A Review on Various Method of Power Generation in Automobile Suspension System

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Abstract - In current scenario, power is the primary need for the survival of human life. Researches shows that large amount of power is generated from non-renewable energy resources compared to that of renewable energy resources. The extensive usages of available resources in recent years created a demand for the future generation. To overcome this problem we need to utilize renewable energy sources for power generation and conservation. Therefore the focus now is shifting more and more towards the renewable source of energy, which are essential and non-polluting. In this paper it is mainly focused to provide the detailed survey of power generation mechanism from renewable energy resources includes piezoelectric mechanism, rack and pinion mechanism, piston mechanism and the roller mechanism.

Keywords: Suspension, renewable energy, power generation, rack and pinion.

I. INTRODUCTION

Energy is utilized by each and every organisms in the universe for its survival. As in this fast moving world, the population is increasing day by day and the conventional energy sources are lessening. The extensive usage of energy has resulted in an energy crisis over the few years. Therefore to overcome this problem we need to implement the techniques of optimal utilization of conventional sources for conservation of energy.In this paper it is mainly considered on generating the electricity in the suspension system of the automobile and store the energy in the battery or alternator as conventional method by simply driving the vehicle. Current sports bikes are normally without kickers and this power generation method can be used to charge the battery within short span of time. In this paper few of the power generation methods in the vehicle suspension system is discussed.

Every automotive suspension system has two goals: passenger comfort and vehicle control. The function of the shock absorber is to dampen the vibrations of coil and leaf springs used in the suspension system. These vibrations are generated when vehicle passes over a road bump. The kinetic energy generated from the suspension system is converted into electrical power by using various mechanism. This paper is mainly concentrate on few power generated mechanism in vehicle suspension system. The followings are the topics considered to be reviewed in power generation methods.

1. Piezoelectric Method

Energy harvesting can be done by this method with effectively and efficiently. The principle of the piezoelectric material is to convert the mechanical stress (such as vibration, load) into electrical energy. To obtain the pollutionfree energy source and to utilize and optimize the energy being wasted. This power generation is more sustainable, economic and ecological by utilizing in the technology. The high sensitivity of piezoelectric transducers makes them useful in microphones, where they convert sound pressure into electric voltage, in precision balances, in accelerometers and motion detectors, and as generators and detectors of ultrasound. They are also used in nondestructive testing, in the generation of high voltages, and in many other applications requiring the precise sensing of motion or force.

2. Rack and Pinion Method

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 a linear "gear" bar called "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. Rack and pinion gears are used to convert rotation into linear motion. The flat, toothed part is the rack and the gear is the pinion. A piston coaxial to the rack provides hydraulic assistance force, and an open centered rotary valve controls the assist level. A rack and pinion gears system is composed of two gears. The normal round gear is the pinion gear and the straight or flat gear is the rack. The rack has teeth cut into it and they mesh with the teeth of the pinion gear.

3. Fuel Piston Method

The Piston mechanism consist of a cylinder arrangement with the piston mounted on the connecting rod. This mechanism converts linear motion of the piston into electrical energy. The current generation is denser. This mechanism require more kinetic energy for the generation of desired electrical power. The design and the implementation of this mechanism is more difficult but the generation of electrical energy is high in range.

4. Roller Mechanism

The roller mechanism consist of a materials such as bar shaft, couplers like clutches, hub of dynamo, linear motor. The bar shaft replace the function of speed breaker thus vehicle rotates the roller on passing the speed breaker. The roller rotates the hub of the dynamo with the help of chain and pulley. The hub of the dynamo is attached to the bicycle tyre therefore power is generated while riding the bicycle.

II. REVIEW ON POWER GENERATION METHODS

Mukthi Nath et al. [1] experimentally investigated on piezoelectric materials, solid materials (crystal and ceramics), biological matter (DNA, bone and proteins) and non-conducting materials to generate power. Mechanism of piezo electricity is reconfiguration of the di-pole by reorientation in its polarization. Polarization can be depend on the following factors (i) The orientation of piezo with in the crystal, (ii) Crystal symmetry and (iii) The applied mechanical stress. The result from this experiment is the generation of 12500V from the $1cm^3$ quartz by applying2 KN mechanical load. The major problem of in this experiment is strong electric field can break the dipoles and depolarization of the piezoelectric material. This method is used in buzzer and solar system and also it is used in the tele communication system.

Parthiba Arun V and Divyesh Mehta [2] experimentally tested piezoelectric (Quartz) dielectric hysteresis, stability, depolarization, Coupling factor, electrical depolarization, mechanical polarization, pyro electric effects and thermal polarization. In this testing method the mechanical Q factor and dielectric loss factors are reversible to each other. In electrical depolarization a material temperature and static fields are concerned along with the 200 and500 V/mm and also voltage production can be achieved under Curie point ($0\ ^0C$) as well as coupling factor is used to measure the effectiveness.. Experimental result of the quartz as dielectric constant is 4.5, coupling factor is 0.09, charge constant is 2.0, voltage constant is 50 and the quality factor is established transverse of the vibration under full scale voltage range of ±200 V. This analytical exploration proved that, to have proficiency of over 35%, more than three times greater than solar system, and also 8.4 W of generated power from PZT mounted in shoe. The properties of the piezo is such as Modulus of piezoelectric 63 GPa, Strain coefficient $-179X10^{-12}$ m/volt and Density is 7700 kg/m^3. In 25 Hz frequency at 100 kΩ the measured current is 0.345 mA and percent error is 0.95% (very less). Damping circuit has been included to reduce the effect of the damping factors.

Henry A et al. [3]mathematically established transverse of the vibration under full scale voltage range of ±200 V. This analytical exploration proved that, to have proficiency of over 35%, more than three times greater than solar system, and also 8.4 watts of generated power from PZT mounted in shoe. The properties of the piezo is such as Modulus of piezoelectric is 63 GPa, Strain coefficient is $-179X10^{-12}$ m/volt and density is 7700 kg/m^3. In 25 Hz frequency at 100 kΩ the measured current is 0.345 mA and percent error is 0.95% (very less). Damping circuit has been included to reduce the effect of the damping factors.

Kiran Boby et al. [4] theoritically reviewed on the generation of electrical power from piezoelectric crystal for the agriculture application, home application, and street lighting applications. The materials used are $PbTio_3$, $PbZro_3$,

PVDF and PZT. From this material, the produced voltage is in terms of µA. From various experiments the output levels can be calculated between current to voltage ratio. When the force acting on the force sensor the current gradually increased 0.4 µA depending on voltage. In parallel connection force sensor gives 7 µA as well as a series connection gives voltage level is around 3 µA. By using MOSFET (two) in the inverter circuits, it implement the power upto 12V – 14V. Eventually by using mathematical calculations the output power generation is around 39 V (maximum in piezo tile).

Amod Kumar Pandey et al. [5] experimented that the electrical energy is generated from the speed breakers due to the motion of the vehicle by using the rack and pinion arrangement. The roller attached with gear arrangement will rotate when a vehicle moves over it. It is found that a maximum of 15W power can be obtained from this method. If the kinetic energy of the roller is 4541 J then 5V electrical power is generated at 4 Sec and it will give the efficiency of about 40% and if 6469 J of kinetic energy will act on roller then 5.5 V electrical power is generated at 4-5 Sec. It is experimentally described that the current installed capacity of India's is 255.012 GW. The peak power shortage of our nation is 7.4%. It is derived that this mechanism will generate 1000 W electrical power when the number of rollers is increased.

A.Padma Rao et al. [6] investigated the generation of electrical energy from the kinetic energy of the moving vehicle. In this paper it is mainly focused on the conversion of potential energy into electrical energy. Due to the motion of the vehicle the kinetic energy is used to generate the electrical energy. In this method the electrical energy is generated from the special arrangement called power hump. Power hump is nothing but it is the electro-mechanical unit. It employs both the electrical and mechanical techniques for the electrical power generation and the storage of power.

Aniket Mishra et al. [7] described in this paper that the kinetic energy of the moving vehicle can be converted into mechanical energy of the shaft through the rack and pinion arrangement. This method is made through rack and pinion gears, ball bearing, spur gear, flywheel, shaft and generator. The mass of the vehicle travelled through speed break is 300kg then the output power developed for one minute is 7.37 W and for one hour is 441.4 W and for one day is 10.8 W. Thus the electrical energy generated by the vehicles in one day is sufficient for running the four street lights at a time for a whole night. Now a days the conventional energies are become very low in quantity so it is the right time for focusing on the alternative sources. This process is a pollution free power generation and no any need of man power during the power generation.

Pankaj D.Jagtap et al. [8] investigated experimentally on the three methods of power generation from the kinetic energy of the moving vehicle. They are rack and pinion, roller and the air piston methods. The roller mechanism setup is very cheap and easy to install and it requires very less maintenance thus it gives 50% efficiency. The rack and pinion mechanism implies moderate cost and difficult to install and it needs weekly maintenance with 70% efficiency. The air piston mechanism is very difficult to install and it is very costly process and it requires daily maintenance with 85% efficiency. It is concluded that the rack and pinion mechanism is the cheap and efficient method for producing the electrical energy from speed breakers.

Qihui Yu et al. [9] made investigation on generation of power by using piston mechanism. In this mechanism the compressed air engine (CAE) is used to convert compressed air power into mechanical energy. Now a days researches are implemented to improve the efficiency by using this technology. In this paper mathematically derived model and principle of CAE are established. CAE technology is continuously researched to increase the performance and efficiency .The efficiency attained is about 31.17% by using this method. The output power from this CAE is 2 KW at the pressure of 2.99 MPa. In this paper the improved NSGA 2 has been introduced.

Chih-Yung Huang et al. [10] investigated on the compressed air as mechanical energy for generating electricity. The generated of power of 0.96 W at the pressure of 5-9 bars in 9.9 Nm of torque. The power generated using this method is 0.96 W with the pressure of 5-6 bar and 9.9 Nm of torque. The air flow rate to engine is about 1050 l/min .It reduces the performance. It can be improved by increase intake and exhaust dimensions by 4 stroke engine is modified into 2 stroke engine. This paper describes the methods to increase power output from same input pressure of 2.2 bars. It is found that 13% higher power is obtained by using this method.

B.K.Ravivarma et al. [11] proposed the energy generation methods using air piston mechanism. The renewable source of energy from vehicle bumpers can be utilized. This paper describes about the hydraulic piston mechanism to generate electricity. To produce mechanical energy the pressurized hydraulic fluid is allowed to pass into turbine.

From this method it can generate power approximately about 70.5 W and the average kinetic energy produced is around 1000 N. By applying this method, it is easy to get 500 W of power in a very short time.

Mikalson and rosekilly [12] numerically designed and simulated the free piston diesel engine generator. It is proved that the change in design parameter will vary many operational parameters. It is found that the fuel efficiency is good with mechanical simplicity in engine and also the emission is reduced with lower temperature levels. The efficiency of the engine reaches the maximum of 40 % to 43% with increase in compression ratio. From the result it is concluded that the boost pressure is 1.68×10^5 Pa, Speed generated is 30HZ and the output power obtained is 44.4 W.

Rajesh Kannan Megalingam et al. [13] experimentally states that dynamo or alternator is used for conservation of energy produced during riding of bicycles. Both dynamo and alternator are used to convert mechanical energy into electrical energy. Alternator can generate 100 W – 300 W by applying a load of 0.5 kg. By using dynamo comparatively less load is used then alternator and with a load of 270 grams, it produce 3W (6V, 500 mA) or more than alternator has better efficiency than dynamo but the size of alternator is big. Alternator requires high speed of about 1000 rpm and also the cost is high. Where dynamo can run in speed of 130 – 170 rpm and cost is also less. The produced energy is stored in battery and used to power the laptop, washing machine, refrigerator, water pump, washing machine, lawn motors, blenders, and other mechanical application.

Antonin Stribrsky et al. [14] experimentally states that linear motor is fitted in the suspension system for power generation. During the sprung and unspring of the shock absorber linear motor is actuated thus it convert vehicle vibration caused by road disturbances in to electrical energy. The produced energy is stored in accumulator and it can used by vehicle accessories. Thus it reduce the load of generator over the engine results in increased vehicle efficiency. The force of 2027 N act on the suspension then the linear actuator is induced to produce a power of 21.8A and continuous AC output of 320V. The weight of the vehicle is directly proportional to the current generated. The weight of the vehicle has to consider for the active suspension, car stability and passenger comfort.

B. Santhosh sarma et al. [15] experimentally investigated on roller mechanism that is mounted on speed breaker and generator so that when a vehicle passes over the speed breaker it rotates the generator. The output voltage is generated during the vehicle passing through the speed breaker. The load of vehicle is directly proportional to the voltage and current generated. The vehicle speed is inversely proportional to the voltage and current generated due to more grip between vehicle and speed breaker at low speed. And also there is some anti-directional rotation of roller, it can be converted into positive voltage by using bridge rectifier. The generator can produce a power of 1.67 W in a minute by a constant mass of vehicle 205kg passing over the speed breaker.

Junzhi Zhan et al. [16] made experimentally investigation with motor generator that is fitted with the power train of the front and rear wheel of the vehicle to generate electrical power. The brake is applied, brake controller is actuated to connect motor generator with the power train results in reduction in speed of vehicle and there is regeneration of energy from braking system. The two types of RBS (Regenerative Breaking System) are serial and parallel RBS, serial RBS (Regenerative Breaking System) is the combination of friction based adjustable breaking and RBS with integrated braking circuit. The parallel RBS is the combination of friction based braking system and RBS operated one by one, without integrated system which can be adjusted manually. By using RBS about 76.2 % of power can be regenerated from the initially spent energy. The energy regeneration higher in parallel RBS and drivability is better in serial RBS.

III. SUMMARY OF IMPORTANT INVESTIGATION

S.NO	AUTHOR NAME	MECHANISM	OBSERVATION	COMMENT
1.	Mukti Nath Guptha et al.	Piezoelectric effect	Relation between voltage and time is proportional by Euler - Bernoulli theorem (theoretical models).	When 2 KN load applied through piezo crystal, the electrical output voltage power is 12500 V.
2.	Parthiba Arun and Divyesh Mehta.	Piezoelectric effect	Voltage gradually increased by increasing of time under the random force and it yields an efficiency of 65-75 %.	20 - 30 V of power generated from an observational experiment.

3.	Henry A. Sodano and Daniel J. Inman.	Piezoelectric effect	Magnitude and frequenciesare reversible to each other.	Analytical investigation gives around 8.4 watts usable power is generated.
4.	Kiran Boby et al.	Piezoelectric effect	Current and voltages are consistently augmented for the ferroelectric materials.	The maximum voltage power that can be generated across the piezo tile is 30 – 40V.
5.	Amod Kumar Pandeyet al.	Rack and pinion mechanism	This method is economical, easy to install and Non-polluting.	This method will generate 1.2 V when the kinetic energy of 10057 J will act on the roller at 4 Sec.
6.	A.Padma Rao et al.	Rack and pinion mechanism	The electrical energy is generated by utilizing the kinetic energy of the moving vehicle is the best method of generating electrical energy with the efficiency of70 - 80 %.	Electrical energy of 2.452 W is generated by the vehicle of mass having 150 kg by one push of speed breaker.
7.	Aniket Mishra etal.	Rack and pinion mechanism	If the speed of the vehicle is increased then large amount of power is generated. Speed is directly proportional to energy.	Various methods of generation of electrical power in speed breakers is discussed in this paper.
8.	Pankaj D.Jagtap et al.	Rack and pinion mechanism	The rack and pinion mechanism is the best method for efficient and moderate cost of producing the electric power from speed breaker and it gives 60 – 80 % efficiency.	It is observed that the rack and pinion mechanism will give the efficiency of 1.5 times greater than the roller mechanism.
9.	Qihui Yu et al.	Fuel piston mechanism	The output power generated is increases with respect to decreasing in efficiency	It is experimentally proved that 0.8761 KW of output power is obtained when 3 MPa of pressure acts on compressive air engine.
10.	Chih Yung Huang et al.	Fuel piston mechanism	Generated voltage is directly proportional to applying pressure. The 2 stroke engine is modified into 4 stroke engine.	From this paper it observed that the air driven engine efficiency is more than 13 % under 2-7 bar of pressure.
11.	K.Ravivarma et al.	Fuel piston mechanism	The power generation of Output power production is proportional to area of cylinder.	It is perceived that the hydraulic method can generate power output about 70.5 W.
12.	R.Mikalsen and A.P.Roskilly.	Fuel piston mechanism	At low temperature, the emission is reduced when compared to other methods with high	It is witnessed that, the free piston engine obtained output power is 44.4 W.

			efficiency.	
13.	Rajesh Kannan Megalingam et al.	Roller mechanism	By using alternator power production can be achieved 30 times more than dynamo.	Alternator can produce a power of 50W to 100W which depends on speed of pedaling.
14.	Antonin Stribrsky et al.	Roller mechanism	The load applied by the vehicle is directly proportional current generated with the efficiency of 50 – 60 %.	The force of2027 N is applied on the generator a 21.8 A current is producedwith a continuous AC voltage of 320V.
15.	B.Santosh Sarma et al.	Roller mechanism	Electromagnetic induction is directly proportional to electrical energy. The speed of the vehicle is inversely proportional to the voltage generated.	The mass of the moving vehicle is about 205 kg acts over the speed breaker, the generator produce a power of 2.3 KW in a day.
16.	Junzhi Zhang et al.	Roller mechanism	The efficiency of electrical energy regeneration of parallel regenerative breaking system is higher than the serial regenerative breaking system.	When the break is applied on the vehicle the energy of about 76.2% can be regenerated from the initially spent energy.

IV. CONCLUSION

In this paper the overview of power generation methods are described, how to generate a power in different manner. The renewable energy sources can be generated apart from the non-polluting environment. This review paper concerned about the country economical level on the road side. The piezoelectric mechanism, rack and pinion mechanism, piston mechanism and roller mechanism are gives unique results about power generation on the vehicle. On considering the various parameter involved in all power generation mechanism. The rack and pinion mechanism is more efficient with moderate cost of operation and maintenance.

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ABBREVATIONS

S.NO	SYMBOLS	ABBREVIATIONS	S.NO	SYMBOLS	ABBREVIATIONS
1.	KN	Kilo Newton	11.	Kg/m^3	Kilogram per meter cube
2.	V	Voltage	12.	µA	Milliamphere
3.	cm	Centimeter	13.	W	Watts
4.	V/mm	Voltage per millimeter	14.	Kg	Kilogram
5.	^0C	Degree celcius	15.	J	Joule
6.	Pzt	Piezoelectric transducer	16.	N	Newton
7.	GPa	Giga Pascal	17.	Nm	Newton meter
8.	Hz	Hertz	18.	MPa	Mega pascal
9.	KΩ	Kilo ohm	19.	l/mm	Liter per meter
10.	mAh	Milli amphere	20.	rpm	Revolution per meter