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A Study of Pedal Power System for Energy Generation in Nnewi.

By

[1]Okoye Onyinye Vivian

[2]Okpala Uchechukwu Vincent

3Okeke Nwando Blessing

[4]Isaac-Onerime Olajumoke Susan

[1]Department of Physics and Astronomy, University of Nigeria, Nsukka, Enugu State, Nigeria.

[2]Department of Industrial Physics, Chukwuemeka Odumegwu Ojukwu University, Uli, Anambra State Nigeria.

[3,4]Department of Physics Education, Federal College of Education, Technical, Asaba, Delta State, Nigeria.

E-mail: ifarauc@yahoo.com, okoyeonyinyejude@gmail.com, blessndo@yahoo.com, jumokebabatunde@yahoomail.com

ABSTRACT

Here, we studied how we can put the energy wasted in exercising and achieving body fitness at gym centres in Nnewi into good use. A bicycle was used to transform human energy into mechanical energy through the pedals to the chain sprocket system and to electrical energy by the alternator.The electrical energy was converted to chemical energy in the battery for future use. DC power generated by the battery was converted to AC power by 1kVA power inverter, and it became available for the output load.The bicycle was pedalled at a speed of 220 RPM, average energy of 5999J was spent at 30 minutes interval for about 6 trials in one gym centre. This energy, 5999J was multiplied by five gym centres in Nnewi. It was found that a total of 29995J of energy which would have wasted in the process of gyming was used in generating electricity. The pedal powered generator had overall peak efficiency of 88.79 % at a load of 100 W and the lowest efficiency of 13.29 % at a load of 1000 W. This simply means that the higher the load applied, the lower the efficiency. The energy produced could be used to power low voltage devices like charging of mobile phones, laptops etc.

Keywords: *Pedal Power, Ennergy Generation, Nnewi and Efficiency.*

1.1: Introduction

Energy scarcity is a serious problem in recent times due to depletion of renewable energy sources, increasing population, environmental pollution and global warming [1].The use of fossil fuels and other non-renewable sources of energy must be reduced in order to keep Greenhouse gas emissions lowand alleviate the use of diminishing resources. The idea of human powered energy generation has been implemented inmany different situations. Some examples include hand-crank radios, shaking flashlights, and receiving powerfrom gym equipment [2].Exercising the body using bikes helps in improving metabolic functions, cardiovascular system, respiratory system and burning of considerable amount of calories, [3].Pedal power uses the most powerful muscles in the body: the quads, hamstrings, and calves, converting ninety-five percent of exertion into energy [4].Pedal power will serve very well in energy generation in remote places and villages where conventional power cannot be easily accessed. It will supply the power needed to charge battery-operatedgadgets like mobile phones, lamps, radio, communication devices, etc. This work produced portable power-generating unit, which serves as a power generator and cycle exerciser.

1.2: STUDY LOCATION

The study was carried out at Innoson Kiara Academy, Nnewi. The Academy is a Technical and Vocational Training Institute which is in affiliation with Innoson Vehicle Manufacturing Company Ltd. Nnewi is a city in Anambra, Nigeria. It is located at 6.02 latitude and 6.92 longitudes at an elevation of 151 meters above sea level.Nnewi has a population of 391,227 as at 2006 census. It spans over 1,076.9 square miles in Anambra state, [5]. Nnewi is the 2nd biggest city in Anambra, [6]. The first indigenous car manufacturing plant and first wholly made in Nigeria motorcycle were made in Nnnewi, [5,7]. Nnewi people are best known for their entrepreneurship and industrialization, and as such has high demand for electricity.

1.3:Experimental Design.

In this work, we connected an alternator to the rear bicycle hub usingbelt pulley system for proper transmission of motion. The alternator was to charge the battery. 75 AHr. Battery was used to store the electrical charges produced by the alternator.We used an indicator system to determine the rate at which the battery charged. Tachometer was used to measure the speed (RPM) of the pedal power generator system.I KVA power inverter was used to convert the direct current stored in the battery to alternating current in order power home electronic appliances.As the bicycle was pedalled, the chemical energy from the rider was converted into mechanical energy, and then into electrical energy by the car alternator. The car alternator connected to the rear bicycle hub using pulley – belt arrangement, produced electric current when the bicycle was pedaled at a reasonable speed. Block diagram of the pedal generator system is as shown on figure 1.1.

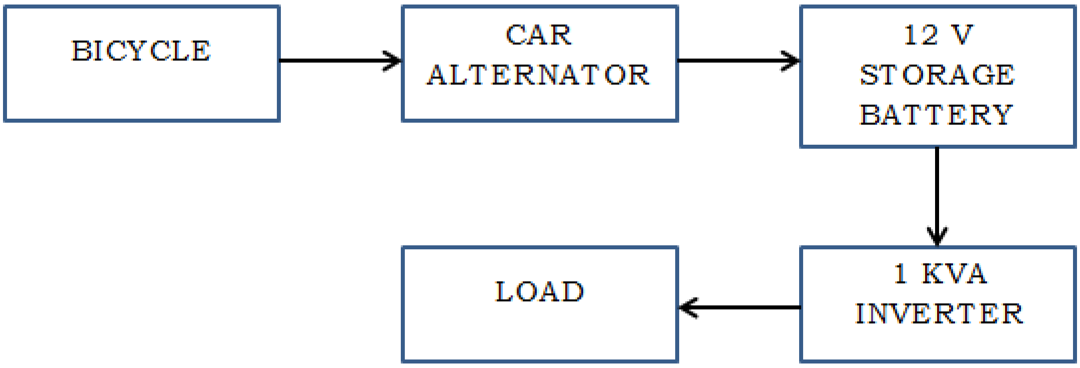

Fig. 1.1: Block Diagram of a 1 KVA Pedal Powered Generation System

In figure1.1, human energy was transformed into mechanical energy through the pedals to the chain sprocket system and to electrical energy by the alternator.The electrical energy is converted to chemical energy in the battery for future use. A DC power generated by the battery was then converted to AC power by a power inverter, and it became available for the output load.

1.4: Results and discussions

1.4a: VARIATION OF GENERATED CURRENT, VOLTAGE AND POWER WITH PEDALLING SPEED

We determined the relationship between speed of the alternator and voltage using a tachometer and multimeter respectively. For different speed, different voltage and current were recorded as shown on table 1.1.

Table 1.1: Variation of voltage, current and power with Speed

SPEED (RPM)	Generated Voltage (V)	Generated Current (Amp)	Generated Power (W)
220	1.50	0.90	1.35
286	2.00	0.93	1.86
523	5.00	1.92	9.60
563	5.30	1.99	10.55
621	5.50	2.40	13.20
652	6.00	2.52	15.12
666	6.20	2.59	16.06
680	6.40	2.98	19.07
705	6.80	3.70	25.16
728	7.30	5.20	37.96
729	7.42	6.30	46.75
741	7.50	6.71	50.33
770	7.62	6.94	52.88

783	7.80	7.20	56.16
808	9.10	7.81	71.07
811	9.40	9.32	87.61
839	9.80	9.50	93.10
890	9.90	9.82	97.22
894	10.20	10.71	109.24
979	10.40	11.20	116.48
991	10.70	11.94	127.76
1120	12.44	12.40	154.26
1190	12.90	12.48	160.99
1270	13.61	12.90	175.57
1285	13.62	13.20	179.78
1309	13.73	13.53	185.77
1311	13.81	13.70	189.20

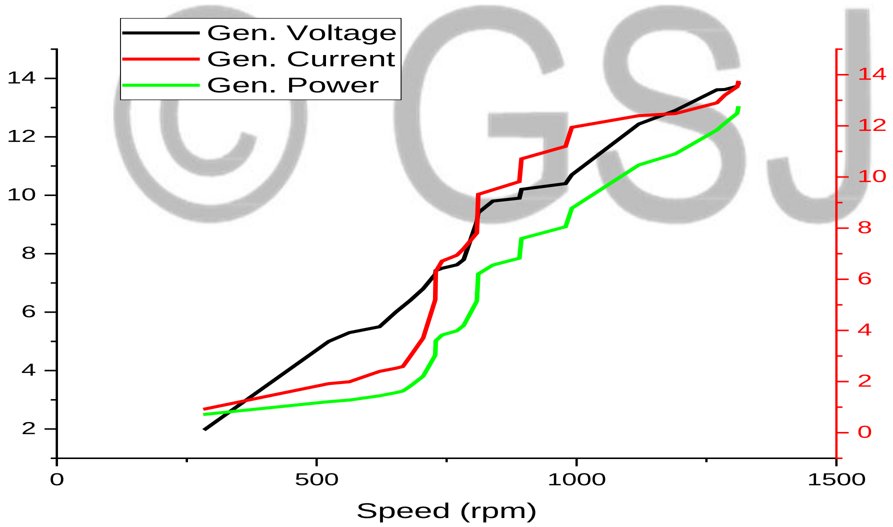

Fig 1.2: Variation of generated current (I), Voltage (V) and Power (P) with pedalling Speed

Fig.1.2 shows the variation of current, voltage and power with the pedalling speed. The pedalling speed increasedwith the generated current, voltage and power. The lowest speed of 220 rpm generated 0.90 A, 1.50 V and 1.35 W, while the highest speed of 1311 rpm attained generated 13.70 A, 13.81 V and 189.20 W.

1.4b: PERFORMANCE EVALUATION OF PEDAL POWERED GENERATOR

A power inverter of 1000 W was connected to convert the direct current stored in the inverter by the alternator to an alternating current. The output characteristics of the generator was recorded on table 1.2. Generated power was calculated using $P = IV$.

Table 1.2: Variation of Output Characteristics without Load

Generated Voltage (V)	Generated Current (Amp)	Generated Power (W)	Load (W)	Output Voltage (V)	Output Current (A)	Output Power (W)	Efficiency (%)
1.50	0.94	1.41	0	210	0	0	0
2.00	0.96	1.92	0	215	0	0	0
5.00	1.92	9.60	0	220	0	0	0
5.30	1.95	10.34	0	224	0	0	0
5.50	2.20	12.10	0	225	0	0	0
6.00	2.51	15.06	0	227	0	0	0
6.20	2.58	16.00	0	228	0	0	0
6.40	2.99	19.14	0	226	0	0	0
6.80	3.72	25.30	0	230	0	0	0
7.30	5.10	37.23	0	220	0	0	0
7.40	6.20	45.88	0	222	0	0	0
7.50	6.41	48.06	0	230	0	0	0
7.70	6.94	53.44	0	228	0	0	0
7.80	7.09	55.30	0	225	0	0	0
9.10	7.80	70.98	0	220	0	0	0
8.70	8.12	70.64	0	230	0	0	0
9.40	8.90	83.66	0	230	0	0	0
9.90	9.08	89.89	0	226	0	0	0
10.20	9.45	96.39	0	229	0	0	0
10.40	9.60	99.84	0	225	0	0	0
11.80	10.94	129.09	0	220	0	0	0
12.90	11.40	147.06	0	230	0	0	0
12.44	11.48	142.81	0	225	0	0	0
13.22	11.90	157.32	0	228	0	0	0
13.41	12.20	163.60	0	230	0	0	0
13.50	12.50	168.75	0	225	0	0	0
13.59	12.88	175.04	0	230	0	0	0

In table 1.2, it was observed that when there was no load connected to the inverter, there was no flow of current and output power becomes zero. Consequently, the efficiency of the system is zero.

Table 1.3: Variation of Output Characteristics with Load of 100 W

Time (Sec)	Load (W)	Input Voltage (V)	Output Voltage (V)	Input Current (A)	Output Current (A)	Input power (W)	Output Power (W)	Efficiency (%)
30	100	12.60	225	6.34	0.31	79.88	69.75	87.31
60	100	12.64	220	6.27	0.30	79.25	66.00	83.28
90	100	12.65	220	6.22	0.29	78.68	63.80	81.08
120	100	12.35	218	6.37	0.27	78.67	58.86	74.81
150	100	12.56	215	6.26	0.25	78.63	53.75	68.36
180	100	12.44	210	6.30	0.24	78.37	50.40	64.31

Table 1.3 shows the recorded results for performance of 1KVA power inverter system when the load of 100 W was connected. The result revealed the relationship between the output power and efficiency as time progressed.

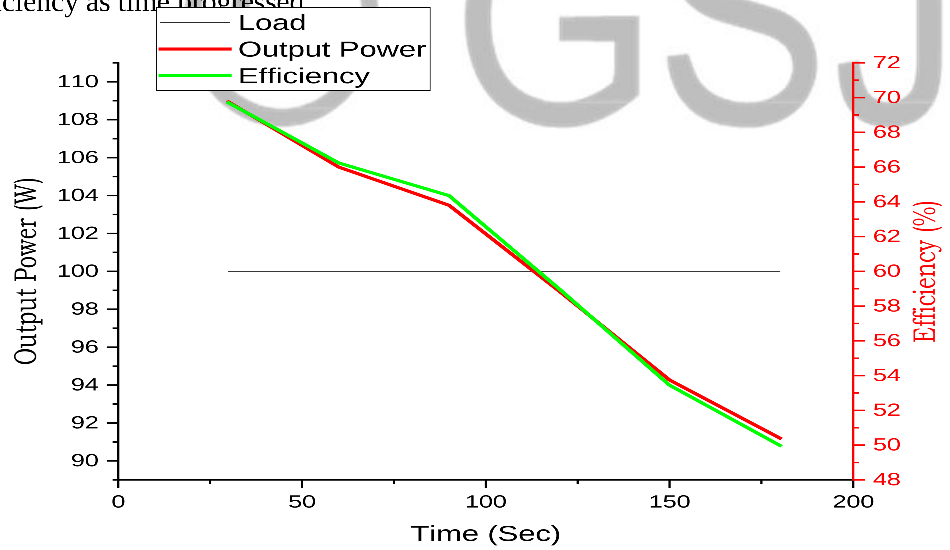

Fig. 1.3: Variation of efficiency and output Power with Time for 100 W loads

In fig 1.3, the output power and efficiency of the system decreased as the time of usage increased. The highest power output when a 100 W loads were connected was 69.75 W and the highest efficiency of the system was 87.31 %. These values were recorded at 30 sec of usage. At 180 seconds of usage, the lowest output power and efficiency of 50.40 W and 64.31 % respectively, were recorded. This is because, the battery discharged with time of usage. Energy dissipated is power multiplied by time. It then implies from table 1.3 that average energy of 5999J was spent at 30 minutes interval for about 6 trials in one gym centre. If we multiply 5999J by five gym centres in Nnewi, we have 29995J. This implies that 29995J of energy which would have wasted in the process of gyming was put into good use.

Table 1.4: Variation of Output Characteristics with Load of 0 W – 1000 W

Trials	Load (W)	Input Voltage (V)	Output Voltage (V)	Input Current (A)	Output Current (A)	Input Power (W)	Output Power (W)	Efficiency (%)
1	0	12.66	225.00	0.00	0.00	0.00	0.00	0.00
2	100	12.61	218.00	7.63	0.39	96.21	85.02	88.37
3	200	12.64	200.80	7.61	0.42	96.19	84.34	87.68
4	300	12.80	188.00	7.08	0.41	90.62	77.08	85.05
5	400	12.01	153.70	7.54	0.48	90.56	73.78	81.47
6	500	12.72	144.70	7.12	0.44	90.57	63.67	70.29
7	600	12.48	131.10	6.75	0.36	84.24	47.19	56.03
8	700	12.70	92.95	5.28	0.29	67.06	26.96	40.19
9	800	12.38	43.92	4.55	0.24	56.33	10.54	18.71
10	900	12.35	27.27	3.53	0.21	43.59	5.73	13.14
11	1000	11.68	28.23	2.40	0.13	28.03	3.67	13.09

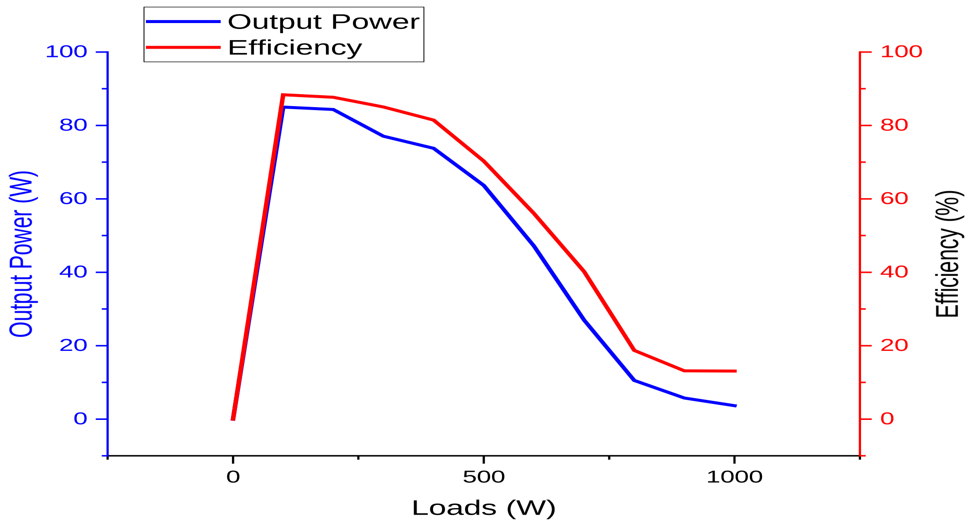

Fig. 1.4: Variation of Output Power and Efficiency with Loads (0 W – 1000 W)

In figure 1.4, the result on table 1.4 is plotted. The power of the pedal generator decreased with increase in load capacity. The maximum and minimum values of output power were 85.02 W and 3.67 W respectively, and these were obtained at a less load capacity of 100 W and 1000 W. The efficiency of the system decreased with increase in the load capacity applied. The peak efficiency of 88.37 % was recorded at a load of 100 W and the lowest efficiency of 13.09 % at loads of 1000 W was also recorded. The lowest efficiency obtained was as a result of a high load connected to the generator.However, it can be deduced that, to operate the 1 KVA pedal powered generator more efficiently, the maximum load to be connected must be below 600 watts.

1.5: CONCLUSION

We have successfully studied pedal power system for energy generation in Nnewi and seen how energy wasted in the process of maintaining body fitness can be turned into good use. When the bicycle was pedalled, the generated current, voltage and power increased as the pedalling speed increased as was shown in figure 1.1. The lowest speed of 220 rpm generated 0.90 A, 1.50 V and 1.35 W, while the highest speed of 1311 rpm attained generated 13.70 A, 13.81 V and 189.20 W.No current flow was observed when the Bicycle was not pedalled.When there was no load connected; there was no output current and power. Consequently, no efficiency was recorded as shown in Table 1.2.When we connected 100 W, the highest power output was 69.75 W and the highest efficiency of the system was 87.31 %. These values were recorded at 30 sec of usage. At 180 seconds of usage, the generator showed the lowest output power and efficiency of 50.40 W and 64.31 % respectively, as on figure 1.2. This was because, the battery discharged with time of usage. The Efficiency was always lowered when a high load capacity was connected. Therefore to operate the pedal powered generator more efficiently, the maximum loading of the machine must be below 600 watts.

Finally, when the bicycle was pedalled at a speed of 220 RPM, total energy of 5999J was spent at 30 minutes interval for about 6 trials in one gym centre. This energy, 5999J was multiplied by five gym centres in Nnewi. It was found that a total of 29995J of energy which would have wasted in the process of gyming was used in generating electricity. The pedal powered generator had overall peak efficiency of 88.79 % at a load of 100 W and the lowest efficiency of 13.29 % at a load of 1000 W. This simply means that the higher the load applied, the lower the efficiency. The energy produced could be used to power low voltage devices like charging of mobile phones, laptops etc.

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