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Fuelless Power Generating Set and Power Inverter System: Analysis of Load and Efficiency Appraisal

I. O. Adewumi[1*] and B. A. Adelekan[1]

[1]Department of Agricultural Engineering, Federal College of Agriculture, I.A.R.&T, P.M.B 5029 Moor Plantation, Ibadan, Nigeria.

Authors' contributions

This work was carried out in collaboration between both authors. Author IOA designed the study, performed the statistical analysis, wrote the protocol, wrote the first draft of the manuscript and managed literature searches. Author BAA supervised the design of the work, proofread and edit the whole manuscript. Author BAA also gave his professional advice in order to have a very successful research. He managed the analyses of the study and literature searches. Both of the authors read and approved the final manuscript.

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ABSTRACT

There is need for engineers to search for alternative power source as it is important due to need for a cleaner source of power that is environmental friendly. Fuelless power generator as fuelless generation is a device that is understood to function without the need for internal combustion engine which usually request for fuel as a source of input while power inverter or an inverter is an electrical power converter that changes direct current (D.C) to alternating current (A.C). Both inverter and fuelless power generating set was designed and constructed at Federal College of Agriculture, Moor Plantation Ibadan, Nigeria by the author. This research will focus on comparison of the two devices in terms of there load performance. The performance evaluation of the machine revealed that when there is no load acting on the machine, the efficiency of the machine is said to be at 0%. It can be concluded that the machine had the highest efficiency of 97.40% at a load of 100W and the lowest efficiency of 71.70% at a load of 600W. It was also observed that there is a

**Corresponding author: E-mail: adexio@yahoo.com;*

decrease in the output of the machine when there is a high increase in the load. The result of the performance evaluation of the fuel-less power generating set shows that the machine is said to have an average efficiency of 56.43% at load of 600W for continuous operation. The peak efficiency of the constructed fuel-less power generating set will be 89.1% at load of 100W. For comparison, the result obtained from Power inverter, has clearly confirmed that the highest efficiency recorded is at 96.27% which is more higher than that of the fuel-less power generating set which is at 89.1%, at a load of 100W respectively.

Keywords: Fuelless generator; inverter; load efficiency; environmental friendly; performance evaluation.

1. INTRODUCTION

Adelekan [1] revealed that in contemporary times, a great deal of interest has been generated worldwide regarding the use of biofuels namely biogas, bioethanol and biodiesel for energy supply. The most ambitious goal thus far in respect of the development and exploitation of renewable energy sources appear to be that articulated by the European Renewable Energy Council.

Grafham [2] cited in [3] has reported that electricity, for sometimes now has been one of the most useful source of energy. Its usefulness stern from the various uses it is put to its availability ease of conversion from other source of energy and above all, it's very clear nature since there is no by-product and residual, during and after usage. It is for this standing qualities that people look on to electricity as a sort of necessities in their lives depending so much on it continued availability as it place such a prominent role in the normal function of the household. Electrical unit and in many other industrial processes where this dependence cannot just be compromise so, having being natured to depend so much on electricity, it is desired not to have any interruption in it supply.[4] has intensively investigated other method of power generation including a charged particle collector patented in 1901.

Chatterji and Shimi [5] has perceived that as wind, solar and other clean and green energy sources gain popularity worldwide, engineers are seeking ways to make renewable energy systems more affordable and to integrate them with existing ac power grids. His findings examined integrating the PV arrays to the smart nano grid using an artificial intelligent (AI) based solar powered cascade multilevel inverter. The AI based controller switching scheme has been used for improving the power quality by reducing the Total Harmonic Distortion (THD) of the multi-level inverter output voltage.

Suryakumari and Kantarao [6] examined the Optimal Power Flow (OPF) problem in electrical power system which is considered as a static, non-linear, multi-objective or a single objective optimization problem. The study presents analgorithm for solving the voltage stability objective reactive power dispatch problem in a power system. The proposed approach employs cat swarm optimization algorithm for optimal settings of RPD control variables. Generator terminal voltages, reactive power generation of the capacitor banks and tap changing transformer setting are taken as the optimization variables. CSO algorithm is tested on standard IEEE 30 bus system and the results are compared with other methods to prove the effectiveness of the new algorithm. As a result, the proposed method is the best for solving optimal reactive power dispatch problem.

Grant [7] has described a power inverter or an inverter as an electrical power converter that changes direct current (D.C) to alternating current (A.C). While [8] as termedfuelless power generator as fuelless generation is a device that is understood to function without the need for internal combustion engine which usually request for fuel as a source of input. Even so, the concept of a mass produced fuelless engine has remained an interesting preposition to engineers today.

1.1 Source of Power for Both Fuelless Generator and Power Inverter

Jordan [9] has stated two major sources for power inverter which is;

i. Battery Power Inverters: - This converts battery voltage into conventional house hold AC voltage allowing the user to use electronics devices when AC power is not available.

ii. Solar Power Inverter: - This are used primarily to change direct current via an electrical switching process. Solar panel inverter is electronically synthesis alternators.

In order way, [10] has find out from his research that direct current via 12V/24V battery is the only source of power for fuelless generator for now. The findings shows that the direct current (D.C) motor needs torque for rotation which will set the alternator in to a rotary motion that will later convert direct current into alternate current.

The focus of this paper is to analyze the output of both fuelless power generating set and power inverter in terms of their load capacity, so as to make recommendation of the preferred device to masses for use, especially the rural farmers.

1.2 Transformer

The transformer is based on two principles; firstly, that an electric current can produce a magnetic field (electromagnetic) and secondly, that a changing magnetic field within a coil of wire induces a voltage across the ends of the coil (electromagnetic induction). Changing the current in the primary coil changes the magnitude of the applied magnetic field. The changing magnetic flux extends to the secondary coil where a voltage is induced across its ends [11].

The ideal transformer induces secondary voltage Es = Vs as a proportion of the primary voltage Vp = Ep and respective winding turns as given by the equation.

$$\frac{Vp}{Vs} = \frac{Ep}{Es} = \frac{Np}{Ns} = a \qquad (1)$$

Where $\frac{Vp}{Vs} = \frac{Ep}{ES}$ = a is the voltage ratio and

$\frac{Np}{Ns} =$ a is the winding turns ratio, the value of these ratios being respectively higher and unity for step down and step – up transformer.

Vp – designates sources impressed voltage
Vs– designates output voltage
Ep and Es – designates respective e.m.f induced voltage.

Any load impedance Zl connected to the ideal transformer's secondary winding causes current to flow without losses from primary to secondary circuits, the resulting input and output apparent power therefore being equal as given by the equation.

$$Ip \times Vp = Is \times Vs \qquad (2)$$

Combining the two equations yield the following ideal transformer identity.

$$\frac{Vs}{Vp} = \frac{Is}{Ip} = \frac{NP}{Ns} = \text{a} \qquad (3)$$

The load impedance Zl is defined in terms of secondary circuit voltage and current as follows:

$$Z1 \quad = \frac{V1}{I1} = \frac{Vs}{Is} \qquad (4)$$

The apparent impedance zl of this secondary circuit load referred to the primary winding circuit is governed by a squared turns ratio multiplication.

Factor relationship derived as follows:

$$\text{Zl} = \frac{VP}{IP} = a^2 \frac{Vs}{Is} = a^2 \frac{Vs}{Is} = a^2 \times ZI \qquad (5)$$

2. MATERIALS AND METHODS

This research paper was focus on performance evaluation of the power inverter and fuelless power generator design and constructed at the workshop of Federal College of Agriculture Moor Plantation Ibadan Oyo State Nigeria. The one of the main tools and materials used for this experimental research includes load bank, 100 and 200 Watt bulb, extension socket, multi-meter, fuelless power generator, power inverter, stop watch and excel package.

Fig. 1. Load tool box

The power inverter was constructed according to the rules and regulation of Institute of Electrical Electronic Engineering [12] Materials used for construction and evaluation of a inverter were carefully sorted for locally at Ifeleye in Ibadan, Nigeria. The inverter components are divided into various units namely,

(i) Transformer
(ii) Capacitor
(iii) Resistor
(iv) Diode
(v) 13amp socket (output)
(vi) 13amp plug
(vii) Relay
(viii) Alternator
(ix) Fuse holder
(x) Multivibrator
(xi) Inverter case and ducted board

Adewumi [10] has stated that the fuelless power generating set consists of five major units, which includes the following;

1. The power supply Unit
2. Conversion Unit
3. Control Unit
4. Output Unit
5. Charging Unit

The materials for construction includes the d.c motor, alternator, frame for rigidity, transformer, diode, charging panel and 12V battery. Direct coupling method was adopted during the construction of the fuelless power generating set.

Fig. 2. Fuelless power generating set

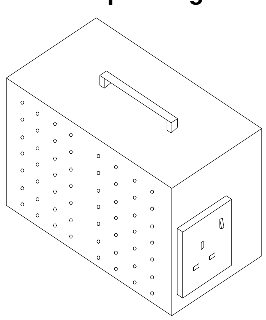

Fig. 3. Power inverter

The load bank was connected to the fuelless generator and power inverter in order to power the light bulbs on the bank, which was connected to the extension wire. Stop watch was used to record the time at interval of 60 seconds for five different runs. While the multi-meter was used to read the voltage output in Volts with Current in Ampere and the mean voltage with current result was computed.

3. RESULTS AND DISCUSSION

3.1 Performance Evaluation of 1000W (1KVA) Fuelless Generator

Output efficiency was computed using the data obtained after testing, according to Institute of Electrical and Electronics Engineers [12] reported by [3] as shown in the tables below. Load capacity used for this research work ranges from 0 watt to 1000 watts; that is from 0% to 100% loading. The speed of the motor used was 9000 rpm while that of the alternator was 6000 rpm. This simply means that there is direct coupling of the motor and the alternator since the speed is in ratio 1.5: 1. The power factor was kept constant (Φ = 0.85), since the standard range from IEEE is between 1 – 0.7 and local load bank was used in testing the machine which consist of light bulbs. Each test was replicated five times. The Institute of Electrical and Electronics Engineers [12] cited by [3] was used as basis for comparison for a fuel-less power generator and Inverter System.

The Table 1 shows the result obtained from the evaluation of the power fuel-less generating set. The Table simply reveals the relationship between voltage and current at both input and output levels. The efficiency of the generator decreases with increase in the input load of the generating set. Therefore to operate the fuel-less power generating set more efficiently, the maximum loading of the machine must be below 600 watts. From the result obtained, it can be deduced that when there is no loading on the machine, the efficiency will be 0% as there is an input voltage with zero output voltage. This result has clearly confirmed that the highest efficiency recorded is at 89.1%, at a load of 100W. It was also observed that there is a decrease in the output of the machine when the load increases.

3.2 Performance Evaluation of 1000W (1KVA) Power Inverter

Usually both power inverter system and fuel-less power generator makes use of battery (12/24V) as their input source (Input voltage) which simply

Table 1. Output efficiency for fuelless power generator

Trials	Load (W)	Input voltage (V)	Output voltage (V)	Input current (A)	Output current (A)	Input power (W)	Output power (W)	Efficiency (%)
1	0	12.662	225	0	0	0	0	0
2	100	12.6	218	7.34	0.378	92.48	82.41	89.096
3	200	12.65	200.8	7.794	0.42	98.59	84.3	85.524
4	300	12.804	188	7.07	0.396	90.514	74.238	81.996
5	400	12.748	153.6	8.16	0.484	104.026	74.308	71.51
6	500	12.716	144.6	7.8	0.436	99.184	62.936	63.406
7	600	12.474	131	6.748	0.362	84.176	47.496	56.432
8	700	12.6	92.948	5.282	0.296	66.558	27.454	41.196
9	800	12.376	42.92	4.552	0.238	56.368	10.194	18.222
10	900	12.344	27.264	3.532	0.212	43.67	5.766	13.384
11	1000	11.68	28.24	2.3	0.13	26.922	3.638	13.578

Source: Own Research

means that both of the devices convert direct current to alternating current.

Table 2 showed the result for performance of 1KVA power inverter system. The result revealed the relationship between voltage and current at both input and output level of the machine. The input power is usually higher than the output power of the device as shown in chart below (Fig. 1). The principle of the higher the load, the lower the voltage output which was also confirmed by [3] was also showed in Fig. 4. The efficiency of the inverter decreases with increase in the input load of the generating set. Therefore to operate the inverter more efficiently, the maximum loading of the machine must be below 800 watts.

From the result obtained, it can be deduced that the highest efficiency recorded is at 96.3% which is more higher than that of the fuelless power generating set which is at 89.1%, at a load of 100W respectively. It was also observed that there is a decrease in the output of the generator when the load increases.

3.3 Comparison of Fuelless Power Generating Set and Power Inverter System

The comparison between the constructed fuel-less power generating set and power inverter system are shown in Fig. 5.

It can be clearly showed from the result of the performance evaluation of both fuel-less power generating set and power inverter system that in terms of performance efficiency, the power inverter system is still much better than the constructed fuel-less generator based on some certain conditions that the alternator and d c motor used for the construction were not specially made for the machine and mechanical loose in fuel-less power generating set is more than that of power inverter. Table 1 reported that the highest efficiency of fuel-less power generating set was 89.1% at 100W and Table 2 reported that the peak efficiency for power inverter was 96.3% at same load of 100W respectively.

Table 2. Evaluation of power inverter

Trials	Load (W)	Input voltage (V)	Output voltage (V)	Input current (A)	Output current (A)	Input power (W)	Output power (W)	Efficiency (%)
1		12.634	241.8	0	0	0	0	0
2	100	12.624	229.08	8.406	0.446	106.118	102.176	96.3
3	200	12.632	236.28	7.42	0.344	93.734	82.224	87.6
4	300	12.636	231.86	7.44	0.344	94.01	79.754	84.6
5	400	12.316	221.2	6.74	0.306	83.012	67.692	81.5
6	500	12.296	217.8	6.38	0.282	78.456	61.432	78.4
7	600	12.308	218.6	5.9	0.244	72.62	53.356	73.5
8	700	12.16	204	4.98	0.214	60.562	43.68	72.1
9	800	11.22	179.8	3.6	0.126	40.41	22.662	56.0
10	900	10.66	164.8	2.42	0.064	25.876	10.784	39.6
11	1000	10.3	146.8	1.9	0.032	19.606	4.772	23.4

Source: Own Research

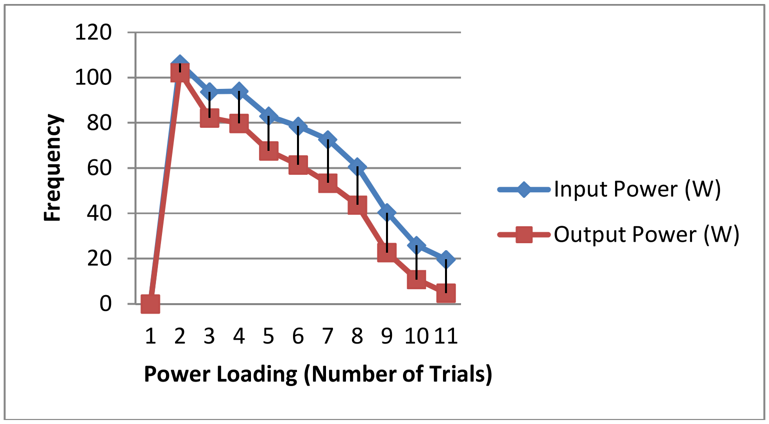

Fig. 4. Input and output power

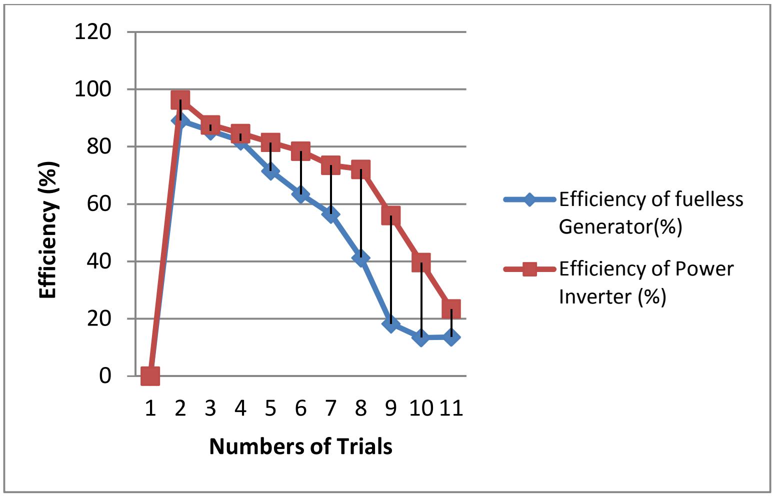

Fig. 5. Efficeicncy of fuel-less generator and inverter system

4. CONCLUSION

Based on the above analysis, it has been clearly stated that in terms of load and power efficiency, power inverter has capacity of performing better than fuelless generating set. Since fuelless power generating set shows an appreciable voltage at load of 500W, I will recommend that the maximum voltage rate for the power output of fuelless generating set be set at 500W for 1000W capacity.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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