise, and can improve air quality in the country since no poisonous pollutant is involved. Again, it is cost-effective because no financial lavish on fuel and lubricants is involved. It is light in weight and occupies little space and can be transported along easily during camping or trekking trips.

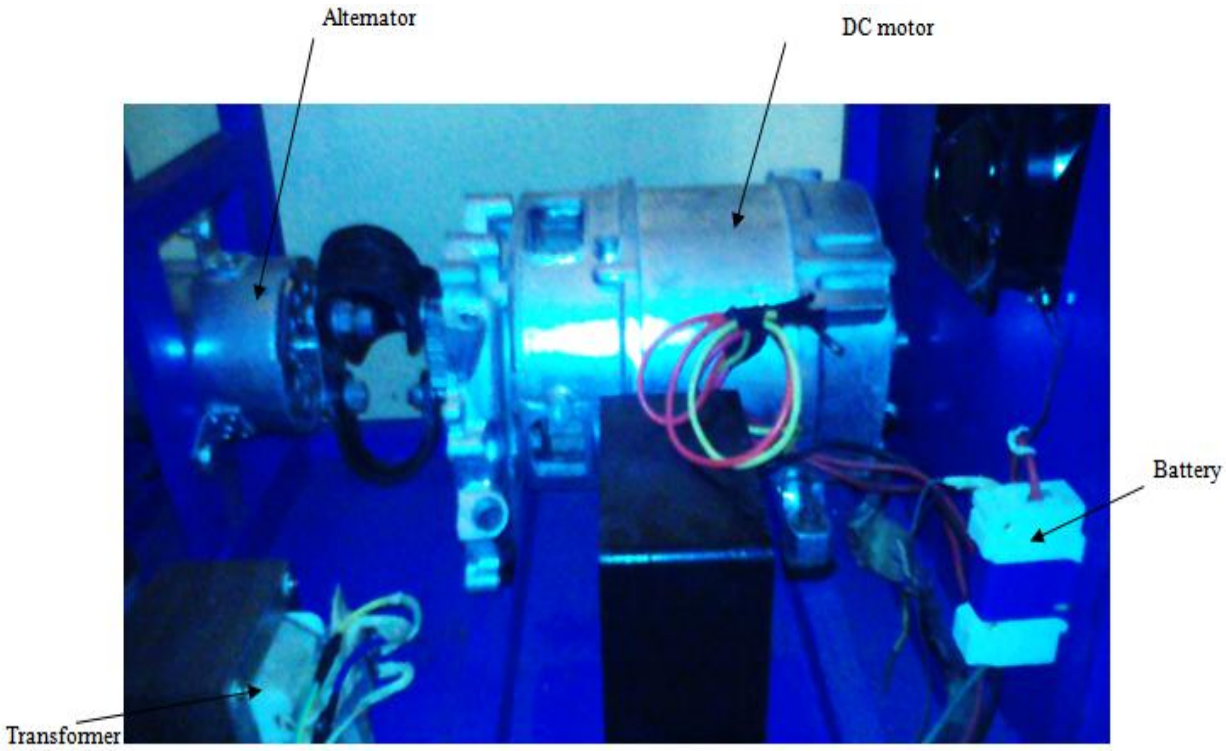

Figure 2: Diagram showing the major components of the fuel less generator.

Figure 3: Finished and final packaging of the self-induced fuel less generator

VI. PERFORMANCE EVALUATION AND ANALYSIS OF THE FUELLESS GENERATOR

The next step in the design process is to perform analysis and performance evaluation. Basically, we need performance evaluation to test that the system we designed in fact meets some of the desired specifications. Table 1 and figure 4 showed the results obtained from the fue lless generating set. The table and the plots simply portrayed the relationship between voltage and current at both input and output levels. The efficiency of the generator decreases with increase in input load of the generating set. The input power of the device is usually higher than the output power. Therefore, to operate the generator more efficiently, the maximum load of the machine must be below 1000 watts (see table 1).

Table 1: Efficiency of the 5KVA Fuel less Generator at various Loads (culled from [4])

Trials	Load (W)	Input voltage (V)	Output voltage (V)	Input current (A)	Output current (A)	Input power (W)	Output power (W)	Efficiency (%)
1	0	63.31	1,125	0	0	0	0	0
2	500	63.0	1,090	36.7	1.89	462.4	412.05	89.11
3	600	63.25	1,004	38.97	2.1	492.95	421.5	85.51
4	700	64.02	940	35.35	1.98	452.57	371.19	82.02
5	800	63.74	768	40.8	2.42	520.13	371.54	71.43
6	900	63.58	723	39.0	2.18	495.92	314.68	63.45
7	1000	62.37	655	33.74	1.81	420.88	237.48	56.42
8	1100	63.0	464.74	26.41	1.48	332.79	137.27	41.25
9	1200	61.88	214.6	22.76	1.19	281.84	50.97	18.09
10	1300	61.72	136.32	17.66	1.06	218.35	28.83	13.20
11	1400	58.4	141.20	11.50	0.65	134.61	18.19	13.51

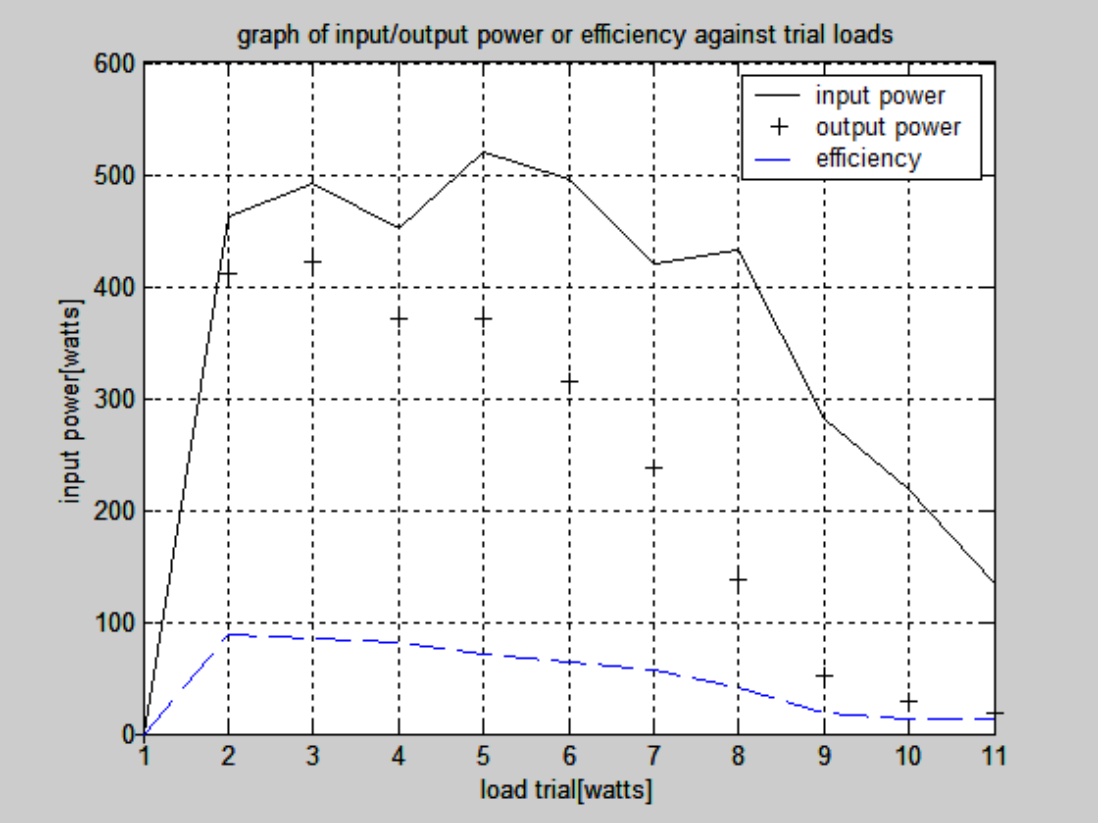

Figure 4: Showing the plots of input power, output power or efficiency against the trial loads

VII. CONCLUSION

A good number of health issues and challenges associated with air pollution in Nigeria are quite enormous and adequate care should be taken to curtail them. Air pollution resulting from vehicles/ other mechanical emissions like generating sets, climate change and environmental degradations, gas flaring and burning of fossil fuel put together are the root cause of various human ailments. Some of the human ailments caused by air pollution include: asthma, increase in respiratory symptoms like coughing, difficult or painful breathing, chronic bronchitis, decreased lung function and premature death. Therefore, fuel less generators and such likes are good steps in the right direction to fight this ugly trend. Again, fuel less generators is cost-effective as no more financial cost on fuel and lubricants are involved.

Steady power supply supported by fuel less generators is the only solution to solving Nigerian poor economic problem. When these generators are mass-produced, jobs will be available for the roaming jobless youths and crime wave is reduced in the country.

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