Power Generation Using Hydraulic Mechanism at Speed bumper

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Abstract-The extensive usage of energy has resulted in an energy crisis, and there is a need to develop methods of optimal utilization, which will not only ease the crisis but also preserve the environment. The focus now is shifting more and more towards the conventional energy, which are essentially, non-polluting. In this paper we approach a new mechanism to generate power from speed bumper, because the number of vehicles passing over the speed bumper in roads is increasing day by day. This proposed system is to extract the kinetic energy of vehicle flow in the streets entitled as generating power from speed bumper through hydraulic mechanism. It is more efficient than other existing models, which enable to accommodate conventional, both in terms of balancing electricity supply and demand in energy across the global.

INDEX TERMS: Conventional energy, Hydraulic mechanism, Power generation, Speed bumper, vehicle flow, MHD Generator.

1. INTRODUCTION

Energy crisis has become a great bottleneck in our sophisticated life and the demand for electricity continues to rise in all parts of the world. Population rise and economic growth are the two main reasons for energy insufficiency.

The number of people without access of electricity remained unacceptably high at 1.3 billion, around 20% of the world's population. [2] Consequently, the developing countries share of global electricity demand jumps from 27% in 2000 to 43% in 2030. The International Energy Agency says the world will need almost 60% more energy in 2030 than in 2002.

The most optimistic estimates have fossil fuel lasting no more than 100 years; however, they may become economically undesirable in much less time. Obviously, our world move towards the renewable resources to sustain with electricity, only if we utilize the resources properly by implementing this kind of new mechanism will leads to heal our world from power shortage.

In the current scenario, when every day the newspapers are flooded with news on accidents due to high speed, speed bumpers are becoming more and more crucial. [1] These help to reduce the speed of vehicles, thereby enabling a comparatively smooth drive.

Figure 1: Conventional Speed Breaker

Roads and highways are provided with speed bumper to control the speed of traffic in congested areas. This energy loss on speed bumpers can be utilized for useful purposes. This paper describes the potential of such type of energy available on roads and its utilization for useful work. The mechanism, which is used to generate power from speed bumper, is elaborated.

Case study:

Some of the eminent engineers proposed various systems for generating power from speed bumper. Overview of those mechanisms and its constrains are described below

1.1 Crank Shaft Mechanism

The mechanism works as; when a passing vehicle slows on a speed bumper the bumper would dip vertically downwards due to the weight placed on it, this vertically translational movement is then converted into rotational movement by means of crank shaft system which then can be used to drive a dynamo to generate electricity. [3]

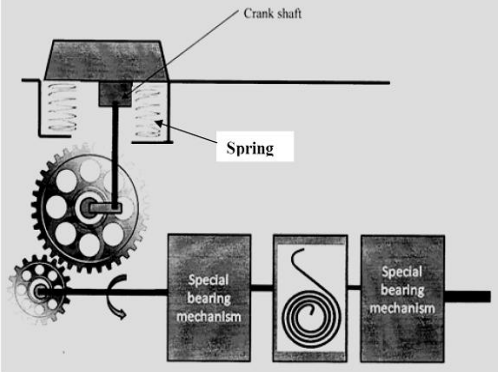

Figure 2: Crank Shaft Mechanism

Limitations: Crank-shafts are required to be mounted on bearings which creates balancing problem leading to mechanical vibrations which in turn damage the bearings.

1.2 Roller Mechanism

A roller is fitted in between a speed breaker and some kind of a grip is provided on the speed bumper so that when a vehicle passes over speed breaker it rotates the roller. This movement of roller is used to rotate the shaft of D.C. generator by the help of chain drive.

Figure 3: Roller Mechanism

Limitations: In the case of roller mechanism, Maintenance will be very difficult and it Might cause collision.

1.3 Rack And Pinion Mechanism

Figure 4: Rack and Pinion Mechanism

Whenever the vehicle is allowed to pass over the dome it gets compressed with the help of spring and the rack which is attached to the bottom of the dome moves downward in reciprocating motion. Since the rack has teeth connected to gears, there exists conversion of reciprocating motion of rack into rotary motion of gears but the two gears rotate in opposite direction. By the use of ball bearings, one of the rotary motions is utilized to generate power. [4]

Limitations: This mechanism fails if any occurrence of variable load (which is bit obvious in case of vehicles!!) leads to balancing problem.

In addition to these limitations, all those above mentioned methods have one common loss called frictional loss. But in case of this proposed hydraulic mechanism overcomes these limitations.

2. EXPERIMENTAL PROCEDURE

2.1 Hydraulic System

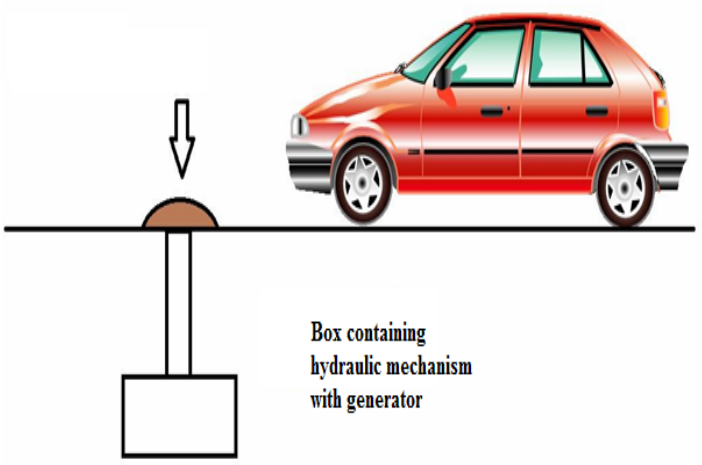

Figure 5: Hydraulic System

Requirements:

Cylinder and piston

Control valves

Oil tank

Generator coupled with turbine

2.2 Block Diagram:

This system is to generate power by converting the energy generated by a vehicle going up on a speed bumper into electrical energy. This arrangement consists of speed bumper assembly, cylinder and piston arrangement, water turbine, Generator and Stabilizing Unit with battery for storing the generated output.

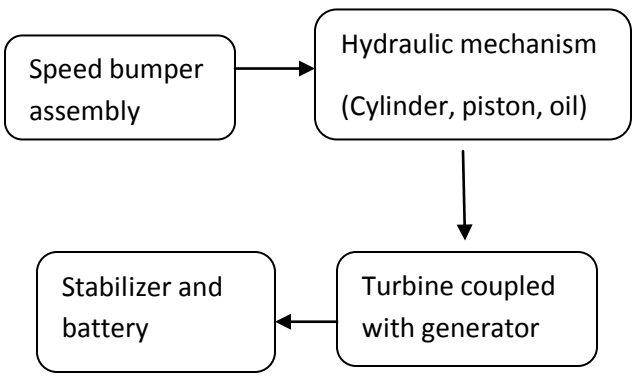

Figure 6: Block Diagram

2.3 Hardware Description

Cylinder and piston

Simplex single acting cylinder discharges the oil for each stroke. The forward stroke discharges the cylinder and the back stroke or reverse stroke fills the cylinder with the help of control valves. The single-acting piston-type cylinder uses fluid pressure to provide the force in one direction, and spring tension, is used to provide the force in the opposite direction.

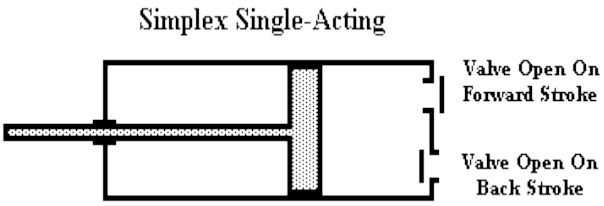

Figure 7: Cylinder and piston

Control Valve

A control valve or non-return valve is a mechanical device, which normally allows fluid to flow through it in only one direction. Control valves are two-port valves, meaning they have two openings in the body, one for fluid to enter and the other for fluid to leave. The mechanism of control valve is described in figure 8. Fluid flow in the desired direction opens the valve, while backflow forces the valve closed.

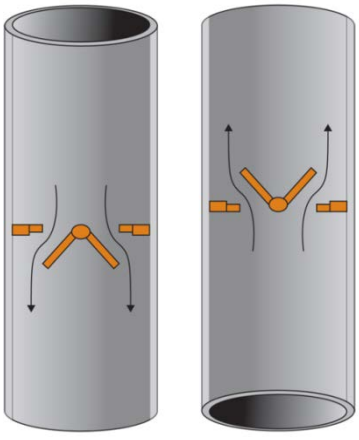

Figure 8: Valve Mechanism

Check valves work automatically and most are not controlled by a person or any external control; accordingly,

most do not have any valve handle or stem. The bodies (external shells) of most control valves are made of plastic or metal.

Turbine

This turbine has a similar look and physical principle like a classic water wheel. A pelton turbine consists of a set of buckets or cups mounted on a hub. Pelton turbines are not immersed in oil. Instead, a pelton turbine operates in air with the wheel driven by jets of high pressure oil hitting the buckets or cups. In this method automobile oils are used with a density of 880-940 kg/m^3

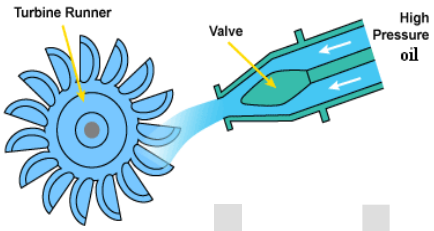

Figure 9: Turbine

Kinetic energy of the oil jets is transferred in to turbine. Hence the oil is being squirted through nozzles onto the blades where it is deflected by 180° and thus gives almost all of its energy to the turbine.

Generator

An electrical Generator is a machine which converts mechanical energy into electrical energy (or power). For this model a permanent magnet DC generator with drum type armature, wave winding is suitable which is shown in fig 10.

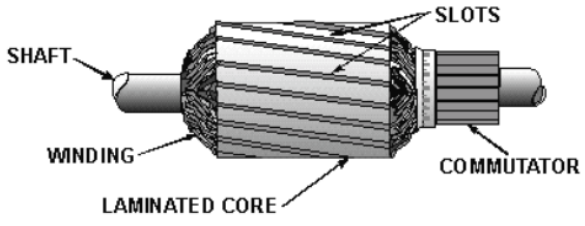

Figure 10: Generator

The e.m.f induced in any parallel path in armature

$$E = (\Phi NPZ) / (60 * A)$$

where,

E = e.m.f induced in the armature

Φ = flux per pole in Weber

N = armature rotation in revolutions per minute (r.p.m)

P = No. of generator poles

Z = total number of armature conductors

A = No. of parallel paths in armature (always A=2 for wave winding).

In the above equation, flux per pole, number of generator poles, total number of armature conductors are constant. Hence the electricity generated from the generator is directly proportional to the speed of the rotation. This e.m.f. causes a current to flow if the conductor circuit is closed with a load.

2.4 Working Principle

When the vehicle (load) passes over the speed bumper which is made of cylinder and piston arrangement, then the piston rod is subjected on a compressive force which in turn the oil gets pressurized and comes out through the outlet nozzle which strikes the turbine blades then the potential energy of oil is used to run the turbines to which the electric generator is coupled. Here the mechanical energy available at the speed bumper is converted in to electrical energy through a generator.

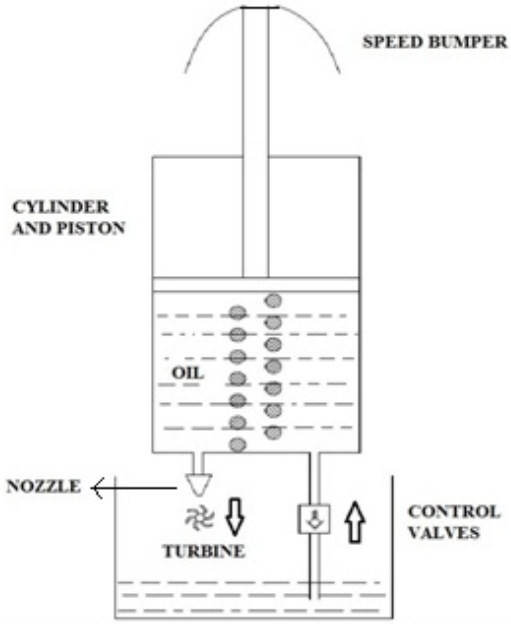

Figure 11: Working principle

Due to spring tension, the exhausted oil is recycled back to the cylinder with the help of inlet control valve. Hence, the speed breaker gets back to its original position.

So, if we implement one such speed breaker on a busy highway, we can able to tap maximum amount of electricity from the waste kinetic energy of a vehicle.

2.5 Stabilization Circuit

In order to store the electrical energy in battery, stabilizer is required. To design a stabilizer we need to consider the output current values.

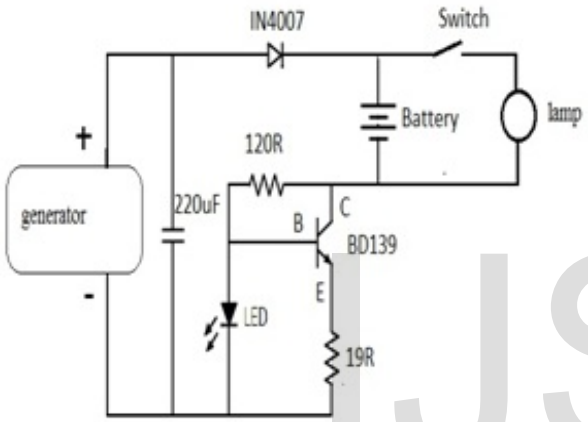

Figure 12: Stabilization Circuit

Battery is chosen according to the output power, which is generated from the proposed model. The following circuit is used for 6V, 1.2Ah battery. Based on the Ah value of battery resistor value should be altered in the below circuit, for proper charging.

The higher charge current, the more critical the charge time must be checked. When faster charging is used, it is advisable to discharge the battery completely before charging. Using a charge current of 1/10 of the capacity will expand the lifetime of the battery. The charge time can easily be doubled without damaging the battery.

2.6 output power calculation

Kinetic energy is the energy of motion. An object that has motion - whether it is vertical or horizontal motion - has kinetic energy. The amount of translational kinetic energy (from here on, the phrase kinetic energy will refer to translational kinetic energy) that an object has depends upon two variables: the mass (m) of the object and the speed (v) of the object. The following equation is used to represent the kinetic energy (KE) of an object.

$$KE = \frac{1}{2} * m * v^2$$

Where

m = mass of object

v = speed of object

This equation reveals that the kinetic energy of an object is directly proportional to the square of its speed.

Theoretical calculation:

Kinetic force = ½ mv^2 **(eq 1)**

Here

m= mass of the fluid

v= velocity of the fluid.

The following figure 13 expresses the dimensions of a prototype in cm, to carry out theoretical calculations.

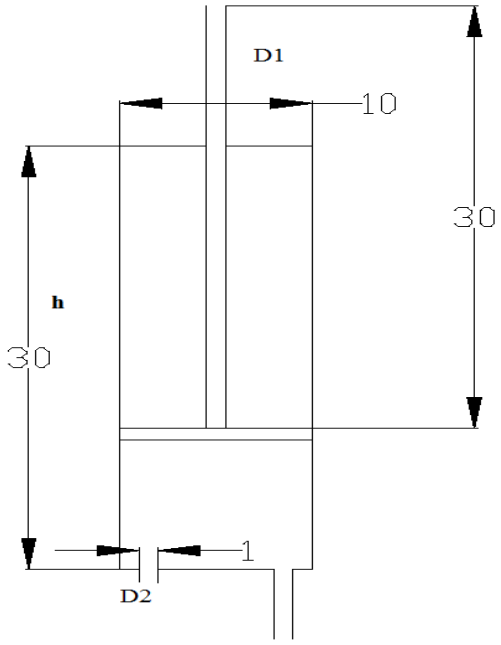

Figure 13: Prototype dimensions

Diameter of the cylinder (D_1) = 10cm

Height of the cylinder (h) = 30cm

Diameter of the Nozzle (D_2) = 1cm

To calculate **M**:

Mass of the fluid is given by the product of density of the fluid and volume of the cylinder, i.e.,

M= density of oil in kg/m^3 * volume of cylinder in m^3

= 860 * $\pi r_1^2 h$

= 860 * (3.14*0.05^2 * 0.3)

M = 2.0253 kg. **(eq 2)**

To calculate **V**:

Velocity of the fluid is given by the ratio of, product of the area of cylinder and velocity of piston to the area of nozzle.

i.e.,

V = (area of cylinder * velocity of piston in m/s) /area of nozzle

Area of cylinder $a_c = \pi r_1^2$

Area of nozzle $a_n = \pi r_2^2$

Velocity of the piston v= (distance / time)

= 0.25/1

= 0.25 (m/s)

By substituting the above values in velocity of the fluid we get,

V = (πr_1^2 * piston velocity) / (πr_2^2)

V = (3.14*0.05^2*0.25) / (3.14*.005^2)

= 25 m/s (since it is jet velocities multiply V by 0.4)

Hence Velocity of the oil **V** = 10 m/s **(eq 3)**

By substituting the value of mass and velocity (2&3) of the fluid in kinetic force,

K.F = ½ mv^2

= ½*2.025*10^2

= 101.25 N or J **(eq 4)**

Torque:

Torque is meant by turning or twisting moment of force about an axis. It is measured by the product of force and radius at which this force acts.

Work done by this force in one revolution = force * distance (Nm).

T = kinetic force * radius of turbine in m

= 101.25 * 0.05

Hence torque T = 5.0625 Nm **(eq 5)**

Output power calculation:

Power developed is given by **P** = (2πNT)/60

Where

N = speed in revolution per minute

T = output torque

Analyzed speed N = 500rpm, by substituting the values of N and T we get

P = (2*3.14*500*5.062) / 60

Output power **P** = 4.5 watts

In this mechanism, generated power is directly proportional to the area of cylinder.

Table 1: Output power relation

S.no	Radius of the cylinder in (cm)	Area of cylinder In (m^2)	Output power in (watts)

1	5	0.00785	4.5
2	10	0.03	70.5

3 CONCLUSION

This is actually a process, an evolution of the electricity network for generation in a way that is interactive, flexible and efficient. While considering a toll plaza, nearly 15 vehicles passing per minute; the average kinetic force obtained from the vehicles is around 1000 N at speed bumper. Hence, the power produced from this mechanism is estimated around 500 Watts**.** Future aim of this research is to develop our country by enriching it in utilizing its sources in more useful manner for roadside as well as domestic applications. There is an ever increasing demand for energy in spite of the rising prices of oil & other fossil fuel / depletion of fossil fuels. So this idea will be helpful to enhance more power.

4 FUTURE WORK ENHANCEMENTS

Magneto hydrodynamic power generation provides a way of generating electricity directly from a fast moving stream of ionised fluids without the need for any moving mechanical parts - no turbines and no rotary generators, hence this system reduces electrical losses also.

The MHD generator can be considered to be a fluid dynamo. This is similar to a mechanical dynamo in which the motion of a metal conductor through a magnetic field creates a current in the conductor except that in the MHD generator the metal conductor is replaced by a conducting fluid. [5]

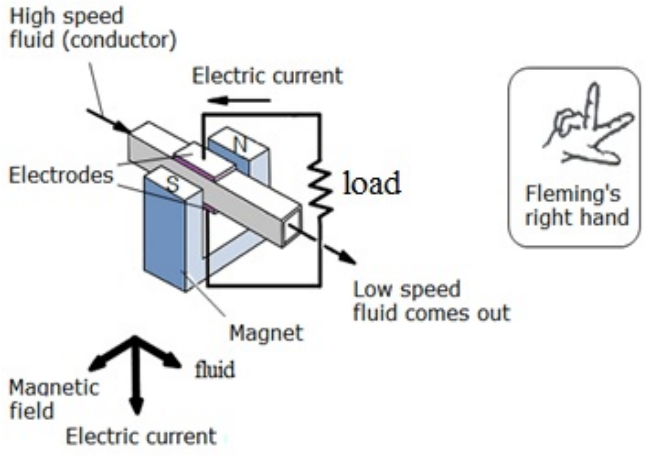

Figure 14: The MHD generator

The flow (motion) of the conducting fluid through a magnetic field causes a voltage to be generated (and an associated current to flow) across the electrodes, perpendicular to both the fluid flow and the magnetic field according to Fleming's Right Hand Rule. This system will enhance copper loss and stray loss.

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