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FUELLESS GENERATOR: COMPARISON OF TWO PROTOTYPE DESIGN

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ABSTRACT*: This research effort focus on comparison of two prototype designs, construction and performance evaluation of V-belt and direct coupling fuelless power generating set. Search for renewable energy is important as the fossil fuel depletion as been noticed. There are basically three ways of transmitting mechanical power from one point to another. Belt and pulley drive, Gear and chain and direct coupling. The two power generating sets were locally constructed at the Federal College of Agriculture, Ibadan Nigeria. These researches technically investigate two out of the three ways of mechanical power transmission system (Belt & Pulley and Direct Coupling Design). The evaluation of the work shows that coupling design of power fuelless generating is better than Belt and Pulley design of the generating set with efficiency range of 0% -89.9% for direct coupling while 0% - 73.23% for V-belt design.*

KEYWORDS: Fuelless Generator, Prototype , Design

INTRODUCTION

Abdullah et al (2012) has observed that at present, the importance of alternative energy source has become even more crucial matter not only due to the continuous depletion of limited fossil fuel stock but also for the safe, better and greener environment. Adewumi (2014) has noticed that power generation, transmission and distribution has been an indispensable factor in the progress of an economy, ranging from manufacturing, banking, media, health care, aviation, etc. It has however been proved that power skyrocket the productivity of a country. Environmental pollution which leads to degradation or depletion of ozone layer is one of the major problems caused by the use of generator with fossil fuels (Ajav, 2012). Other problem includes land and water pollution, noise pollution, increase in price of fossil fuel year in year out, among others.
Recently, increase in energy demand and limited energy sources in the world caused the researchers to make effort to provide new and renewable energy sources for the usage in an economical and safe way. Besides being clean and of low running cost, renewable energy possesses the privilege of abundance and can be used wherever available (Hassan and Mohammed, 2011).

The self-excited induction generators (SEIG) have been found suitable for energy conversion for remote locations. Self-excited induction generators (SEIG) are frequently considered as the most economical solution for powering costumers isolated from the utility grid. SEIG has many advantages such as simple construction, absence of DC power supply for excitation, reduced maintenance cost, good over speed capability, and self short-circuit protection capability.

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The fuelless 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), carbon-dioxide (CO_2), etc. The speed are adjustable or can be built to run at one speed with engine which does not run on any type of gasoline, oil or other combustible fuel. The free electrical energy produced by the fuel-less generators is replaced back into the motor and reused by the motor (Maini, 1998).

Ajav and Adewumi (2014) has described car battery as a secondary cell or lead accumulator. The active materials are spongy lead, *Pb* (-ve plate), lead oxide, PbO_2 for the positive plate and sulphuric acid. When the cell is giving current hydrogen irons thrift to the positive plate and SO_4^{2-}irons to the negative. In the process they attack the plates, and reduce the active materials of each to lead sulphate. Atere (2009) has cited in Adewumi (2014) stated that the negative plate reaction is:

$$Pb + SO4^{2-} - electron \rightarrow PbSO4 \quad (1)$$

The chemical reaction at the positive plate is generally given as:

(i) $PbO_2 + 2H^+ + 2electron \rightarrow PbO + H_2$

(ii) $PbO + H_2SO4 + H_2O$

So altogether; we ha $PbO_2 + H_2SO_4 + 2H^+ + 2electrons \rightarrow PbSO_4 + 2H_2O$ (2)

However, H_2SO_4 molecules do not exist in solution – they are dissociated into $2H^+$ and SO_4 irons. We may therefore write equation 2 as:

$$PbO_2 + SO_4^{2-} + 4H^+ + 2electrons \rightarrow PbSO4 + 2H_2O \quad (3)$$

In this discharging reaction water (H_2O) is former and sulphuric acid consumed; the concentration of the acid, and therefore, its density, fall. A battery consists of a container, calls, and electrolytes, positive poles. Usually, the cell has tow unlike plates or poles, with chemicals between them. One pole, called the positive (+ve) pole, so that current flows when they are joined by a wire.

Coupling

Diabana (2009) has observed that power can be transferred from the motor to rotate the alternator and this can be done majorly with three methods, namely;

i. Belt and pulley drive
ii. Gear and chain
iii. Direct coupling

The three aforementioned methods was designed to transfer power from the D.C motor to either reduce or increase the speed to the required speed, the most appropriate method of transmission of power is to use direct coupling (Diabana, 2009). This method was considered due to the fact that the generator has to run continuously for minimum of 8 hours. Thereby reducing loss of power when compared with other methods. A round bar was machined at both sides to different diameter and drilled to accommodate the diameter of the shaft of the D.C motor and the shaft of the alternator. The side of the shaft is drilled to 43mm and other sides with 32mm. Slot are cut on both sides with key to hold the shaft in alignment when in motion.

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Shaft in Series

Khurmi and Gupta, 2005 has ascertained that "when two shafts of different diameter are connected together to form one shaft, it is then known as composite shaft. Since the driving torque is applied at one end and the resisting torque at the other end, then the shaft are said to be connected in series. In this case, each shaft transmit the same torque and the total angle of twist is equal to the sum of the angle of twist of the two shaft.

Torsional Shear Stress

Adewumi (2014) has established that the fuelless generating set machine member (D.C Motor and alternator) are subjected to the action of two equal and opposite couples acting in parallel planes or torque or twisting moment, which can be referred to as torsion. The stress that set up by torsion is known as Torsional Shear Stress, which is zero at the centroidal axis and maximum at the outer surface. To calculate the Torque transmitted by the shaft (N.m)

P = 2 x 3.142 x N x T (9) 60

where, P = Power transmitted by the shaft (Watts) = 1000W

N = Number of revolution (r.p.m) = 9000 rpm

T = Torque (N.m) = ?

P = 2 x 3.142 x N x T

By substituting the values; 60

1000W = 2 x 3.142 x 9000rpm x T 60

T = 60000 56556 T = 1.06N.m This simply means that the torque required to rotate the shafts coupled together is 1.06N.m

Self Charging Circuit

The Transformer (Self Charging Circuit) A transformer is a device (electrical machine) which is used to change the value of an alternating voltage (or convert on a.c. at a low voltage into one at a high voltage or vice versa). If a transformer is used to convert an a.c at a low voltage into one at a high voltage, it is called a ***step-up transformer*** and if on the other way round, ***a step-down transformer*** (Chew, 2010).

For this research work a step down transformer was used to reduce the 220 Volts from the alternator to 12 Volts for re-charging the battery. Transformer varies in size from miniature unto used in electronics to huge power transformers used in power stations. Atere, (2009) has observed that a transformer will only work when an alternating voltage is connected. It will not normally work from a D.C. supply such as a battery. An alternating voltage applied to the primary winding produces an alternating current, which sets up an alternation magnetic flux throughout the loop. This magnetic flux induces an *e.m.f.* in the secondary winding, as desivited by Faradays' law,which says that "*when a conductor is cut by a transformer magnetic field, an e.m.f. is induced in that conductor*". Since both windings are linked by the same magnetic flux, the induced *e.m.f.* per turn will be the same for both winding. Therefore, the *e.m.f.* in both windings is proportional to the number of turns.

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MATERIALS AND METHOD

The materials for constructing the fuelless generators (V-belt and Direct Coupling design) were locally source at Ogunpa Market area in Ibadan Oyo State Metropolis, Nigeria. The machine was fabricated at the Federal College of Agriculture, Moor Plantation Ibadan Nigeria workshop.

Ajav and Adewumi (2014) has observed in their research that 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 therefore includes the 12V direct current battery, alternator, direct current motor, transformer, self-induced charging panel and frame for rigidity and stability.

Design Procedure

In the design of the fuel-less generating set, the following procedural steps are used to achieve the aims and objectives of the research work.

STEPS	COUPLING PROTOTYPE	V-BELT PROTOTYPE
1	Fabricating a crankshaft and boring a reasonable hole that will conveniently fit in to the DC motor with thread hole for bolting the motor to the crankshaft.	Shaft was fabricated to the DC motor in linear direction to the alternator.
2	Fitting the fabricated crankshaft in to the DC motor	Pulley of 3inches was fixed on the crankshaft of the alternator. It was fastened with the use of a metallic key having a specified length and diameter suitable for the key space on the alternator.
3	Inserting the DC motor with crankshaft into the crank casing of the alternator.	A pulley of 9inches diameter was also fixed on the crankshaft of the D.C motor.
4	Fitting the armature of the alternator into the casing.	For the purpose of torque transmission from the D.C motor to the alternator, a V-belt of 38mm was introduced.
5	Dropping the stator core of the alternator into the armature	Constructing a frame for the generator to provide support and rigidity.
6	Inserting a long bolt through the bearing end of the stator and tighten firmly to connect the motor and the alternator together.	The capacitor was connected to the yellow cables.
7	Replacing the cover of the alternator and fasten both the cover and the crankcase together.	Connecting the terminals of the DC motor to the equivalent terminals of the battery.
8	Constructing a frame for the generator to provide support and rigidity	
9	Connecting the diode to green cables and capacitor to the yellow ones.	
10	Connecting the terminals of the DC motor to equivalent terminals of the battery	
11	connecting the red cables to the mains as output	

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RESULT AND DISCUSSION

Machine Evaluation

The evaluation of the machine will be calculated using the formula below as stated by Akintunde et al (2003); Efficiency $= \frac{\text{output power}}{inputpower} x\ 100$

Output Efficiency for fuelless Power Generator (Coupling Design Protoype)

Table 1 below shows the result of performance evaluation for the 1000W (1KVA) fuel-less power generating set. The load bank was connected to the fuel-less generator 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 in the Table 1 below. Output efficiency was computed using the data obtained after testing, according to Institute of Electrical and Electronics Engineers (IEEE, 1999) reported by Aremu (2009) as shown in the Table 1 above. Load capacity used for this research work ranges from 0 watt to 500 watts; that is from 0% to 500% loading. The speed of the motor used was 9000rpm while that of the alternator was 6000rpm. 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 ($\Phi = 0.85$), 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 (IEEE, 1999) cited by was used as basis for comparison for a fuel-less power generator and Inverter System.

Table 1: Performance Evaluation of Fuelless Power Generating Set (Coupling Design Prototype)

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	89.1
3	200	12.65	200.8	7.794	0.42	98.59	84.3	85.5
4	300	12.804	188	7.07	0.396	90.514	74.238	82.0
5	400	12.748	153.6	8.16	0.484	104.026	74.308	71.5
6	500	12.716	144.6	7.8	0.436	99.184	62.936	63.4

Output Efficiency for fuelless Power Generator (V-Belt Design Prototype)

The data in the table 2 below was derived from performance evaluation of 1KVA V-belt fuel-less generating set. The evaluation of the fuel-less generating set was done by loading it with varying loads that range from 0 watt to 500watts bulbs for a time of 300seconds for each load. The voltage of the generator was taken with the help of digital multi-meter.

From the result, it was observed that as the voltage reduces the current increase. This result support Ohm's law finding that states that the higher the voltage in the circuit, the higher the current.

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Table 2: Performance Evaluation of Fuelless Power Generating Set (V-Belt Prototype)

Trials	Load (W)	Input Voltage (V)	Output Voltage (V)	Input Current (A)	Output Current (A)	Input Power (W)	Output Power (W)	Efficiency (%)
1	0	12.76	183	0	0	0	0	0
2	100	12.66	174	5.34	0.28	67.64	48.30	71.42
3	200	12.79	161	5.79	0.34	74.05	54.35	73.23
4	300	12.75	145	8.34	0.48	106.34	69.21	65.05
5	400	12.66	124	8.78	0.55	119.09	69.10	62.34
6	500	12.70	103	9.34	0.65	118	67.6	56.92

Comparison of V-Belt and Coupling Design of Fuelless Generator

There are basically three ways of transmitting mechanical power from one point to another. Belt and pulley drive , Gear and chain and Direct coupling as noticed by Diabian (2009).

This research technically investigate two out of the three ways of power transmission (Belt & Pulley and Direct Coupling Design). The evaluation of the work shows that coupling design of power fuelless generating is better than Belt and Pulley design of the generating set with efficiency range of 0% -89.9% for direct coupling while 0% -73.23% for V-belt design.

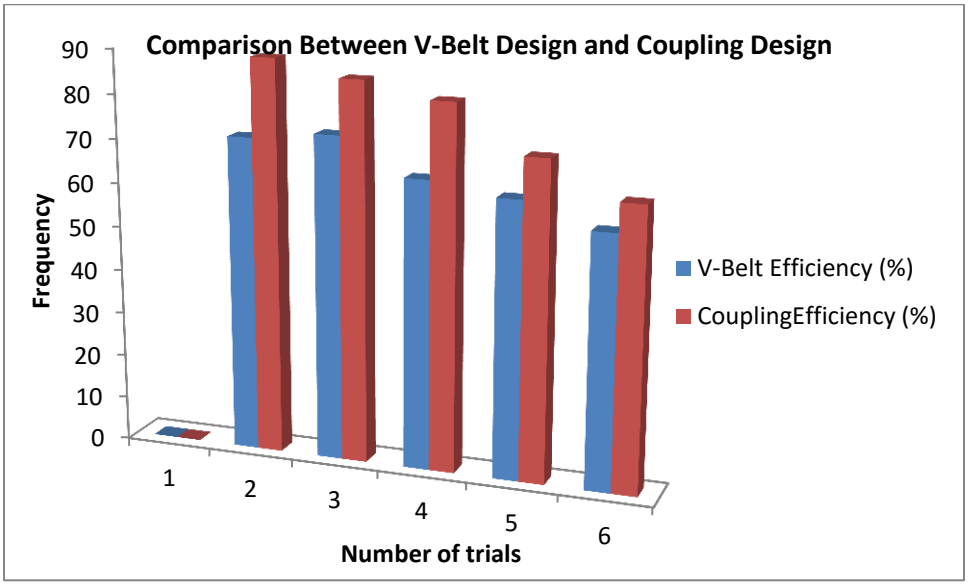

Figure 1: Comparison of V-Belt and Direct Coupling Design

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CONCLUSIONS AND RECOMMENDATIONS

The following conclusions were drawn from the comparison of V-belt and Direct Coupling design, construction and performance evaluation of 1000W (1KVA) fuelless power generating set;

i. It can be deduced that the machine (fuelless power generating set) Coupling prototype had the peak efficiency of 89.1% at a load of 100W while 73.23% at load of 200W for V-belt and pulley design.
ii. The research has shown clearly that for both designs there is a decrease in the output of the machine when there is a high increase in the load.
iii. After proper statistical analysis, the machine is said to have an average efficiency of 56.4% for V-belt while 62.5% for direct coupling design.

Recommendations

Based on the design, construction and performance evaluation test conducted on both fuelless power generating set design (V-Belt and Direct Coupling), the following recommendations were made for further study;

(i) In order to obtain a good performance characteristic, a voltage well above 12V battery voltage should be used to power the power generator.
(ii) Design of special d c motor, alternator and transformer for the purpose of construction of fuelless power generating set has to be encouraged by engineers in society in order to has clean and renewable energy especially for agricultural production.
(iii) The appliance can be adopted and made available for use in agricultural establishments.

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