GENERATION OF POWER USING RACK AND PINION ON BICYCLE SUSPENSION SYSTEM

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Abstract
Rack and Pinion mechanisms are used in many applications like Hydraulic press, star lift, rack railway, actuators etc. In this present work a rack and pinion, battery, dynamo and other components are used to generate electricity. It is generated when the suspension system undergoes deformation resulting in movement of gear. This energy is converted to electric energy. Here we use CATIA software to create the models which is as explained below. The entire model is tested using a battery of 12V, 9V by considering the key parameters in design. The result obtained shows the theoretical value 10.5W, experimental value 6.3W with an efficiency of 47.5%.

Keywords: power generation , bicycle suspension, green energy, mountain biking

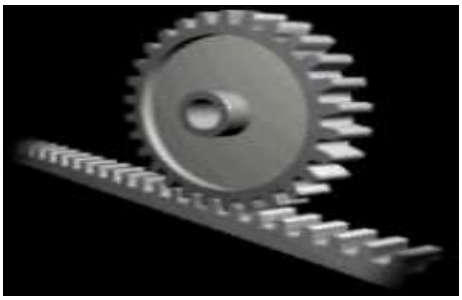
Introduction

The consumption of conventional energy is day by day increasing rapidly and this is leading to the energy crisis. The increasing power demand results reduce in conventional resources for power generation and an increase the pollutants emissions [1,2]. To minimize the emission of greenhouse gases, renewable energy technologies are widely used for electricity generation. Solar and wind technologies are frequently used for electricity generation. This converts kinetic energy into electric energy. The Mounting alignment of rack and pinion drives is critical to the performance and lifetime of the axis .racks can be mounted in any position.

The rack should be mounted with the teeth facing down or covered to minimize contamination. Apart from cars, it is also used in many applications. This study contains the analysis of rack and pinion used in a bicycle. The analysis is done using traditional materials like structural steel. Already existing manufacturing equipment can be used to produce it. This makes it relatively cost-efficient to produce. CATIA software is used for designing. To improve the power generation technologies and to make them more sustainable, non – conventional technologies have been discovered[3,4]. Energy generated by using wind, tides, solar, geothermal heat, and biomass including farm and animal waste is known as non-conventional energy. [3]All these sources are natural, renewable, or inexhaustible and do not cause environmental pollution, and are eco-friendly. Moreover, they do not require heavy expenditure. The non-conventional sources of energy are abundant in nature. Most of the non – conventional sources have been boons at hand only to the well-developed countries. The developing countries that lag in technical assets and financial limitations are striving to install the technologies of the latest trends and advanced versions. With the vast development of the technologies and understanding of them, many other creative techniques of power generation have emerged. The newly developed techniques are aimed at cost-effectiveness. Thus they become more affordable in the countries like India, where installation cost and space occupancy are serious issues. One such creative technique is power generation through speed breakers. The idea is to tap the potential energy that a vehicle would acquire when it is lifted over the speed breaker as it rolls over it. It is achieved in three possible ways. The ways are the Use of a lever mechanism Use of a roller mechanism and the Use of rack and pinion mechanism. The rack and pinion mechanism has advantages over the other two. When compared with the roller mechanism, the slip of the tires over the speed breaker is avoided as is possible in the roller mechanism. The slip of the tires would pose more trouble to the vehicle user than the power generated. Now our project is to completely utilize the technique of using rack and pinion mechanism for power generation.

Rack and Pinion Assembly

The figure 1 shows rack and pinion mechanism is used to convert rotary motion into linear motion and vice versa. A round spur gear, the pinion, meshes with a similar gear which has teeth set in a straight line, the rack. A rack and pinion is a type of linear actuator that comprises a pair of gears which convert rotational motion into linear motion. A circular gear called the pinion engages teeth on the rack, rotational motion applied to the pinion causes the rack to move, thereby translating the rotational motion of the pinion into the linear motion of the rack. And linear motion into rotary motion.



FigureNo1: Rack and Pinion

Dynamo

The table 1 shows dynamo is an electric generator that creates direct current using a commutator. Dynamos were the first electrical generators capable of delivering power for industry, and the foundation upon which many other later electric-power convertor devices were based, including the electric motor the alternating motor alternator. It is known that the supplies of fossil fuels are limited and their utilization as energy source causes environmental degradation due to unfinished ignition when used as energy source, in addition to this as the world population increase the order for energy sources increases, so the issue of a steady replacement of fossil fuels with renewable energy source is of major consideration for most countries. Renewable power generation system is currently preferred for clean power generation. With ongoing revolution in the generation. Power generated by suspension can be converted from mechanical to electrical energy by using either dynamo or alternator.

Table No.1: Specifications of Gear

Pitch Diameter of Pinion	60mm
Circular Pitch	9.42mm
Gear Ratio	3
Addendum	3mm
Dedendum	3.75mm
Addendum Dia	66mm
Dedendum Dia	52.5mm
Rack Length	300mm
Pitch	15.5mm
Depth of tooth	10mm

Statement of the Problem

Due to increase in power requirement for the cyclist to drive the bicycle there raised the development of generation of alternate source of power generation. In order to achieve this the proposed invention a mechanical system coupled with dynamo for generation of dc power through the motion of gear in rack and pinion system mechanism of the spur gear is developed

Objectives of the study

- To design, develop the power generation unit for Bicycle Suspension.
- Testing and validating design of Bicycle.

Review of Literature

Suchit Moon et al [1]- **"**Power Generation using Vehicle Suspension". This literature review is to go through the main topics of interest. The literature reviews is concerned with design of spur gear, DC generator, design of shaft, Selection of bearings & shock absorber with Theoretical and experimental evaluation. The linear moment crank is converted into the rotary motion which is fixed to the shaft. As dynamo rotates it leads to the generation of energy. The design is done using SOLIDWORKS and analysis is carried out using CFD. Here we are using a mechanical motion rectifier (MMR) to convert oscillatory vibration into unidirectional rotation of the generation. From this experimental result output power at the alternator is 3W for a minimum 5mm lift of the rack. The variation of the lift of ±5mm to ±20mm DMM shows that LED lamps glow when we operate the rack by hand. The rack & pinion gear is transmitted to the DC generator of the bearing & this generates electricity. This experiment results indicate the advantage of the motion rectifier is important compared to the flexibility of the prototype by model.

R. Shashank et al [2]– "Design and development of suspension system for power generation". The Kinetic energy is stored in the springs when reciprocating and the frequency of vibration is attenuated by dampers only to dissipate all the energy in the form of heat. An electro-magnetic regenerative suspension converts the energy stored by the springs into electric energy that is easy and commodious to store and reuse, has high performance, increased efficiency, and requires fewer space requirements. The prototype Suspension system was modeled using a 3-D Modeling tool. CAD model helped in visualizing the Suspension system, and the right combination of assembly and appearance. To measure the potential drop occurring in the current-carrying conductor, the ends of the copper windings were connected with wires. The other end of the wires was connected with multi-meter adapter pins. A multimeter was used to measure the potential drop occurring at the current-carrying conductor due to the spring actuation. The voltage reading obtained was in the range of 100 mV to 350 mV. Upon increasing the actuation speed, the voltage was increased up to700 mV. The results of the electricity generated from the Suspension System for Power Generation in terms of voltage are depicted. The electricity generated was in the range of 125 mV to 350 mV (with increased actuation speed, up to 700 mV), which is less, but it can be increased with the use of neodymium magnets which have higher flux density.

Meghraj P. Arekar et al – "Power Generating Shock Absorber"**.** The Power-Generating Shock Absorber (PGSA) converts this kinetic energy into electricity instead of heat through the use of a Linear Motion Electromagnetic System (LMES). The LMES uses a dense permanent magnet stack embedded in the main piston, a switchable series of stator coil windings, a rectifier, and an electronic control system to manage the varying electrical output and dampening load. The bottom shaft of the PGSA mounts to the moving suspension member and forces the magnet stack to reciprocate within the annular array of stator windings, producing alternating current electricity. From the perspective of comprehensive performance including vibration control ability. Regenerative efficiency and application reliability, the configuration of the hydraulic transmission, and the self-powered MR damper show the best attraction. With the improvement of technology, Power Generating Shock Absorber may become one of the promising trends in the vehicle industry. An electromagnetic linear generator and regenerative electromagnetic shock absorber is disclosed which converts variable frequency, repetitive intermittent linear displacement motion to useful electrical power. The innovative device provides for superposition of radial components of the magnetic flux density within a coil winding array. Due to the vector superposition of the magnetic field and magnetic flux from a plurality

of magnets, a nearly four-fold increase in magnetic flux density is achieved over conventional electromagnetic generator design with a potential sixteen-fold increase in power generating capacity. As a regenerative shock absorber, the disclosed device is capable of converting parasitic displacement motion and vibration encountered under normal urban driving condition to a useful electrical energy for powering vehicles and accessories or charging batteries in electrical and fossil fuel powered vehicles. The disclosed device is capable of high power generation capacity and energy conversion efficiency with minimal weight penalty for improved fuel efficiency

Results and Discussion

Acceleration :

It's a rate of change of the velocity of an object w.r.t time. We need acceleration to find the force acting, so from the inclined plane formula we got the acceleration.

i.e. With the help of omni inclined plane calculator , considering the parameters of

angle of inclined plane, ɵ= 30º ; Weight =75kg ; The obtained acceleration to be, a = 2.9 m/s² .

W.K.T Force requried to move the vehicle is F = m*a

Therefore,

Force :

It can be described as a push or pull on an object[4].

F = m*a where, m= mass of the person in kg

a= acceleration in m/s²

Consider the average human weight = 75kg. So, the force, F= 75*2.9 = 217.5N

Torque :

Its the product of force and radius[5].

i.e. T = F*r

= 217.5*60 = 13050 N-mm Where, F = Force in Newton(N)

r = radius of drive train gear in mm

Power : Defined as, The amount of energy converted per unit watt [6].

i.e. P = 2ΠNT / 60*1000 Where, N = no. of rotation of the wheel = 80rpm

T = Torque in N-mm

= 2*Π*80*13050 / 60*1000

= 109.32 kW

Impact on the suspension:

Uing, $\sigma i = \frac{W}{A}\left(1+\sqrt{1+\frac{2hAE}{Wl}}\right)$ Where, E = Young's Modulus

h = Height of free fall in m

As, h = 0. Because of free fall, no object is falling

Therefore the above equation can be reduced to,

$\sigma i = 2(W/A)$ Where, σi = Impact load in N/m^2

$= 2(0.675/ 0.8042)$ W = Weight of mechanism in kg

$\sigma i = 1.678\ N/m^2$ A = Area of suspension = $\Pi r^2 = \Pi*(16)^2$

$=804.2mm^2 = 0.8042m^2$

r = radius of suspension in mm = 16mm

W.K.T,

$F = \sigma i * A$

$= 1.678* 0.8042$

$= 1.35N$

Therefore,

Power due to impact = Force * Acceleration [7]

$Pi = F*a$ Where, a = acceleration due to gravity in m/s^2

$= 1.35*9.81$

$Pi = 13.243\ Nm/s^2$

Considering the time for the compression, t = 1.5 seconds

Therefore,

Total impact Power = Pi*t

$= 13.243* 1.5$

$= 19.86\ Nm/s$

Power generated by the working mechanism:

Therotical , $P = V*I = 21* 0.5 = 10.5W$

Where, V = voltage of battery

I = Current in ampere

Experimental,

$P = V*I = 21* 0.3 = 6.3W$ Where, V = voltage of battery

I = Current in ampere

Conclusion

When there is slow rotation of the pinion, the current produced is less, when compared to the fast rotation. We get some similar brightness out of the LED, when compared with therotical and experimental values. Comparing theoretical and experimental values there is difference in voltage and current. So we can take the average and we get a value as 8.2W of as our output. The efficiency is got is 47.5%.

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