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Power Generation through Magnetic Coupling

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A B S T R A C T

This project aims at production of electricity by using the concept of the rotation of secondary shaft due to the primary railway axle caused by the moving train by using an electrical power generation system. This device could be placed along railway bogies or locomotive axles. An electrical power generation system comprises a variable capacitor and a power source. The magnetic coupling here by used will transfer power from locomotive axle to the generator shaft without contact that will implies no contact / friction load on railway locomotive shaft. That will beneficial for power generation without altering or damaging ongoing system.

Keywords: DC motor, Magnet, Battery, Bearing, Shaft.

1. Introduction

Now days, electricity has become a need of every single human, demand of electricity increasing day by day. This new generation needs lots of electrical power for their different operations. Due to this many sources are wasted and exhausted in a large amount. There are various ways to generate electricity. The human bio-energy being wasted if it can be made possible for utilization it will be very useful energy sources. The human waste foot energy is being used to produce electricity this would be a great evolution in electricity generation. The average human can take 3,000 -5,000 steps a day.

The main objective is to build a power generation system such that it can contribute to the present power generation system as the need of energy is growing day by day. The generated power is eco-friendly as well as inexhaustible means the power can be generated as long as the railways are in function. This can be achieved by utilizing the energy resources along the railway tracks i.e., by utilizing the mechanical energy supplied by both wind gusts from train as well as mechanical energy supplied by the train when it is in motion. The proposed technique relates generally to generating electricity and, more particularly, to a method and a system for generating electricity along a railroad track. Many known railroad systems employ a variety of wayside equipment alongside the railroad tracks.

Within a network, railroad tracks often span rural and unpopulated areas, and as such, providing power to wayside equipment in remote locations may be a challenging and costly task. At least some known railroad systems run power lines into remote areas to power wayside equipment. However, depending on the location, such power systems may be expensive to install and to maintain. Unfortunately, traditional automated devices generally obtain operating power from an external power source, which is not generally available in remote areas. That is, the automated device receives operating power that is generated at a remote location and that is delivered over a power grid, and coupling the grid to the device can be a costly proposition, especially in remote areas. In certain instance, local power sources, such as batteries, have been employed. In any event, even if a local or external power source is provided, these power sources may not provide a cost-effective mechanism for producing sufficient levels of power for operation of the automated testing devices. Therefore, there is need for a system and method for improving electric power generation with respect to rail systems.

A magnetic coupling uses permanent magnets to transmit torque between an input and output shaft without mechanical contact. Torque densities comparable with mechanical gears can be achieved with an efficiency >95% at full load and with much higher part load efficiencies than a mechanical gear. For higher power ratings a magnetic gear will be smaller, lighter and lower cost than a mechanical gear. Since there is no mechanical contact between the moving parts there is no wear and lubrication are not required. Magnetic gears inherently protect against overloads by harmlessly slipping if an overload torque is applied, and automatically and safely re-engaging when the fault torque is removed. Provides a unique ability to convert an applied mechanical train into an electrical potential or vice versa. Our project includes how to utilize the energy which is wasted, creates pollution to the environment. The sound energy of the moving train wheels which is nothing but pollution can be converted into electrical energy with the help of train axle power generation.

2. Literature Survey

Chaitanya1, Gedda Gowtham2 This paper aims at production of electricity by using the concept of the rotation of wind turbine due to the wind caused by the moving train and also by using an electrical power generation system. As anyone living near railway tracks will tell you, speeding trains generate quite a bit of wind as they whoosh past. The idea is to design a wind turbine that can be installed between the sleepers on a track, and as the train passes overhead, the wind drives a turbine to generate electricity. This device could be placed along railway or subway lines, and make good use of an otherwise wasted resource. An electrical power generation system comprises a variable capacitor and a power source. The power source is used in the form of a generator to prime the variable capacitor that effectively multiplies the priming energy of the power source by extracting energy from the passing vehicle. By alternately priming the variable capacitor using charge from the power source and discharging it at a later time in a cyclic manner to change the capacitance, a significantly large amount of electrical energy is produced due to change in capacitance.[1]

Itika Tandon1, Alok Kumar2 In this paper we are representing the methodology of electrical power generation using human footstep. This is about how we can generate electricity using human's waste foot energy and applications for the same. When human walk-in surroundings some force exerts on surface this force can be used to generate electricity. The idea of converting pressurize weight energy into the electrical energy is possible by piezo-electric crystal. The power generating floors can be a major application if we use piezoelectric crystals as an energy converting material. The piezo-electric crystals have crystalline structure and ability to convert the mechanical energy (stress and strain) into the electrical energy. Whenever there is some vibrations, stress or straining force is exerted by foot on floor then these crystals evenly convert it into electric power which can be used for charging devices viz laptop, mobiles, electronic devices etc. In this paper, we are discussed about applications and generation of electricity in the area of power harvesting.[2]

Teng Lin, John Wang, and Lei Zuo. An efficient electromagnetic energy harvester featured with mechanical motion rectifier (MMR) is designed to recover energy from the vibration-like railroad track deflections induced by passing trains. Trackside electrical infrastructures for safety and monitoring typically require a power supply of 10-100 Watts, such as warning signals, switches, and health monitoring systems, while typical existing vibration energy harvester technologies can only harvest sub-watts or milli-watts power. The proposed harvester is designed to power major track-side accessories and possibly make railroad independent from national grid. To achieve such a goal we implement the MMR, a patented motion conversion mechanism which transforms pulse-like bidirectional linear vibration into unidirectional rotational motion at a high efficiency.

The single-shaft MMR design further improved our previously developed motion mechanism, increased energy harvester efficiency and expanded power harvesting potential. The proposed new design improved reliability, efficiency, and provided steadier power output. Bench test of the harvester prototype illustrated the advantages of the MMR based harvester, including up to 71% mechanical efficiency and large power output. [3]

S. Mukunthan. Energy is the necessity for the economic development of our country. Energy exists in different forms in nature but the most important form is electrical energy. Modern society is so much dependent upon the use of electrical energy that it has become a part of our life. Energy is needed as heat, light, motive power etc. The present-day advancement in science and technology has made it possible to convert electrical energy into any desired form. This has given electrical energy a place of pride in the modern world. We can't imagine the world without electricity. The survival of industrial undertakings and our social structures depend primarily upon low cost and uninterrupted supply of electrical energy. In fact, the advancement of a country is measured in terms of per capita consumption of electrical energy. Our paper focuses on the generation of electrical energy in an innovative and simple manner.[4]

3. Material and component.

3.1 Motor

An electric motor is an electrical machine that converts electrical energy into mechanic magnetic field and electric current in a wire winding to generate force in the form of torque applied on the motor's shaft.

A simple motor has the following parts:

- A power supply – mostly DC for a simple motor
- Field Magnet – could be a permanent magnet or an electromagnet
- An Armature or rotor
- Commutator
- Brushes
- Axle

3.2 SHAFT

In mechanical engineering, a shaft is a rotating machine element, usually circular in cross section, which is used to transmit power from one part to another, or from a machine which produces power to a machine which absorbs power.

They are mainly classified into two types.

- Transmission shafts are used to transmit power between the source and the machine absorbing power; e.g., counter shafts and line shafts.
- Machine shafts are the integral part of the machine itself; e.g., crankshaft.
- Axle shaft.
- Spindle shaft.

3.3 MAGNETS

A magnet is a material or object that produces a magnetic field. This magnetic field is invisible but is responsible for the most notable property of a magnet: a force that pulls on other ferromagnetic materials, such as iron, steel, nickel, cobalt, etc. and attracts or repels other magnets**.**

Permanent magnets have ferromagnetism. They occur naturally in some rocks, particularly lodestone, but are now commonly manufactured. A magnet's magnetism decreases when it is heated and increases when it is cooled. It has to be heated at around 1,000 degrees Celsius (1,830 °F). Like poles (S-pole and S-pole/N-pole and N-pole) will repel each other while unlike poles (N-pole and S-pole) will attract each other**.**

3.4 BEARING

Bearings are "parts that assist objects' rotation". They support the shaft that rotates inside the machinery. Machines that use bearings include automobiles, airplanes, electric generators and so on.

Bearings are mechanical assemblies that consist of rolling elements and usually inner and outer races which are used for rotating or linear shaft applications, and there are several different types of bearings, including ball and roller bearings, linear bearings, as well as mounted versions that may use either rolling.

3.5 BATTERY

A battery is a device that stores chemical energy and converts it to electrical energy. The chemical reactions in a battery involve the flow of electrons from one material (electrode) to another, through an external circuit. The flow of electrons provides an electric current that can be used to do work.

Working of Lead Acid Battery The storage battery or secondary battery is such battery where electrical energy can be stored as chemical energy and this chemical energy is then converted to electrical energy as when required. The conversion of electrical energy into chemical energy by applying external electrical source is known as charging of battery. Whereas conversion of chemical energy into electrical energy for supplying the external load is known as discharging of secondary battery.

4. Design

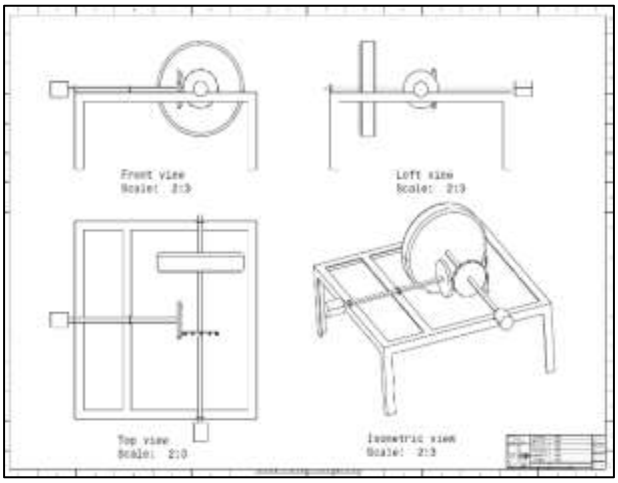

Figure no.1 Detailed drawing

Figure no.2 3D model

The whole construction is done on a base frame fabricated using L angle mild steel channel. The magnetic disc coupling are also formed using mild steel circular plates and permanent magnets are placed on periphery of it. The motors are placed at ends of shaft and fitted to base frame.

5. Calculations

5.1 SHAFT STRENGTH UNDER TORSIONAL LOAD

The shafts are always subjected to fatigue load hence they must be calculated for fatigue strength under combined bending and torsion loading. However, the initial estimate of diameter is obtained from the torque that is transmitted by the shaft. The bending moment variation along the length of the shaft is established after fixing some structural features like distance between supporting bearings and distance between points of application of forces and bearings.

Following notations will be used for shaft.

d = diameter of shaft,

Mt = torque transmitted by the shaft, = 15 Kg cm = 1.47 Nm.

W = power transmitted by the shaft (W)

N = rpm of the motor shaft = 100 rpm

τs = permissible shearing stress,

σb = permissible bending stress, and

Mb = bending moment.

Considering only transmission of torque by a solid shaft.

The power transmitted by shaft and the torque in the shaft are related as

$W = Mt * \omega$

If W is in Watts and Mt in Nm. ω is angular velocity in rad/s and equals 2πN/60

$w = 2\pi N Mt/60$

$Mt = 30w/\pi N$ (1)

The shearing stress and the torque are related as

$\tau = 16\, Mt*10^3 / \pi * d^3$

If Mt is in Nm and d in mm.

$Mt = \pi/16\,(10^{3*}\,\tau\, d^{3)}$ (2)

$d^3 = Mt*16/\pi 10^3\ \ \tau$

In Eq. (3) W is in Watt, τ in N/mm2, N in rpm and d in mm.

For calculating shaft diameter, d, we substitute the permissible value of shearing stress in place of τ. Table below describes permissible values for steel shaft under various service conditions, when the bending is much smaller than torsional loads.

Table1: Allowable Shear Stress for Shafts

Service Condition	τ s (MPa)
Heavily loaded short shafts carrying no axial load	48-106
Multiple bearing long shafts carrying no axial load	13-22
Axially loaded shafts (bevel gear drive or helical gear drive couplings etc.)	8-10
Shafts working under heavy overloads (stone crushers, etc.)	4.5-5.3

So, equation 3 becomes

$d^3 = Mt*16/\pi 10^3\ \ \tau$

Taking allowable shear stress for shafts under small loads in coupling as $\tau = 8$ MPa = $8*10^6$ Pa

$d^3 = Mt*16/\pi\ \tau\ 10^6$

$d^3 = 1.47*16/\pi*8*10^6$

$d^3 = 0.935 * 10^{-6}$m

d= 0.0097 m = 9.7 mm

Considering factor of safety as 1.5, the shaft size will be

D= 1.5*d

D= 1.5*9.7

D= 13.5 mm.

En8 Rounds Bright Drawn / Turned bars available sizes

Table- 2 dimeter of shaft

Diameter Size in mm	5	6	8	10	12	15	18	20
	22	24	25	28	30	32	35	40
Diameter Size in inches	1/4	5/16	3/8	7/16	5/8	1/2	3/4	11/16
	7/8	1	11/4	13/8	17/16	15/8	13/4	21/4

So selected shaft diameter closest to D= 13.5 mm is = D=15 mm.

This is taken as 15 mm to add better safety and availability in market.

So, we take diameter of second shaft will also be 15 mm.

5.2 Basics of magnetic and mechanical gears:

A gear can be defined as a mechanism that transfers torque from one shaft to another shaft by the use of magnets or mechanical teeth. Some mechanical gears are very similar to magnetic gears for instance the magnetic spur gear. The similarity of these two gear types.

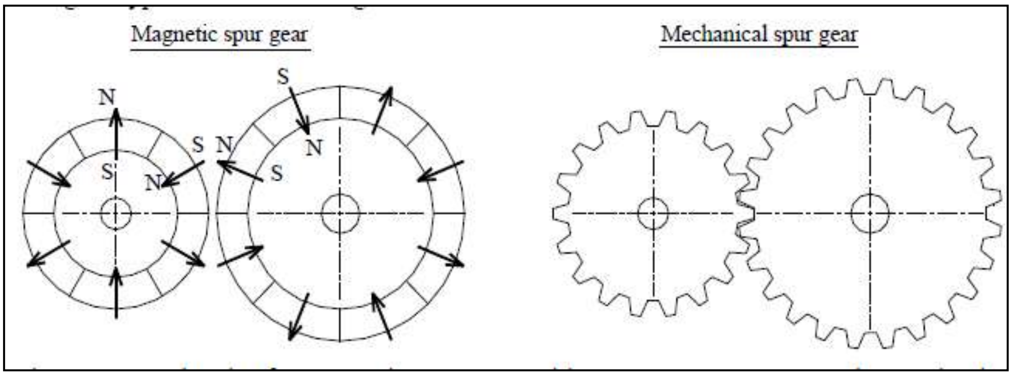

Fig 5.2. A sketch of a magnetic spur gear with permanent magnets and a mechanical spur gear.

The traditional mechanical gear uses steel teeth to transfer torque. Gear wheel teeth have physically contact with each other, and there will be wearing on the tooth flanges. The magnetic gear does not have the same wear, because there is no direct contact. Permanent magnets on the gearing wheels transfer the torque between the two wheels. Since the magnetic gear does not have direct contact, there will be a fictive torsion spring effect between gear wheels. The torsion spring effect can be explained by imaging one wheel fixed and the other wheel is rotated a small angle. Then there will be a certain torque interaction between the gear wheels depending on angle displacement of the second wheel.

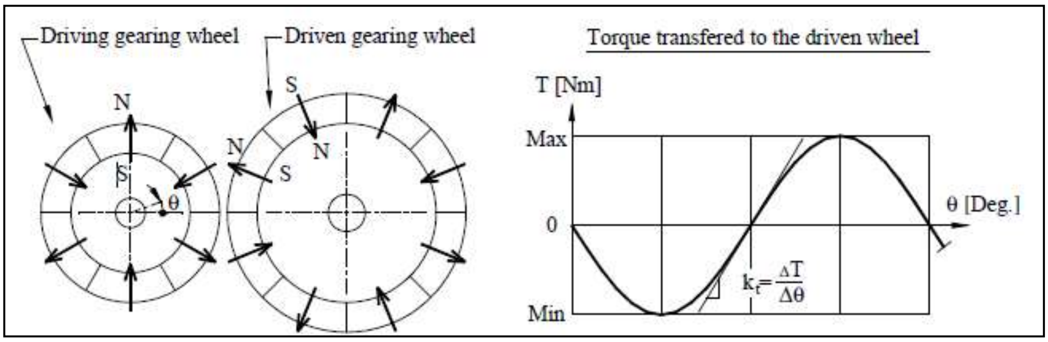

Fig 5.3. A magnetic gear and a torque diagram, where the torque versus turning angle on the driving gear wheel.

6. conclusion

There are many places which use electricity and thus those places are responsible for not proper usage of electricity. The ability to transmit power without contact whilst continuing to transmit mechanical power from one to the other makes these couplings ideal for applications where prevention of cross contamination is essential. A lot of energy is being used for various purposes and no one actually has a count of how it is wasted. One such huge form of energy is Electricity. Electricity is generated from various sources and is been used for various activities. There is no regulatory body which is concerned about the wastage of electricity.

We are using the principle of magnetism which transmits the rotational mechanical energy of first shaft in equivalent rotational energy of second shaft. Which can be converted into electrical by generator and can be stored in batteries and used whenever and wherever required. We can use this electrical power as a free service in railways like water service, lighting, HVAC (heating ventilation and air conditioning).

7. Reference

[1] Chaitanya, Paidimukkula Bhanu, and Gedda Gowtham. "Electricity through Train."

[2] A Unique Step towards Generation of Electricity via New Methodology Itika Tandon1, Alok Kumar2

[3] Lin, Teng, John Wang, and Lei Zuo. "Energy Harvesting from Rail Track for Transportation Safety and Monitoring." (2014).

[4] Mukunthan, S. "Train Wheel Electricity Generation."

[5] Bharathi, S., et al. "A Method for Generating Electricity by Fast Moving Vehicles." Applied Mechanics and Materials. Vol. 110. Trans Tech Publications, 2012.

[6] Ashvini Sherwade 1, Ashwini Pawar 2, Bhagyashree Ghadge 3, Deepika Srivastava. "Automatic Railway Gate Control & Power Generation." International Journal of Innovative Research in Science, Engineering and Technology, Vol. 5, Issue 2, February 2016.

[7] Kunhabdulla, Sajid PP, Praveen Merala, and Ashutosh Sahoo. "Power Generation from Vibrations on the Sleepers beneath Railway Tracks for Railway Stations." International Journal for Innovative Research in Science and Technology 1.3 (2014): 106-113.

[8] Design and Construction of a Prototype Solenoid Coil for MICE Coupling Magnets Author: Wang, Li

[9] Transmitted Torque Analysis of a Magnetic Gear Mechanism with Rectangular Magnets Yi-Chang Wu∗ and Chih-Wen Wang

[10] Iannuzzi D., Tricoli P. Optimal Control Strategy of Onboard Super Capacitor Storage System for Light Railway Vehicles, 2010 IEEE International Symposium on Industrial Electronics (ISIE 2010). 2010:20-285.

[11] Richardson, M.B. Flywheel energy storage system for traction applications, 2002 IEE Int. Conference Power Electronics, Machines and Drives. 2002:.275-279.

[12] Bassani, R. Magnetoelastic Stability of Magnetic Axial Bearings. Tribol. Lett. 2012, 49, 397–401.

[13] Power Consumption. J. Tribol. 1996, 118, 839–846.

[14] Carter, C. Barry; Norton, M. Grant (2007). Ceramic Materials: Science and Engineering.

[15] Fraden, Jacob (2010).Handbook of Modern Sensors: Physics, Designs, and Applications.