DESIGN, CONSTRUCTION AND PERFORMANCE EVALUATION OF A NON – FUEL HYBRID GENERATOR; AN APPROACH TO BOOSTING RENEWABLE ENERGY

by

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ABSTRACT

In this work, we examined the design, construction and performance operation of a non – fuel hybrid generator as an approach to boosting renewable energy. In this system, 7.5kVA alternator was driven by 2kVA AC motor connected to an A.C. mains using the principle of electromagnetic induction. The induced electrical energy in the motor was converted to mechanical energy used to set the 10kg flywheel and alternator in motion. Results of the performance evaluation showed that our non - fuel hybrid generating set had the highest efficiency of 94.77 % at a load of 100W and the lowest efficiency of 13.2% at a load of 7000W. This implied that the higher the load applied, the lower the performance efficiency of the device. Since the non - fuel hybrid power generator shows an appreciable efficiency at load of 4000W, it is suggested that the maximum load that can be powered by this device be set at 4000W for 7500W capacity. Our generating set is not all that efficient but can add to environmental friendly source for sustainable development.

Keywords: Non-fuel Hybrid Generator, Flywheel, Power and Efficiency.

1.1 INTRODUCTION

The problem of fossil fuel is of great environmental concern in the areas of pollution which has significantly led to depletion of ozone layer depletion and climate change, (Ajav, 2000). Hence, the need for environmental friendly energy sources. Non – fuel generator has been in existence but made use of battery power to start DC motor, and therefore requires charging. In this study, we designed fabricated and carried out performance evaluation of a non-fuel hybrid generator system using an alternator, AC motor and fly wheel assembly which require no charging. Fly wheel can be seen as an approach to energy storage, (Joseph B., et-al., 2002). In some fly wheel energy storage systems, electricity is used to accelerate and decelerate the flywheel, (Torotrak, 2011). It involves converting and storing of electrical energy, (Amiryar et-al., 2017). Energy storage can be chemical, thermal, mechanical or magnetic, (Medina P. et-al. 2014; Chen H., 2009).

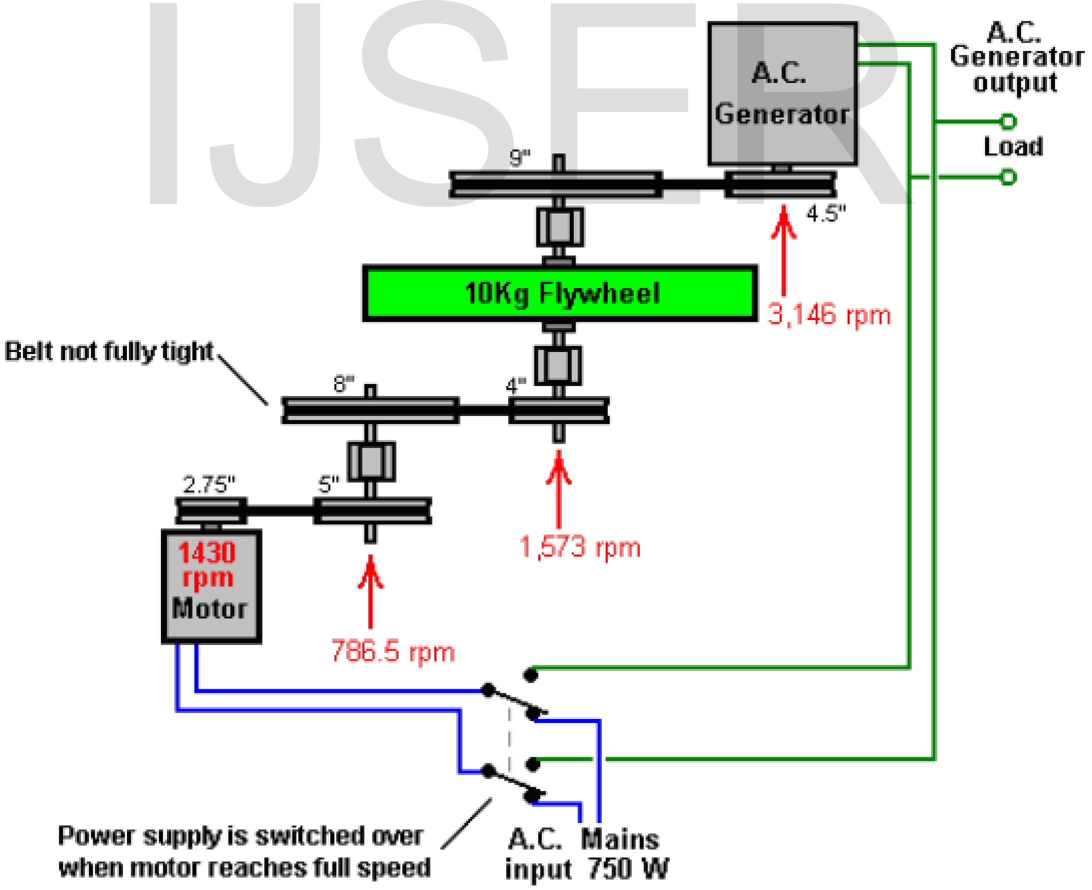

Figure 1.1: Mechanism of operation

In this system, we used A.C source to start the AC motor. The AC motor was used to drive a series of pulley and belt arrangement, which formed a gear train arrangement that doubled the speed at the shaft of alternator. The inertia of flywheel was increased by increasing the radius and weight of the flywheel. The AC motor was at low speed, low voltage input motor, the generator was high speed, and high voltage output alternator. When we connected the motor to A.C source, it caused a rotation on the flywheel. When the motor reached the highest speed (constant speed), we switched the power by applying the electrical energy generated by the alternator. Since the design used a 2 kVA AC motor and 7.5 kVA AC alternator, when the AC motor was switched to the alternator's output, 2 kVA was deducted from alternator's output and 5.5 kVA remained as the non – fuel hybrid generator's output which was ready to power loads.

1.2 Performance test

The load bank was connected to the non-fuel hybrid fuel 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 and tabulated. Output efficiency was computed using the data obtained after testing, in accordance with the standards of Institute of Electrical and Electronics Engineers (IEEE, 1997; Eyer *et al*, 2004). Load capacity used for this research work ranged from 0 watt to7000 watts; that is from 0% to 100% loading. The speed of the motor used was 1500rpm while that of the alternator was 1440rpm. This simply means that the speed of the motor and alternator is in ratio 1:1. The power factor was kept constant (Φ = 0.85), the standard by IEEE. Local load bank was used in testing the machine which consisted of light bulbs, drilling machine, and milling machine. Each test was replicated five times.

Fig 1.2: Load tool box

1.3 **Data collection**

During the experimental test, load of different watts were connected and the following parameters were measured. This includes: input current, input voltage, output current and voltage. Power input and output were calculated using the formula;

$$P = IV \qquad 1.1$$

Efficiency of the system when loads of different watts were connected was calculated and properly tabulated using

$$Eff. = \frac{Power\ output}{Power\ input} \times 100\% \qquad 1.2$$

1.4 RESULTS AND DISCUSSIONS

1.4a. Input characteristics analysis

The input characteristics; input current and input voltage generated by AC motor were measured with a digital multi meter and tabulated in Table 1.1.

Table 1.1: Input characteristics of non – fuel hybrid generator

Time (S)	Load (W)	Input Voltage (V)	Output Voltage (V)	Input Current (A)	Output Current (A)	Input Power (W)	Output Power (W)	Efficiency (%)
60	0	12.69	0	7.46	0	0	0	0
120	0	12.66	0	7.44	0	0	0	0

180	0	12.63	0	7.41	0	0	0	0
240	0	12.61	0	7.39	0	0	0	0
300	0	12.59	0	7.38	0	0	0	0
360	0	12.57	0	7.35	0	0	0	0

1.4b. Discussion of the result

It was observed from the table that as the voltage increased, the current also increases. The maximum input voltage recorded was 12.69V, and that of input current of 7.46A were recorded. Also, the minimum input voltage of 12.57V and that of input current of 7.35A were as recorded.

1.4c. Results of the performance evaluation of non-fuel hybrid generator with loads of 100W.

Table 1.2: Output characteristics of non – fuel hybrid generator when a load of 100 W was connected

Time (S)	Load (W)	Input Voltage (V)	Output Voltage (V)	Input Current (A)	Output Current (A)	Input Power (W)	Output Power (W)	Efficiency (%)
60	100	12.65	220	7.25	0.37	91.71	81.40	88.76
120	100	12.66	215	7.32	0.34	92.67	73.10	78.88
180	100	12.62	210	7.27	0.42	91.74	88.20	96.13
240	100	12.57	220	7.45	0.40	93.65	88.00	93.97
300	100	12.55	225	7.46	0.41	93.62	92.25	98.53
360	100	12.63	218	7.35	0.38	92.83	82.84	89.24

Table 1.2 is the result obtained during a performance test of non – fuel hybrid generating set when a load of 100W was connected. The alternator's output current and voltage were measured, while the output power and efficiency of the generator were calculated.

1.4d Power variation with number of trials for 100 W loads

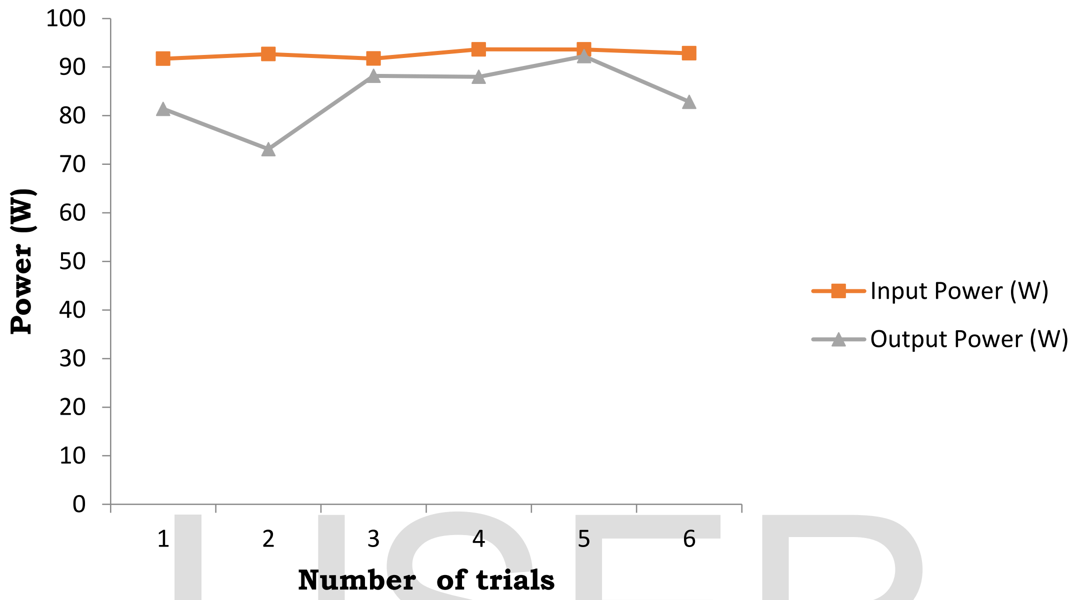

Fig 1.3 Variation of input and output power

Fig 1.3 shows the variation of input power with the corresponding output power when a load of 100 W was connected. The highest power input observed from this figure is 93.65 W, while the maximum output power recorded was 92.25 W. Also, the lowest input and output power recorded were 91.71 W and 73.10W, respectively. This implies that the input power is higher than the output power when a load of 100 W was connected to this non – fuel hybrid generating set.

1.4e: Efficiency variation with number of trials for 100W loads

In figure 1.4, the highest efficiency obtained was 98.53% at the fifth trial, while the lowest efficiency obtained was 78.88% at second trial. This implies that, connecting a smaller load to this generating set allows it to perform optimally.

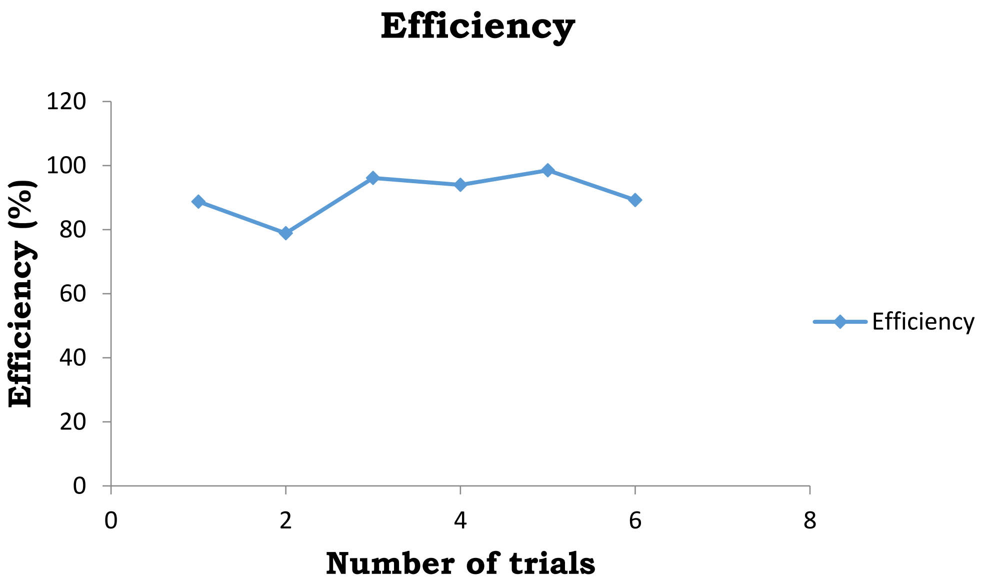

Fig 1.4: Variation of efficiency with number of trials for 100 W loads

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200 W loads was connected and measurement of output parameters were carried out and recorded as shown in table 1.3. It is clear on table 1.4 that there is a relationship between power input and power output of the machine. The input power was higher than the output power of the device which was also observed in Figure 1.5. The highest and lowest input powers were 100.25 W and 94.30 W while the highest and lowest output power were 89.55 W and 76.83 W respectively.

Table 1.3: Output characteristics of non – fuel generator when a load of 200 W was connected

Time (Sec)	Load (W)	Input Voltage (V)	Output Voltage (V)	Input Current (A)	Output Current (A)	Input Power (W)	Output Power (W)	Efficiency (%)
60	200	12.69	199.00	7.90	0.45	100.25	89.55	89.33
120	200	12.43	197.00	7.89	0.39	98.07	76.83	78.34
180	200	12.71	198.00	7.88	0.44	100.15	87.12	86.99
240	200	12.73	200.00	7.90	0.42	100.57	84.00	83.53

300	200	12.71	210.00	7.42	0.40	94.31	84.00	89.07
360	200	12.65	200.80	7.79	0.42	98.57	84.34	85.56

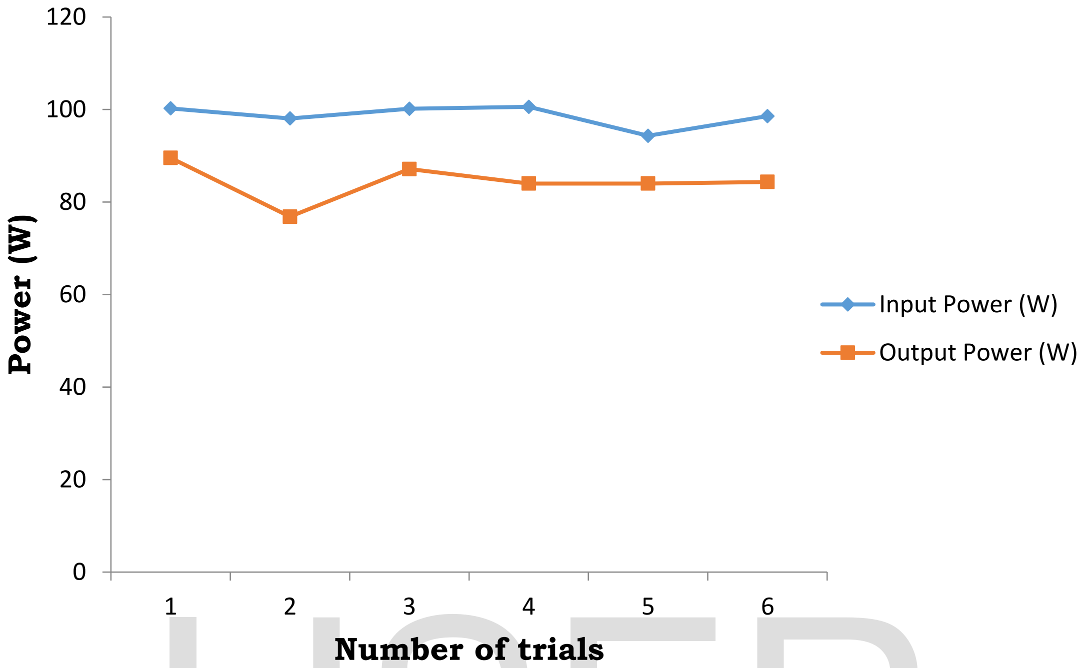

Fig. 1.5: Variation of input and output power

1.4g: Efficiency variation with number of trials for 200W

In Figure 1.6, the highest efficiency recorded was at 89.33% which was lower than the maximum efficiency of 89.33% recorded for 100W. It was also observed that there was decrease in the output of the generator when the load increased.

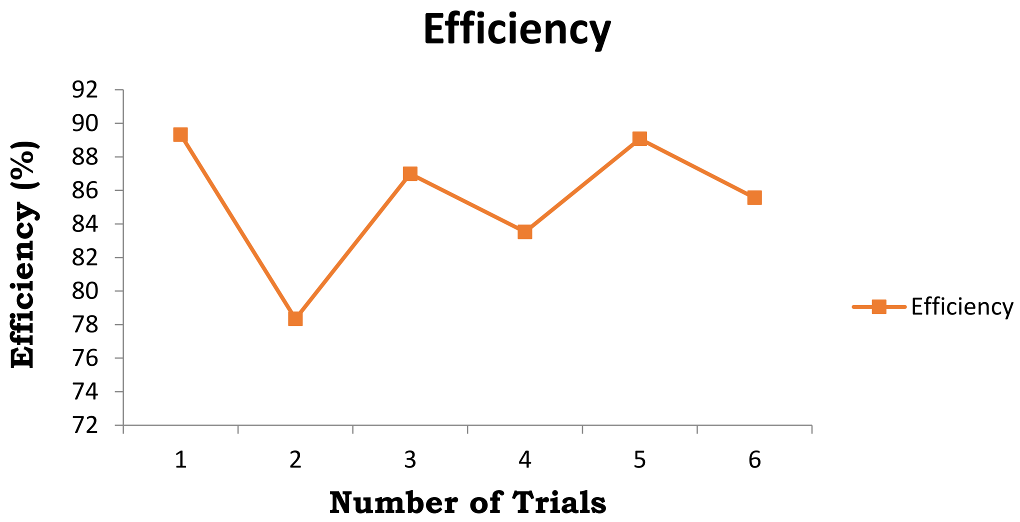

Fig. 1.6: Variation of efficiency with Number of trials for 200 W

1.4h: Performance evaluation of non-fuel hybrid generator with different capacities of loads 0W to 7000W.

Table 1.4 shows input and output voltages, currents and powers and their corresponding frequencies.

Table 1.4: Performance evaluation of non - fuel power generating set (V-Belt Prototype) when loads of 0 W to 7000 W were connected

Load (W)	Input Voltage (V)	Output Voltage (V)	Input Current (A)	Output Current (A)	Input Power (W)	Output Power (W)	Efficiency
0	12.66	225.00	0.00	0.00	0.00	0.00	0.00
100	12.61	218.00	7.34	0.37	92.55	82.40	89.03
200	12.65	200.80	7.79	0.42	98.55	84.33	85.56
300	12.80	188.00	6.89	0.39	88.21	74.44	84.38
400	12.79	183.00	5.79	0.34	74.05	62.22	84.01
500	12.74	180.00	8.16	0.48	104.02	87.12	83.75
600	12.66	178.00	5.01	0.28	63.42	49.84	78.57
700	12.75	173,00	8.34	0.48	106.33	83.04	78.09
800	12.71	165.00	7.28	0.43	92.57	71.94	77.71
900	12.66	158.00	8.91	0.55	112.80	86.9	77.03
1000	12.70	149.10	9.99	0.65	126.87	96.91	76.38

2000	12.53	140.00	7.03	0.33	88.08	46.20	52.44
3000	12.27	92.95	5.28	0.36	64.81	33.64	51.91
4000	12.01	42.93	4.55	0.29	54.66	12.70	23.24
5000	11.92	27.26	3.53	0.23	42.10	6.48	15.41
6000	11.50	27.01	2.31	0.13	26.56	3.51	13.21
7000	11.01	26.00	2.20	0.12	24.22	3.19	13.20

Figure 1.7 is a plot of input and output power variation with different loads of table 1.4. Hence, the input power was higher than the output power. This simply implies that input power is always higher than the output power of our non – fuel hybrid generator.

The maximum input and output power obtained were 112.80 W and 96.91 W respectively, while the lowest input and output power obtained were 26.52 W and 3.19 W. It was observed from figure 1.7 that at load of 0 W, no efficiency was recorded. At load 100 W, the highest efficiency of 89.03 % was recorded, while the lowest efficiency of 13.20% was recorded at load 7000 W. It was shown that the higher the load the lower the efficiency.

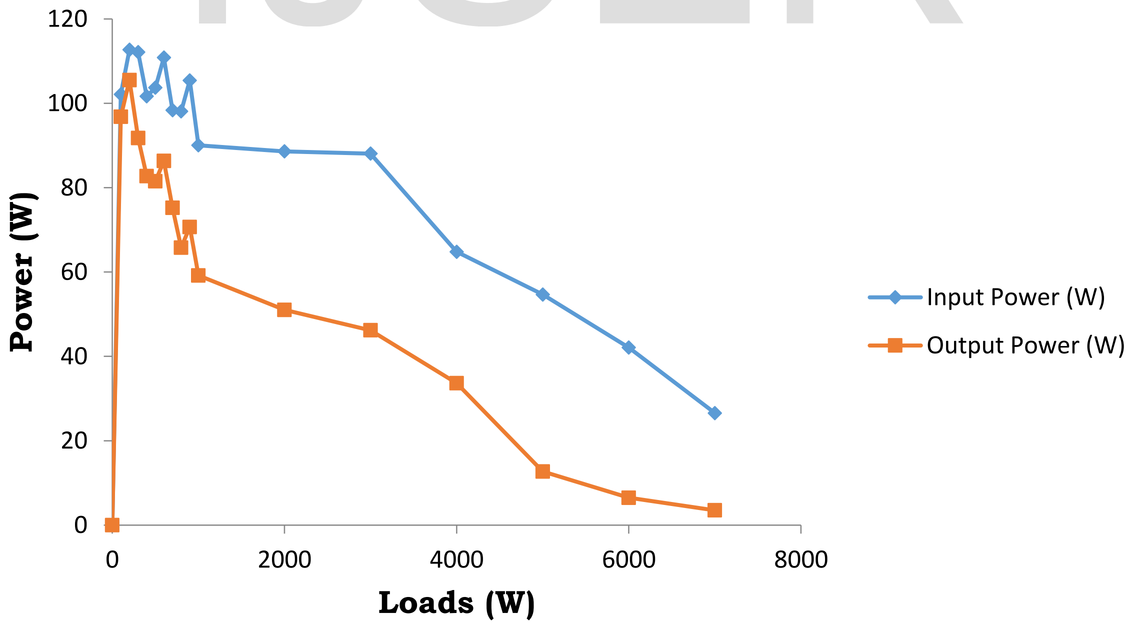

Fig. 1.7: Variation of input and output power for different loads (0W to 7000W)

Conclusion

In this work, we have studied the design, construction and performance evaluation of a non – fuel hybrid generator; an approach to boosting renewable energy The non-fuel hybrid generator has the peak efficiency of 94.77% at load 100 W and the lowest efficiency of 13.20% at load 7000 W. It also revealed that there was decrease in the efficiency of the generator when the load was increased. Since the non-fuel hybrid power generation set showed an appreciable efficiency at load 4000 W, it is concluded that the maximum load that can be powered by this device be set at 4000 W for 7500 W capacity. Our system is not all that efficient but can be used to supplement power supply.

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