Train Axle Power Generation

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Abstract— 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.

Key words: Energy, Energy Harvesting, Non-conventional Method, Rail Road

I. 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.

A. Principles of Operation:

The magnetic coupling works by using the power generated by permanent magnets. No external power supply is needed. These are permanent magnets not electro magnets.

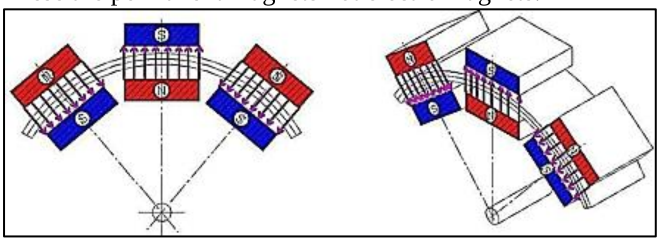

Fig. 1: magnetic poles and forces exerted upon each other

The magnets are installed alternating between poles in a side by side and opposing position as seen in the diagram. The main body of each coupling half is of ferromagnetic material to aid the channeling of the magnetic field correctly and therefore maximizing transmittable torque.

II. Literature Review

A. Itika Tandon, Alok Kumar [1]

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.

B. Teng Lin, John Wang, and Lei Zuo [2]

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.

III. System Description

A. Working Diagram

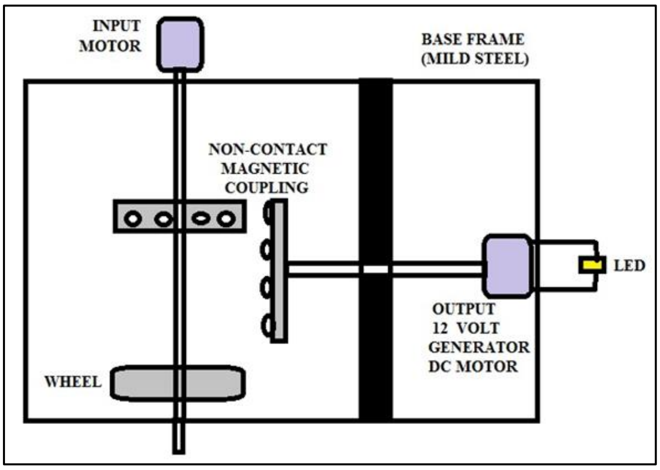

Fig. 2:

B. Working Principal

The system used its driving energy through an input electric motor which drives a shaft to show the rotational motion of the railway axle. The wheel is provided to show the working of railway wheel which also stores the inertia energy of shaft which drives the system. In between the shaft a permanent magnetic coupling is provided which will transfer thr rotational energy from driving shaft to the DC motor generator shaft.

This coupling uses the disc coupling formed by two discs on whos circumfrrence of it the permannet magnets are placed. The magnets emplies the toeque force onto eact other by magnetic force of attraction and by thus when driving shaft is rotated by motor simultaneously the generator shaft also starts moving due to magnetic coupling.

By thus we provide rotational motion to the DC motor generator which will convert the rotational mechanical energy into elevtriclcal energy. Which is indiacted by a LED which glows when elecrticty is produced by generator motor.

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.

IV. CALCULATION & CAD MODEL

A. *Base Frame Design*

1) Mild steel angles are used to support the whole mechanism. These angles are welded together in order to form a frame which will support the rollers and the assembly.
2) We design a basic frame for a prototype by mild steel channel (L beam),
3) L Channel- MS Angles are L-shaped structural steel represented by dimension of sides & thickness. For e.g. 25x25x3 means, both the sides of angles are 25 mm & thickness is of 3 mm. There are various sizes of angles which are as follows :-(there are also equal & unequal angles). Equal angles: - They are angles having both the sides of equal dimensions. For e.g. refer below given diagram, in which both the sides are of dimensions "a".

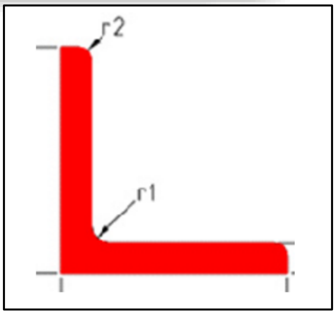

Fig. 3: L-angle bar dimensions

Size	Weight in Kgs.	Gauge	Thickness
in mm	Per Feet	Per Mtr.	
20x20x3	0.274	0.899	3mm
25x25x3	0.335	1.099	3mm
25x25x5	0.548	1.798	3mm
31x31x3	0.390	1.280	3mm

Table 1: Sizes with Section Weight of Equal Angles

By standard available sizes we select the 25 mm so because that will be easily available and have appropriate size for frame.

B. *Design of Frame Safety:*

Frame design for safety FOR 25*25*3 L angle mild steel channel

b = 25 mm, d= 25 mm, t = 3 mm.

Consider the maximum load on the frame to be 50 kg.

Max. Bending moment = force*perpendicular distance

= 50*9.81*150

M= 73575 Nmm

We know,

$M / I = \sigma b / y$

$I = bd^3/12$

$= 25*25^3 / 12$

$I = 32552.08\ mm^4$

$\sigma b = My / I$

$= 73575*12.5 / 32552.08$

$\sigma b = 28.25\ N/mm^2$

The allowable shear stress for material is σ_{allow} = Syt / fos

Where Syt = yield stress = 210 MPa = 210 N/mm^2

And fos is factor of safety = 2

So σ_{allow}= 210/2 = 105 MPa = 105 N/mm^2

Comparing above we get,

$\sigma b < \sigma_{allow}$ i.e. $28.25 < 105\ N/mm^2$

So design is safe.

C. *Shafts:*

VOTAGE OF MOTOR=12V

CURRENT OF MOTOR =3A

Power =current*voltage

=12*3=36W

Input Power by DC motor = 36watt.

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 $2\pi N/60$

$W=2\pi NMt/60$

$Mt= 30W/ \pi N$......eq^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.

$Mt= \pi/16\ (10^3\ \tau d^3)$ ....eq^n 2

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

In Eq. (3) W is in Watt, τin 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 are much smaller then torsional loads.

Service Condition	τs (MPa)
Heavily loaded short shafts carrying no axialload	48-106
Multiple bearing long shafts carrying no axialload	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

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

Taking allowable shear stress for shafts under small loads in coupling as τ= 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

Diameter Size in mm	5	6	8	10	12	15	18	20
	22	24	25	28	30	32	35	40
Diameter Size in inches	¼	5/16	3/8	7/16	5/8	½	¾	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.

Which 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.

D. *Magnetic Coupling*

Magnets are an important part of our daily lives, serving as essential components in everything from electric motors, loudspeakers, computers, compact disc players, microwave ovens and the family car, to instrumentation, production equipment, and research. Their contribution is often overlooked because they are built into devices and are usually out of sight.

1) *Magnetic properties*

Some important properties used to compare permanent magnets are: remanence (B_r) which measures the strength of the magnetic field coercivity (H_{ci}) the material's resistance to becoming demagnetized energy product (BH_{max}) the density of magnetic energy Curie temperature (T_C) the temperature at which the material loses its magnetism

Neodymium magnets have higher remanence, much higher coercivity and energy product, but often lower Curie temperature than other types. Neodymium is alloyed with terbium and dysprosium in order to preserve its magnetic properties at high temperatures. The table below compares the magnetic performance of neodymium magnets with other types of permanent magnets.

Magnet	B_r (T)	H_{ci} (kA/m)	BH_{max} (kJ/m³)	T_C (°C)	T_C (°F)
$Nd_2Fe_{14}B$ (sintered)	1.0–1.4	750–2000	150–440	310–400	590–752
$Nd_2Fe_{14}B$ (bonded)	0.6–0.7	600–1200	60–100	310–400	590–752
$SmCo_5$ (sintered)	0.8–1.1	600–2000	120–200	720	1328
$Sm(Co, Fe, Cu, Zr)_7$ (sintered)	0.9–1.15	450–1300	150–240	800	1472
Alnico (sintered)	0.6–1.4	275	10–88	700–860	1292–1580
Sr-ferrite (sintered)	0.2–0.78	100–300	10–40	450	842

$$F = 0.577 * B^2 *A*N$$

For Neodymium Iron Boron magnet

B= 175 kJ/m³

N= Number of magnets = 6

A= area for 30 mm round magnet= $\pi/4 \ D^2 = 7.06*10^{-4} m^2$

$F=0.577*175^2*7.06*10^{-4}*4$

F=49.9 N

2) *Torque transmitted*

Torque exerted by this magnetic force onto disc coupling is calculated by,

Torque = force*perpendicular distance

Torque = force*radius of disc

Disc diameter= 130 mm so radius will be R= 65 mm= 0.065 m

Torque T = F*R

T= 49.9*0.065

T= 3.24 Nm.

So the torque transmitted by the magnetic coupling is 3.24 Nm.

3) *Power transmitted:*

The power transmitted by the magnetic coupling is calculated by,

P= $2\pi NT/60$ watt.

P= 2*3.142*30*3.24/60

P= 10.18 watt.

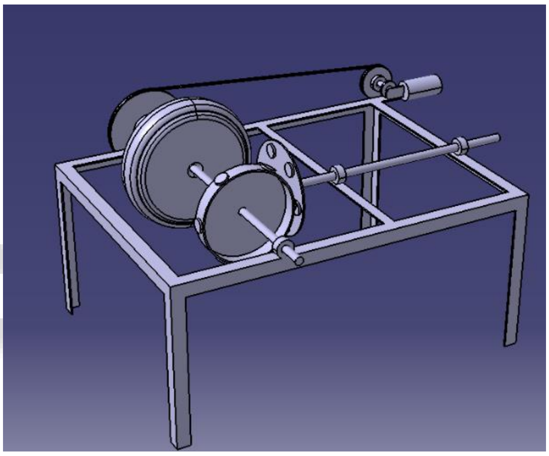

Fig. 4: CAD Model

V. Advantages & Application

A. *Advantages*

- Effective and eco friendly
- No effect on ongoing system cause using non-contact method
- Produced energy can be used or stored according to need
- Due to use of magnetic non-contact coupling there is no friction / wear / and heat production due to it hence power loss is very small.

B. *Application*

- For railway bogies, locomotives to produce electricity.
- This electricity can be used for lighting, water pumping and circulation and HVAC systems in train etc.

VI. 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 been 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.

Design and develop of train axle power generation is successfully completed.

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