An Experimental Study of Generation of Electricity Using Speed Breaker by Hydraulik Mechanism

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ABSTRACT
Lack of electricity is one of the most crippling problems of India. The purpose of this paper is to design a power generating device which acts as an active speed breaker. The prototype is a one-sided, one-way device which emphasizes function over form. This is done with a hydraulic system including an actuator, accumulator, and hydraulic motor. This is coupled to a permanent magnet alternator which converts the low torque, high speed output of the motor into useful electrical energy. All of this is housed inside a steel frame made of rectangular and square hollow tubing, attached to the frame is a paddle on a pivot point which is depressed by the weight of a vehicle. This downward motion is transmitted to the hydraulic actuator which pumps fluid through the system. The actuator was cycled up and down repeatedly in order to charge the accumulator until the system reached the desired pressure. The automatic switch within the system would then open the valve to the motor and the system would discharge and generate power. A hydraulic transducer was also fitted at multiple points within the system to monitor the system pressure before and after the accumulator during the charge and discharge cycles. The goal of this investigation is to propose a setup for power generation which can be used in metropolitan cities as a speed breaker so that when the vehicle passes over the speed breaker, the kinetics energy developed can be converted in the power generation. This provides a starting point for utilities in developing countries to better plan and to overcome from the existing electricity problem up to some extent.

INTRODUCTION

Electricity supply in India has been lagging in terms of service (measured by hours of supply) as well as penetration. Only 31% of the rural households have access to electricity, and the supply suffers from frequent power cuts and high fluctuations in voltage and frequency, with so-called blackouts and brownouts [1, 2]. Erratic and insufficient electricity supply has long been a serious obstacle to higher economic growth in India. In 2002, power generation capacity stood at 120,000 MW which is far below peak demand, [3, 4] not withstanding that total electricity generated rose from 290 TWh to over 500 TWh between 1990 and 2000/2001. Of this generated electricity, thermal capacity accounts for 71 % hydropower for 25%, nuclear energy for 3 % and wind energy for 1 %.[5] The standard of Living and industrialization leap up the pressure on the conventional sources of power. Depletion of conventional sources becomes a problem in present world. And ever rising cost of conventional fuel may be major impediment in economic and social growth of third world nations. All the developing and developed nations are searching for new and newer sources of energy and its efficient use.

Whenever a car slows down, it is dissipating energy through its brakes. With the current technological focus on energy efficiency, a system that could recapture some of this energy could be a great benefit for areas that experience heavy traffic and could make use of an influx of extra energy, which is not necessarily attached to the power grid.

Additionally, the static nature of speed breaker makes them hard on drivers regardless of the speed they are traveling. A collapsing speed breaker could potentially provide a means of speed selecting vehicles as far as the rigidity of the speed breaker is concerned, as in it is easier on slower drivers than speeding driver.

This paper is intended to prove the concept of a power generating speed braker; a paddle that would take the input from the car and generate electricity. For a real installation, such a system would best be deployed in low speed areas where traffic is forced to slow down, such as in parking garages, truck stops, or toll booths. In a real situation the properties of the system could also be changeable as to provide a difference of how hard the bump will feel to a driver, depending on their speed. The working model of hydraulic mechanism is shown in the fig.1

II.HYDRAULIC MECHANISM

Fig.1working model of hydraulic mechanism

HydraulicMechanism	Other Mechanisms
It is complicated in construction	It is simple in construction
There is a less chance of wear and tear of components.	Due to use of mechanical components, chance of wear and tear increases.
It is more reliable and safer than the later	It is less reliable compared to former one
There is less chance of loss of energy during conversion	There is a greater chance of energy loss during conversion
It is more efficient than later.	Compared to former one its efficiency is low.
High investment cost up to 2 lacs	Very low investment up to 6000 Rs. Only
Our design is suitable for one-way roads only	Suitable for two-way roads as well.

Table: 1comparison of hydraulic and other mechanism
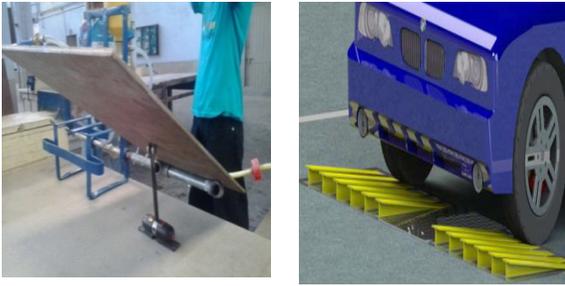
Paddle:

Fig: 2 Experimental Model of Peddle

The initial system that will serve to take the energy from the car and convert it into a linear form is a collapsing paddle that takes the place of the actual speed breaker.

Multiple designs for the paddle were considered in order for the system to be durable, compact, and easy on the driver. Multiple shapes for the paddles were considered, as well as possible orientations to allow for either multiple paddles in series or parallel.

The first dismissed shape was a flat platform that would have a slight upward ramp preceding it and would descend vertically once a car drove over it. The major problem identified with this design was the uneven loading that would likely be experienced in such a scenario, and the need to balance the plate either on multiple pistons or via an extremely stiff plate.

The second dismissed shape was a triangular paddle that would pivot on one end, and slide on the other, and would allow for traffic in two directions if needed, while protecting the sensitive areas underneath the paddle. While the idea was considered it was ultimately dismissed as too complex for the prototype's needs. The alternate orientation ideas, which involve having either multiple paddles in series or parallel, were both dismissed on cost grounds. The piston is expected to be a relatively expensive component, and thus, shrinking it in order to distribute the needed work around a bit was deemed to be impractical.

The final design of the paddle must be lightweight, inexpensive, durable and in a shape that will undergo a simple movement pattern shown in the fig.2.

Energy Transduction:
Multiple different forms of transductions were considered in effort to design a reliable, simple, and cost effective form of energy generation from a source of high force and relatively low frequency impulses. Pneumatic, purely mechanical and electromagnetic transducers were dismissed based on various factors

The advantages of a pneumatic system are that it is very simple and relatively low pressure. Pneumatics operate at relatively safe pressures and pose little to no risk to the operator and operating environment.

The main disadvantage to the system is the physical size required due to the associated properties of air. In order to accumulate enough air at high pressure, a large volume of air per impact of car would be required as most of the volume would be lost during compression. Another issue with a pneumatic system is that operation in dirty environments may allow dirty contaminants into the system resulting in damage of pneumatic motors. Based on the sizing criteria and the compromised reliability, a pneumatic system would not be suitable. A diagram of this is shown in Fig. 3
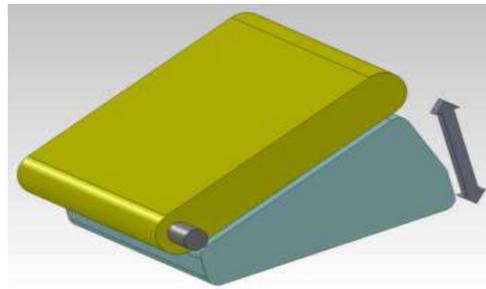

Fig: 3 Pneumatic System

Return Linkage:
The return linkage is meant to bring the paddle back up once it has been depressed. One return linkage type considered for the Power Breaker is a counterweight. This would involve a large weight being connected to the paddle on the opposite side of the of the lever point. This weight would use a reliable force, gravity, to always bring the paddle back up. This weight would have to be large and would make the entire unit, as a module, very heavy. The counter-weight would also need to extend outside of the frame, effectively making the module larger.

Another return linkage considered was a seesaw system. This would make use of two paddles used in a row. A lever system underneath the paddles would rock back and forth like a seesaw. When one paddle is pushed down, the other would be pushed up by the lever on a middle fulcrum. This way, some of the energy harnessed from the weight of the vehicle would be used to prepare the other paddle for use.

The main problem with this is that the paddles would have to be spaced out properly so that no car would sit on both paddles at once. Even with proper spacing, there will always be oddly sized trucks which could sit on both paddles at once and snap the lever with bending forces. The chosen return linkage must be compact enough to fit within the given dimensions and not interfere with other components. It must also work reliably in different temperatures and adverse conditions. A diagram of this is shown in Fig. 4.

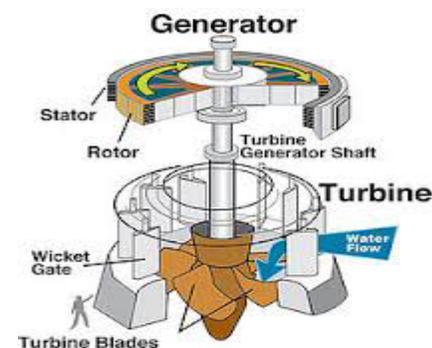**Fig: 4 Return Linkage**

Electrical Generation:

Fig: 5 Electrical Generations

The electrical generation systems will be designed to be coupled to the output of the hydraulic motor shown in the fig.5. Electrical generators operate on the principle that moving a conductor (wire) through a magnetic field will create a voltage difference between the ends of the conductor (wire). This voltage difference will cause electrons to flow thus generating an electric current. The Power breaker will require a generator in the range of 250 Watts that operates at low-torque and high-speeds.

One possible electrical generating system would be a dedicated DC (direct current) generator. The DC generators are rather expensive when compared to the selected alternative, and for this reason was rejected. Another possible electrical generator considered was running a standard DC motor in reverse. Due to slight efficiency losses the option of running a DC motor in reverse was rejected.

The next possibility that was seriously considered was to use a permanent magnet alternator. An alternator acts similarly to a DC generator, with the exception that is generates AC, or alternating current. Permanent magnet alternators are typically used in low speed direct drive wind turbine applications with an output in the range of 200-500 watts. Permanent magnet alternators operate in the speed and torque range of our hydraulic motor thus has been specified for the Power breaker.
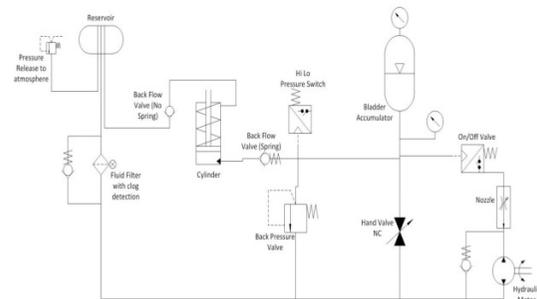

Fig: 6 Hydraulic Schematic Showing Fluid Flow

Hydraulic Components:
Hydraulic System Design
In order to ensure safety, reliability and efficiency the specific dimensions of the hydraulic system have to be precisely calculated. All of the hydraulic components mentioned in the previous section must be interconnected using hydraulic tubing shown in the fig.6. Although the maximum system operating pressure is assumed to be 1800 psi, a pressure of 3500 psi was used in the hydraulic line sizing for safety reasons. In the hydraulic system there are 3 different types of fluid lines: suction, pressure, and return.

Table-2. Hydraulic Line Types describes the various line types and their operating parameters. (Vickers, 2007).

Line Type	Location	Max Fluid Velocity (ft./s)	Max.Pressure (psi)
Suction	Reservoir-Actuator	4	-3(vacuum),4
Pressure	Actuator- Motor	25	3500
Return	Motor- Reservoir	10	50

Table 2: Hydraulic Line Types

The operating parameters of each line type were used to calculate a line size/wall thickness of 0.25"/0.05" based on Lame's thick wall pressure vessel equations. Based on initial line dimensions the frictional losses in the pressure lines were calculated to be approximately 22 psi using a calculated pressure line velocity of 8 ft. /s. The total pressure loss due to obstructions (check valves, expansions, contractions and bends) was calculated to be roughly 23 psi for a combined frictional loss of about 50 psi, or 3.4% of system pressure which is deemed acceptable

The hydraulic actuator acts as a positive displacement pump by simply connecting the outlet and inlet lines. This simple arrangement allows the actuator to be used without port modification and as a result the displacement per stroke is solely based on the rod area and stroke. Each actuator depression will result in a small amount of fluid being stored in the accumulator. With a 3 inch stroke, it will take the passing of approximately 10 cars (all 4 wheels) to fill the accumulator to working volume. A constant flow of traffic moving at about 16 km/h will be sufficient to keep the system operating at full capacity.

All hydraulic components are selected to have ratings to 3000 psi or above despite the maximum operating pressure of the system being 1800 psi. It should be noted that the industry standard for hydraulic pressure rating already includes a safety factor of 4 and as a result the minimum safety factor in the hydraulic system is 6.8.

In summary, the hydraulic system is designed to be a safe and reliable method of converting the high force low frequency system input into a high speed rotational output capable of generating usable power when coupled with a generator. The overall efficiency of the hydraulic system was calculated to be approximately 53%.

Energy Transduction
1 Hydraulic System Outline
The function of the hydraulic system is to capture and store the energy low speed high force impulses and transduce it into a high speed rotational motion. Hydraulics is used because of their proven reliability and safety when properly installed. The hydraulic operating fluid is incompressible ensuring system efficiency is at its maximum.

The hydraulic system is designed to be completely isolated from the external environment using a closed loop system. This isolation ensures the system will not be contaminated by the potentially dirty and moist environment of installation. Various relief valves are included in the design for safety purposes in the case that the closed system malfunctions and unexpected system pressures occur.

2 Permanent Magnet Alternator
An alternator is the device used to convert mechanical energy into electrical energy. Fig: 7 show the Permanent magnet alternators. Here electrical current will be in AC. In this alternator, the electro-magnet is replaced with the permanent magnet and hence the overhead of the external application of electric current to create magnetic field is avoided. The only difference in an alternator and generator is instead of producing current in DC, alternator produces AC.
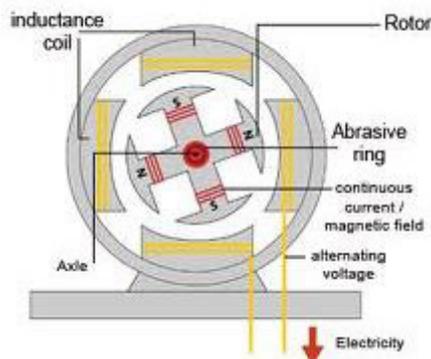

Fig: 7 Permanent magnet alternator.

III. Experimental data
Pressure of Pump = 70 feet of water

= 1.94 35 bar

= 1.9435× 10^5 N/m²

Headh = 70 feet = 21.336 m

P = ρgh

= 1000×9.81×21.336

P = 2.093 bar

Diameter of nozzle = 1.8 mm

Time required for 1 lt volume = 30 sec

Now, Discharge Q = AV

Here

Area of nozzle, A = π/4× (1.8×10^{-3})²

= 2.545×10^{-6}m²

Now, Q = AV

(10^{-3})/30 = 2.545×10^{-6} × V

V = 13.099 m/s

Therefore velocity of jet V_1 = 13.099 m/s

Blade velocity = u = πDN/60,000 m/s

Where N is the turbine rpm= 450 to 550 rpm

Let N = 480 rpm

And outer diameter of blade D = 150 mm

So u = π×150×480/60,000 =3.7699 m/s

Therefore inlet blade velocity u_1 = 3.7699 m/s

For the impulse turbine outlet blade velocity is same as that of the inlet blade velocity.

So u_1 = u_2 = 3.7699 m/s

By the measurement at turbine outlet

Current I = 55 mA

= 0.055 A

& Voltage V = 3.5 V

Therefore power produced P = VI

= 0.1925 W

This power produced is at maximum pressure condition and the maximum pressure is obtained at 10 stroke of piston in pump...

Suppose that 300 vehicles are running over the paddle in 1 hour.

Hence, for 14 hours of regular traffic, power produced **= 80.85 W**

Force needed for one stroke of paddle

= 2 kg×9.81 = 19.6 N

Fig.8 Velocity diagram
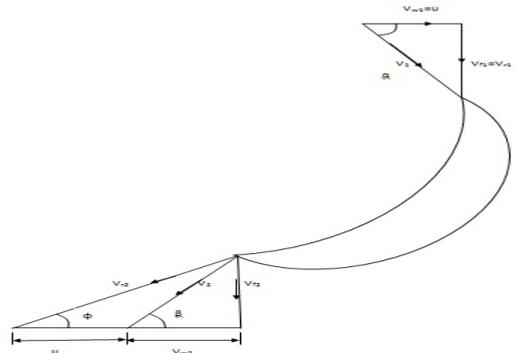
From velocity diagram (fig.8) we calculate following data:

u= 3.7699 m/s	V_{f1}= 12.54 m/s
α= 73.27	V_{f2}= 4.289 m/s
β= 28.15	V_{w1}= 3.7699 m/s
V_1= 13.099 m/s	V_{w2}= 8.014 m/s

CONCLUSION AND FUTURE ASPECTS:
In the coming days, as demand of electricity is increasing every moment, it will prove a great boon to the world, since it will save a lot of electricity of power plants which are wasted in illuminating the

Street light. Future aim of this research is to develop our country by enriching it in utilizing its sources in more useful manner. Any country can only develop when it uses power supply frequently and not by getting breakdown in middle course of time. Now times comes when these types of innovative ideas should be brought into practice.

This is pollution free and non-conventional power generation. We came to know about different aspects of power generation. The concept which we used for the power generation is rather costly than other mechanisms, but obviously safer and more reliable.

The experiments show that if we implement this mechanism on regular traffic roads, it can produce Power up to **4 kW** in a day.

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