

Pedaling Energy Harvesting by Low Speed Gearless Generator

¹Prof T. T. Bellundagi, ²Prof A. S. Jaibhai, ³Prof A. E. Shivdas

^{1,2,3}Assistant Professor, ^{1,2,3}Electrical Dept TSSM'S BSCOER Narhe Pune, India.

¹trupti.t.bellundagi@gmail.com, ²artijaybhay25@gmail.com, ³ashvinishivdas@gmail.com

Abstract - In rural areas of India today also we use bicycle as main medium of transportation. The pedaling energy generated is wasted. It can be used for a better purpose by converting pedaling power in to electrical energy. The same concept of the energy generated due to pedaling can be obtained by gym cycles in urban areas. The energy generated can be stored and can be used for running electrical appliances [1]. These types of systems are already available in markets but they are less efficient, needs more rpm to generate power. This paper presents design of gym cycle which produces same output with less rpm. In this paper low speed generator is designed and modified the position of generator which eliminates gears and belt arrangement. In Low speed generator high power magnets are implemented and number of poles are increased also gauge of winding used is 23. The main intention of this paper is to build straight forward human powered low speed generator. It is clean way of generating energy efficiently.

Keywords – Pedaling Energy, Gearless Generator, harvesting, low speed generator, electrical appliances.

I. INTRODUCTION

World is a storehouse of energy. We all know that energy can either be created or destroyed but can be transformed from one form to another. But we are wasting resources that can produce energy as if they are limitless. If we can renew and reuse the energy we waste, it would help in some way to the problem of scarcity of energy, which is the major threat of present world. Humans are able to generate approximately 150W of power while riding bicycle. However, this power goes waste without any use. If we can make use of this energy, we would be able to power many electronic devices. A dynamo or an alternator can be used for harvesting the energy generated by a cycle rider while riding [2].

Pedal Power Generation using Cycle

There are various renewable energy sources such solar, wind, hydropower etc. In addition, people use fossil fuels, which are non-renewable. These resources are very expensive. Therefore, there is a need for cheap, renewable energy source. As long as we are pedaling and the system is working fine, we can get the power whenever needed[3]. Power generation using bicycle is very cheap and eco-friendly. Even though people have been using pedal power for various day-to-day chores, generating electricity from pedaling was not in vogue until few decades back. Today dynamo equipped bicycles are common which power the incandescent headlights during night.

II. HISTORY

The generator evolved from work by Michael Faraday and Joseph Henry in the 1820s. Once these two inventors discovered and documented the phenomena of electromagnetic induction, it leads to experimentation by others in both Europe and North America.

1832 - Hippolyte Pixii (France) built the first dynamo using a commutator, his model created pulses of electricity separated by no current. He also by accident created the first alternator. He did not know what to do with the changing current; he concentrated on trying to eliminate the alternating current to get DC power.

1860 - Antonio Pacinotti-Created a dynamo that provided continuous DC power[5].

1867 - Werner Von Siemens and Charles Wheatstone create a more powerful, more useful dynamo which used a self powered electromagnet in the stator instead of the weak permanent magnet.

1871 - Zenobe Gramme sparked the commercial revolution of electricity. He filled the magnetic field with an iron core which made a better path for magnetic flux. This increased the power of the dynamo to the point where it was usable for many commercial applications.

1870 - There was an explosion of new designs in dynamos, designs ranged a wild assortment, only a few stood out as being superior in efficiency.

1876 - Charles F. Brush developed the most efficient and reliable dynamo design ever to that point. His inventions were sold through the Telegraph Supply Company.

1877 - The Franklin Institute (Philadelphia) conducts test on dynamos from around the world. Publicity from this event spurs development by others like Elihu Thomson, Lord Kelvin, and Thomas Edison.

1878 - The Ganz Company begins to use AC generators in small commercial installations in Budapest.

1880 - Charles F. Brush had over 5000 arc lights in operation, representing 80 percent of all lamps world wide. The economic power of electrical age had begun.

1880-1886 - Alternating Current systems develop in Europe with Siemens, Sebastian Ferranti, Lucien Gaulard, and others. DC dynamos reign supreme in the lucrative American market, many are skeptical to invest in AC. AC generators were powerful; however the generator alone was not the biggest problem. Systems for control and distribution of AC power needed to be improved before it could compete with DC on a market[6].

1886 - In the North American Market inventors like William Stanley, develop their own AC systems and generator designs. Most of them used Siemens and Ferranti generators as their basis of study.

III. EXISTING SYSTEM

Maha and Kimberly (2010), in the Proceedings of ASME 2010 4th International Conference on Energy Sustainability made us to understand that other gyms in the United States began to harness human power as well.

The Dixon Recreation Center at Oregon State University (OSU) is one of the many facilities retrofitted between the years 2008 and 2009 by the Clearwater, Florida based company known as Re Rev. The company retrofitted 22 elliptical machines at OSU so that the excess energy generated by patrons was diverted to the electric grid.

According to the company's website, "An elliptical machine in regular use at a gym using Re Rev technology will generate one kilowatt-hour of electricity every two days."

Dean (2008) revealed that human legs are up to four (4) times more powerful than human arms. On average, a human can sustain about 100W of power through pedaling for an hour but only hand crank about 30Ww of power in an hour. Wilson (2004) demonstrates that a person's oxygen consumption, and consequently their potential power output, decrease with age,

with the peak of potential power output being between 20-40 years of age

According to Jamie and Aaron (2012), Wind stream, Convergence Tech and Magnificent Revolution have manufactured stationary pedal powered generators. Typical design included a back-wheel stand that elevates the bicycle and causes the back wheel to come in contact with a smaller wheel that is hooked up to a "bicycle dynamo" and a large battery.

Existing system requires more rpm to generate very small power. In existing system generator is placed outside the bicycle, generator shaft and pedals are connected by gear and belt arrangement. Due to belt there is friction losses occur which reduces system efficiency.

IV. PROPOSED SYSTEM

Components of proposed system

1. CONSTRUCTION OF STATOR

A Single phase synchronous motor structure is used. 48 pole stator structures is used. As shown in figure 4.1(a) we can see the structure of stator of single phase synchronous motor without windings[1]. Pole to pole windings is implemented as shown in figure 4.1(b).

Previously it was a single phase winded but after further modifications we implemented a pole to pole connected two phase windings to get twice the output as compared to the previous one. By constructing a 48 pole stator due to which we can control the generator at low speeds. From the stator two phase winding and one ground terminal is taken and further given to the transformer for step down purpose. Copper winding is implemented of gauge 24 SWG.



Fig 4.1(a)

Fig 4.1(b)

2. CONSTRUCTION OF ROTOR

The following figure 4.2(a) shows the construction of Rotor of Single phase synchronous motor with permanent magnets. We have replaced those permanent magnets with Neodymium magnets as shown in figure 4.2(b). In previous design of rotor there were four permanent magnets implemented in stacks of rotor as shown in figure 4.2(a). After the modification of rotor

the neodymium magnets were implemented [2]. After modifications the rotor is now implemented with only three neodymium magnets by doing some modifications. Skilled labour works were required to implement the neodymium magnets in rotor for proper mounting of magnets. The magnets implementing task is difficult and skilled labors are required for doing this work. As we have replaced the permanent magnets with Neodymium magnets, Magnetic field produced is ten times more as compared to permanent magnets. So that greater the magnetic field greater the flux induced in stator windings.



Fig 4.2(a)

Fig 4.2(b)

3. ASSEMBLING OF STATOR AND ROTOR

Following figures 4.3(b) & (c) shows the construction of a generator while assembling the stator and rotor core in the yoke assembly. Then we made such an assembly that the motor was mounted on the cycle. We maintained standard air gap between the stator and rotor core for flux induction. Ball bearings are used on two sides for shaft mounting. Due to which smooth functioning of the rotation of the shaft i.e. reducing mechanical losses in Generator. Figure 4.3(a) shows how stator and rotor assembly is done inside the generator. From the diagram we can thoroughly understand how the construction is done. The green and red are the two phase windings done in the stator poles. It thoroughly explains how the windings in stator poles are constructed. The rotor is mounted in between the stator core with the ball bearings situated at both the end of the rotor shaft mounted.



Fig 4.3 (a)



Fig 4.3 (b)

V. DESIGN CALCULATIONS

Specifications

Average weight of Bicycle = 18kg

Output voltage = 12V DC

Output Power (1 tube & 1 fan) = 12 Watts

Output current (I) = output power/output voltage= 12/12= 1A

No. of Poles = 8, No. of Slots = 48, Insulation Class = Class E

Temp. Range of Class E Insulation = 120°C-130°C

Type of magnet used = Neodymium Magnet N42 SH

Stator winding Gauge = 23(Reducing the gauge of the wire increases the temperature.)

Input: 1) Speed (N) = 50-150 rpm

Output: 1) Current (I) = 0.1- 0.7A

2) Voltage (V) = Up to 150V

3) Current Density for copper (std.) (ρ) = 2.3

4) Flux Density (std.) (B) = 1 Tesla

Given data:

Speed (N) = 100rpm, Current (I) = 0.5A, Voltage (V) = 100V

Electrical Power (Pe) = 100*0.5=50W

Mechanical Power (Pm) = T * ω

T = Torque (Kg-m)

ω = Angular Velocity (rad/sec)

Electrical power Pe = V * I = 100*0.5 = 50W

But we know ω = 2πN/60

ω = 2π*100/60 = 10.47rad/sec

Assume ideal design Pm = Pe

T * ω = V * I So, Pe = T * ω

T = Pe /ω= 50/10.47= 4.77 Kg-m

Motor constant Km which represent power conversion from mechanical to electrical

Rm = Internal resistance, L = Inductance it will negligible effect on output, Km represents Torque (T),

1) How much torque needed to get desired output

2) How many volts the generator will generate across its terminal per unit speed

$$K_m = 2 * N * B * L * R * I \text{ But, } K_m = T$$

$$\text{So, } T = 2 * N * B * L * R * I \text{ -----eqn. 1}$$

I = Generator current flowing through each phase
 N = No. of complete loops of wire interacting with your permanent magnetic field of strength B in T.

L = is interacting length of which is generally rotor length & radius R is radius of generator stator

2 = comes from fact that wire loop must go across & back across same magnetic field.

Assume ideal design $P_m = P_e$

$$T * \omega = V * I$$

$$V/\omega = T/I \text{ \& Back EMF } K_v \approx K_m$$

As generator has 2 phases equation 1 becomes,

$$T = 4 * N * B * L * R * I$$

N = No. of Turns per phase, B = Strength of permanent magnetic field, L = Length of stator core, R = Radius of stator, I = Current of stator as generator have multiple teeth per phase count

$$T = 4 * M * N * B * L * R * I$$

Notice some components, Torque increases with no. of turns.

Torque increases with Radius of stator.

Torque increases with strength of B.

Torque increases with Length of stator L.

Torque increases with Winding current I.

N depends on how much voltage we need to generate.

R, L, M are stator variable which are fix.

B is the strength of magnetic field & it set by the magnet strength. As L & R are already set because we have taken standard stator for implementation of generator. The factors we can control are N & B.

$$\text{So, } T = 4 * M * N * B * L * R * I$$

$$46.77 = 4 * 48 * N * 1 * 0.16 * 0.04 * 0.5$$

$$N = 76.12 \approx 80 \text{ turns/phase}$$

$$\text{So for two phases } 80 * 2 = 160 \text{ turns}$$

$$\text{Current, Current Density } (\rho) = I/a$$

$$\text{Where, Current density } (\rho) = 2.3$$

$$I = 0.5$$

$$a = I/\rho = 0.5/2.3$$

$$\text{Therefore, } a = 0.2173$$

$$a = \pi/4 * d^2$$

$$d = \sqrt{4a/\pi} = 0.5259 \text{ mm}$$

So from that table we get,

$$\text{Gauge} = \text{SWG} = 24$$

Battery capacity:

$$\text{Voltage} = 12\text{V, Current} = 7.5\text{Ah, Power (P)} = V * I = 90\text{W}$$

$$\text{Generated power } P_e = 50\text{W/Hr}$$

$$\text{Charging time} = 1.8\text{Hrs} \approx 2\text{Hrs}$$

$$\text{Load connected} = 20\text{W}$$

$$\text{Running time} = \text{Total power/Load connected} = 4.5 \text{ Hrs}$$

VI. RESULTS

Table 1: Result at different rpm

SPEED (rpm)	VOLTAGE (V)	CURRENT (amp)	POWER (W)
60	11	0.51	5.61
80	15.2	0.61	9.27
100	19.2	0.64	12.28
140	25.8	0.68	17.54
180	30	0.69	21

Table 1 shows results or outputs of our project which are voltage, current and power is calculated at various speeds of bicycle. First reading, at 60 rpm we are getting 5.61 watt power. Similarly for higher speeds we are getting more power up to 21 watt. This Power is converted in to dc and stored in battery and is used to glow the bulb and to run small fan.

VII. CONCLUSION

The pedal operated power generator (bicycle generator) utilizes human energy to produce electricity quickly and efficiently. Using human powered generation gives a power source that is not directly derived from natural sources. An example is that a human powered generator can be operated if there is no sun for solar generation, no wind for wind generation, and no water for hydro generation. The power generated from pedal is perfect for remote areas, hilly regions, strategic location, Islands etc., where electricity generation is scanty if not nil. In these situations, a small portable bicycle power generating unit would be of great help to provide power supply to charge battery-operated gadgets like mobile phones, lamps, radio, communication devices, etc. It is important to visualize new ways to bring power to the people as population continues to grow and power shortages continue to occur.

Pedal powered machines are one of the best ways to solve energy crisis. Let's make do-it-yourself DIY solution to make electricity by your own bicycle generator i.e. pedal power generator. This pedal power generator gives free energy for home lightning, laptop battery charging. During exercise we wasted lots of muscle power. By using this pedal power bicycle generator we can convert this muscle power into electricity.

This is specially designed Pedal power generator which generates electrical energy at very low speed about 60 rpm so there is no needs of chains and other drive mechanism. Low speed alternator is designed using permanent magnet rotor and multiple pole stator which give AC voltage with two phases

which is given to center tap transformer which convert it in to 150V to 12VAC. cycling for electricity generation is good idea to save nature. This pedal power generator is best option for portable power generation, Free energy at any location using human muscle power.

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