International Journal of Current Engineering and Technology
E-ISSN 2277 – 4106, P-ISSN 2347 - 5161

Available at http://inpressco.com/category/ijcet

Research Article

Design based Electrical Power Generation using a Speed Breaker – A Green Power Approach

Vinayaka N[Ȧ*], Pavan Kumar A V[Ȧ], P B Shetty[Ȧ], Kiran Aithal S[Ȧ] and Krithi H Kornaya[Ḃ]

[Ȧ] Mechanical Engineering , NMIT, P.B.No:6429,Yelahanka, Bangalore -560064, India
[Ḃ] Aeronautical Engineering , NMIT, P.B.No:6429,Yelahanka, Bangalore -560064, India

Accepted 10 Aug 2014, Available online 13 Aug 2014, **Vol.4, No.4 (Aug 2014)**

Abstract

In a developing country like India, The struggle to get power is maximum, here is an attempt to generate the power in normal one way road by design based power generation similar to a speed breaker concept. The mechanism is very simple, a constrained inclined plate is used instead of a road hump which can create a to and fro motion if the spring is attached to it. The to and fro motion is converted into the kinetic energy of the flywheel by using a ball bearing and hence electrical power can be generated using that rotational energy. The power generated is considerably large as compared to other small scale renewable energy resources per square area and hence can be successfully implemented in daily life to generate power. From this the scarcity of the power to lit up can be reduced.

Keywords:*Power generation, Fixture, Speed breaker, Chain, Sprocket,Uni-Directional Ball Bearing and Flywheel*

1. Introduction

The mother earth is unique in the solar system, perhaps even in the universe, It is destructive, also in the mean while protects us from the cold hostility of space. Now it is our duty to protect our mother earth from pollution. In normal power generation process from conventional sources induces lot of pollution to the environment like thermal heat, waste gases, high pressured water in case of hydro-electric power plant and have the threat to extinct in next 10-15 years hence we see the non-conventional energy resources which can light up the future.

Energy crisis and pollution are major factors needed to be accounted for. When developing a new system which must be designed to consume minimal power along with less or no pollution to the environment, so it is necessary to utilize renewable energy resources to a greater extent to meet the desired requirement. The concept here is one among them, concentrating on the Powering up, when a vehicle passes on to an inclined constrained plate.

2. Concept

The basic principle is the same of an electrical power generation. When a magnetic flux links with the coil changes, an electro-magnetic force is induced in it. The induced power is stored in a power box and a battery can be utilized whenever required.

But the generation of rotational energy is the major challenge, many concepts have been developed to convert renewable source of energy into rotational energy. The attempt is to convert the weight and kinetic energy of the vehicle to rotational energy and thus generating power.

*Corresponding author: **Vinayaka N**

The system consists of following. These are explained individually in the future discussion.

1. Inclined Plate
2. Fixture and constrains
3. Sprocket and chain
4. Unidirectional ball bearing
5. Flywheel and bearing housing
6. Spring
7. Generator
8. Storage battery

The inclined plate is kept in the place of one way road hump, when the vehicle moves over the inclined plate, the weight of the vehicle causes the inclined plate to move down with a large force, the generated force is transferred to the chain and sprocket. The upper sprocket is connected to the unidirectional bearing which converts the downward motion into rotary motion, the rotational energy generated is sent to the flywheel attached to it with an inline shaft and the energy can be utilized for the generation of electrical power

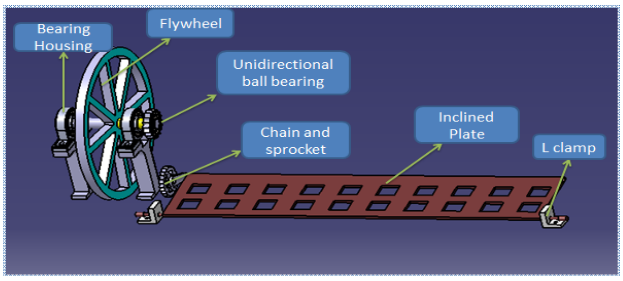

Fig. 1 Proposed Design Assembly

3. Construction and working

3.1 Plate

In the country like India, The Road are different at different locations, when we design something related to road, it is a must to consider all type of loads. The minimum road is considered to be 3200mm. the design of the plate is flexible depending upon the road specifications.

The loads acting is also to be accounted for the calculation of the design of plate, we have to consider from a very high load to the very small load.

Keeping in mind that every mechanical system is designed for the worst case condition, the plate design is done based on the maximum loads acting.Here is a list of few higher loads that are accounted.

BMTC bus= 10200 kg mass at back axle
Multi-Axle Volvo= 14500 kg at back axle
3 axles rigid lorry= 26000 kg gross mass
5 axle vehicle with draw bar trailer = 36000 kg
6 axle draw bar heavy duty lorry = 41000 kg
6 axles artic heavy duty vehicle = 44000 kg

Assuming the chances of overloading of the vehicle, a factor of safety of 3 is considered and the plate is designed.

After all the material we are using place an important role in the design of components. In order to have high strength, a SAE 2340 water quenched steel is considered having the following mechanical properties:

1. Ultimate strength=1206.2Mpa
2. Modulus of elasticity=206.8GPa
3. Yield strength=1034.6Mpa
4. Endurance Strength= 516.2Mpa
5. Rigidity modulus= 82.7Gpa

Using the Soderberg's criterion for the design of fatigue strength of the structural steel of the plate, the dimensions of the plate is calculated. Hencky-Mises theory of failures is assumed for the design.

Considering the fact that the multiple load can happen at different location at the same time, the plate considered is 1000mm x 200mm x 8mm..

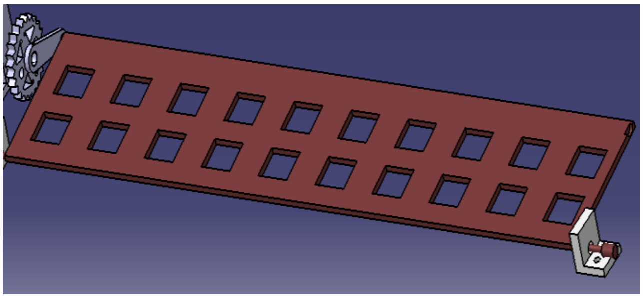

Fig. 2 Plate Assembly

For fixing the plate a stepped bar is designed. Considering the plate as a simply supported beam, the reaction forces are found out. The reaction forces acts as the boundary conditions for fixture design. In order to bear the reaction loads of the plate, a minimum of 11mm shaft is required. In order to obtain the above condition, a stepped bar has been chosen. A 8mm rod is welded to the plate which is of length 10mm and given a step of 11mm bar for 20mm distance. Another reason being considering the fact that the yield strength of the material increase with decrease in the length. Movement of the inclined plate is constrained for 30degree by designing the joint.

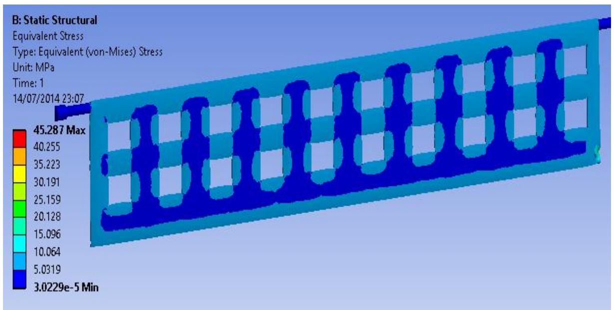

Fig. 3 Static Structural Analysis of Plate

The above figure shows the design and analysis of the plate respectively and the stresses induced are well within the calculated range and can be used safely.

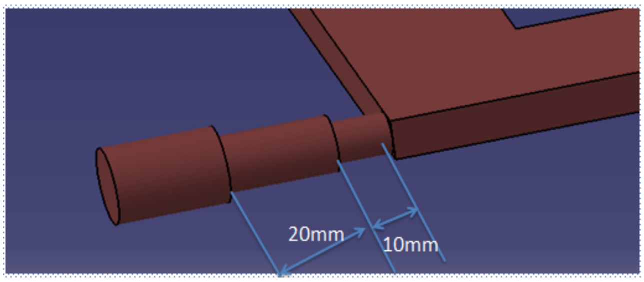

Fig. 4 Design of Stepped bar

3.2 Fixture

This is the important part of the mechanism where the plate is fixed to the ground, after many iterations of design, an L shaped thick plate as shown below is considered because of its high strength and high bending load carrying capacity.

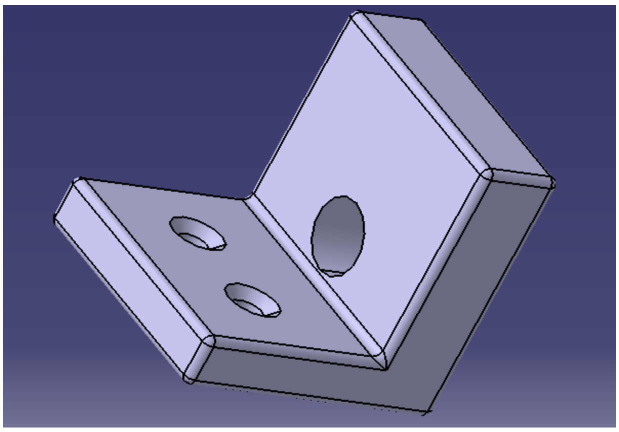

Fig. 5 Fixture

Even an inverted T clamp can be used in order to fix. But L clamp has the advantage of less mass and space when compared to the T clamp. One part will hold the shaft of the inclined plate and the other is being bolted to the ground with 2 countersunk M10 screws. M10 screw is taken in order to withstand the bending loads acting on it.

The thickness of the fixture is calculated from the hit and trial method by considering the bending reaction load and the axial loads. The ANSYS analysis has been done to check the stresses acting on the fixture. The below figures shows the meshed model of the fixture and the analysis results which will give satisfactory design stresses.

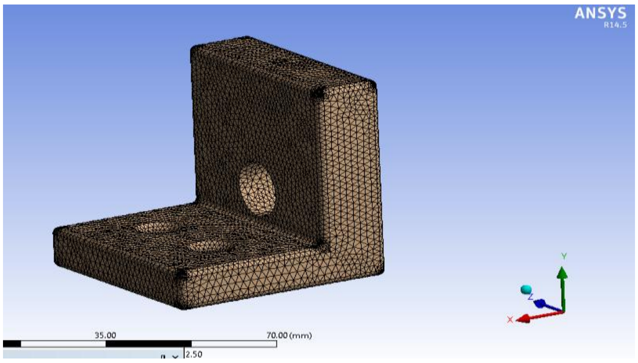

Fig. 6 Meshed model of the Fixture

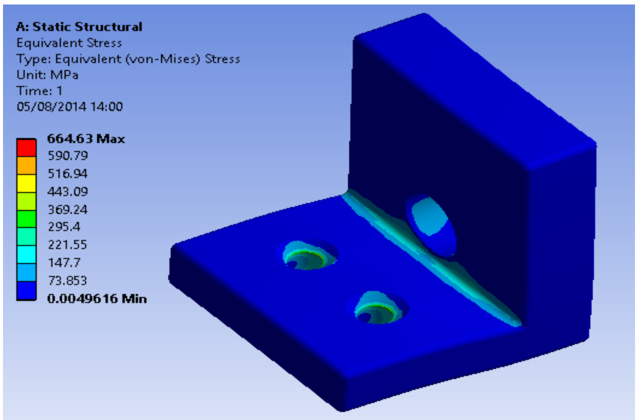

Fig.7 Static Structural Analysis of the Fixture

3.3Chain and sprocket

In the selection of mechanism, the connecting rod will give a jerk for the movement of the bearing, but the chain and sprocket mechanism will give less vibrations and less jerk for the movement. The sprocket link of dimensions 17cm long, 8mm thick bar can transmit the forces effectively to the sprocket.

Considering the sprocket link as a cantilever beam, the maximum bending moment is applied and the dimensions are found out.

Below figure shows the Sprocket link. 2 holes are provided in order to facilitate the fixing of plate at the one end and the sprocket at the other end. The bolts of M3 specifications can meet our requirement.

The driver sprocket has the 24 teeth and driven sprocket has 25 teeth.A centre distance of 188mm is considered in order to design the mechanism, the pitch of 15.87 mm is selected. While designing for the chain to connect the 2 sprockets, according to the calculations it has to transmit the power of 863 W, considering the FOS as 3, ANSI 10B at 300 rpm which can transmit the 3.15 kW.

The chain specifications dimensions are as follows:
Roller chain diameter= 10.16 mm
Breadth = 9.56 mm
Transverse Pitch = 16.59 mm

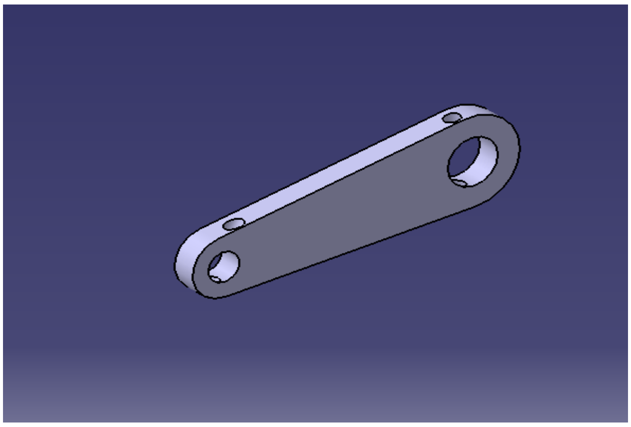

Fig. 8 Sprocket Link

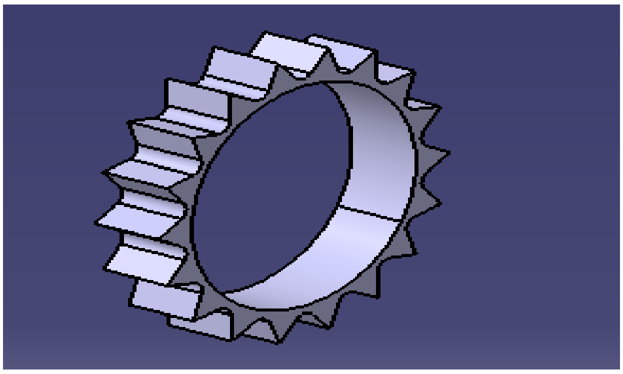

Fig.9 Driver Sprocket

Breaking load = 22.2KN
Duplex = 44.5KN
Triplex = 66.7KN.
Moderate shock factor, $K_s = 1.4$

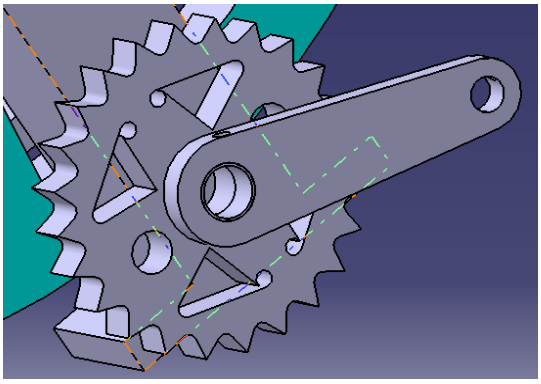

Fig.10 Driven Sprocket

From the equations of

$$Ln = 2\left(\frac{a}{p}\right) + \left(\frac{z_1 - z_2}{2}\right) + \left(\frac{z_1 - z_2}{2}\right)^2 \times \left(\frac{p}{a}\right)$$

The number of links is found to be 48

3.4 Unidirectional ball bearing

The deep groove ball bearing is best suitable in order to convert the motion and acts as unidirectional, if the chain rotates in the opposite way, it doesn't affect the front movement of the ball bearing.

The outer diameter of the bearing 72mm and above that the sprocket is attached which suits the module of the chain, the total outside diameter with the sprocket is 80mm, the inside diameter of the bearing is 30mm and thickness is 19mm.

The dynamic load carrying capacity of the bearing is calculated and found to be 28100N. The life of the bearing is calculated and found to be 50million revolutions.

A rod of 30mm diameter is chosen in order to carry the rotational power to the flywheel.

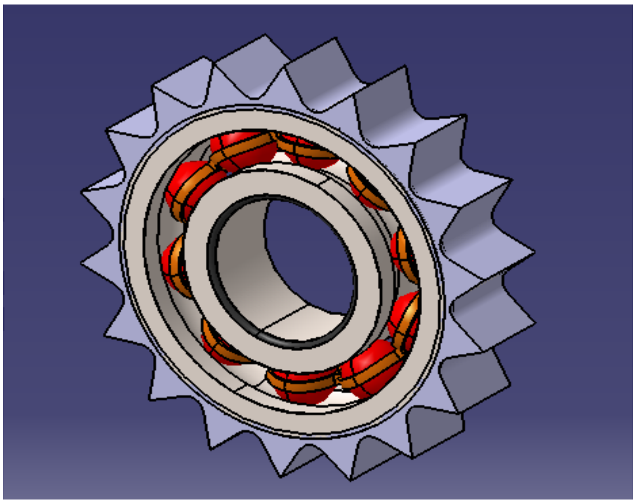

Fig.11 Unidirectional Ball Bearing assembled to Sprocket

3.5 Flywheel

The flywheel is the crucial part of the design, and its mounting is done either on the divider or on the footpath in case of cities and separate housing in case of the rural area in order to avoid accidents. The flywheel is designed for rotation of 250rpm, thickness 25mm and breadth 25mm for rim type.

The moment of inertia is found out by integrating the breadth of the rim over the limits of 30mm and 200 mm and found to be 0.223055kg-m^2 and the torque is 3.39728N-m. The mass of flywheel is found to be 5.576kg and the radius of the flywheel is 200mm.

2 deep groove ball bearings are used in order to fix the rotating shaft and the flywheel to the ground having inside diameter 30mm, outside diameter 90mm, having dynamic load carrying capacity of 42.5KN. The figure shows the fixing of the flywheel to the ground using ball bearing.

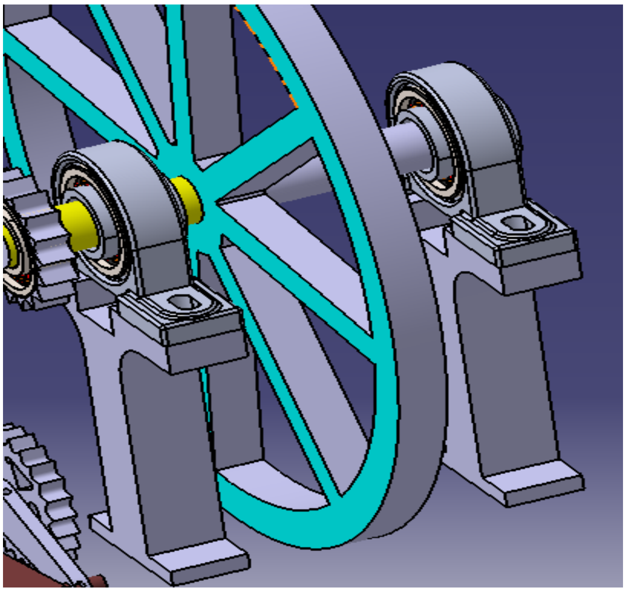

Fig.12 Flywheel

3.6 Design of helical compression Spring

The helical compression spring is used in order to bring the plate back to its original position, the material of C-75 is taken, fatigue analysis is done by considering the Soderberg criteria of fatigue strength and the dimension of the springs that can withstand are mentioned below:

Mean Diameter of spring, D = 98mm
Spring index, C= 8
Wire Diameter of spring, d= 12mm
Free length = 210mm
Deflection, L_f = 96mm
Squared and Grounded, no. of active coils, n' =10

1	**FATIGUE ANALYSIS OF SPRING**		
2	**INPUTS**	**Value**	symbol
3	Minimum force, Fmin	100	N
4	maximum force, Fmax	2943	N
5	Mean dia of spring, D	98	mm
6	Spring index, C	8	
7	active number if coils, i	10	
8	**Modulus of rigidity, G**	80000	Mpa
9	**Endurance stress, Te**	720	Mpa
10	**Yeild shear stress, Ty**	1200	Mpa
11	**additional coils, n**	2	condition for ground(end)
12			
13	**outputs**		
14	Diameter of spring wire, d	12.25	mm
15	Outer dia of coil, Do	110.25	mm
16	Inner dia of coil, Di	85.75	mm
17	total length of coil, l	3078.760801	mm
18	mean force ,Fm	1521.5	N
19	Amplitude force, Fv	1421.5	N
20	Wahl's stress concentration factor, k	1.184017857	
21	shear stress factor, Ks	1.0625	
22	Mean shear stress, Tm	219.4617406	Mpa
23	amplitude Shear stress, Tv	228.4878127	Mpa
24	**Factor of safety**	**1.594472558**	
25	Maximum Deflection, y	123.0053878	mm
26	free length Lo	210.5297143	mm
27	Pitch P	18.60297143	mm
28	Stiffness of spring, Fo	23.92578125	N/mm

Fig.13 Fatigue Analysis Calculator of Spring

The spring is kept in a hollow bore so as to support it; the spring is buried 100mm inside the road in the bore.

The reason being, the spring is designed to take maximum load of 300kg, once it crosses 300kg, the spring will be in completely deflected form and the rest load is taken by the ground itself as it is buried, As soon as the load is removed, the spring comes back to original position as the load acting on the spring now is only the weight of plate that is 27 kg. The most important features considered in order to design the spring is

- Load is always pulsating not reversed.
- Yield strength varies with wire diameter
- Wahl's factor takes care of direct stress as well as bending stress.
- Overload just closes the gap between coils without a dangerous increase in deflection.

3.7 Generator and battery

It is said that the energy is transformed from one form to another. So, we can simply use generators which convert rotational mechanism to get electrical energy. The generated power can be either stored directly to the battery or it can be directly given to the grid. In order to store the generated power, batteries can be used and stored energy can be utilized for many other applications. The Design specifications of the DC generator are as follows:

No of poles = 24
Synchronous speed = 4.1rps
Specific loading = 055 Wb/m^2
Electric loading = 28000 A/m
Quality factor = 0.955
Machine constant = 162
For rectangular poles assuming length/ torque = 3
Length = 59mm
Diameter = 150 mm
Normal peripheral velocity = 1.9635m/s

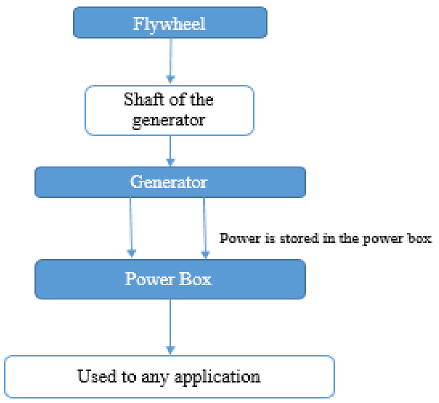

Fig.14 Mechanical to Electrical Energy Conversion

Thus, the mechanical energy can be converted into electrical means as shown in the flow chart above.

Conclusion

The proposed design is highly cost effective and can be used for high power generation and for a longer life as it is used for one way meanwhile controlling the traffic at the other side of road can be done without monitoring as it inhibits the movement serving as Power Generator as well as a Speed Breaker making effective utilization of unused renewable energy source in the current world scenario.

References

Machine Design, An Integrated Approach by Robert L Norton.

ShakunSrivastava, Ankitasthana, (2011), Produce electricity by the use of speed breakers, Journal of Engineering Research and Studies, Vol.2, No.1.

Mukherje, D., Chakrabarti, S, (2005), Non-conventional power plants, New Delhi

Aswathaman.V and Priyadharshini.M, (2011), Every Speed Breaker Is Now A Source Of Power, International Conference on Biology, Environment and Chemistry, IPCBEE vol.1 IACSIT Press, Singapore. Press, Singapore.

Alok Kumar Singh , Deepak Singh, MadhawendraKumar,VijayPandit and Prof.SurendraAgrawal, (2013), Generation of Electricity through Speed Breaker Mechanism, International Journal of Innovations in Engineering and Technology (IJIET),Volume-2, Issue-2,

Pankaj D. Jagtap, Sanket D. Pardeshi, Angad G. Khade,VarunSathe, Comparison of different Mechanisms for Electricity Generation using Speed Breaker Sanket D. Pardeshi, Multidisciplinary Journal of Research in Engineering and Technology Volume 1, Issue 2, Pg.202- 206, ISSN:2348 – 6953

AmanpreetKaur, Shivansh Kumar Singh, Rajneesh, Parwez, Shashank, Power Generation Using Speed Breaker with Auto Street Light, International Journal of Engineering Science and Innovative Technology (IJESIT) Volume 2, Issue 2, March 2013, ISSN: 2319-5967

Design of Machine Elements, RS Khurmi.

Mechanics of Material, Johnston and Beer.

Design data hand book-1, K.H Lingaiah.

Design data hand book-2, K.H Lingaiah.

CMTI design data hand book.

http://en.wikipedia.org