

Design mechanic generator under speed bumper to support electricity recourse for urban traffic light

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Abstract. The electrical energy needs for the traffic lights in some cities of developing countries cannot be achieved continuously due to limited capacity and interruption of electricity distribution, the main power plant. This issues can lead to congestion at the crossroads. To overcome the problem of street chaos due to power failure, we can cultivate to provide electrical energy from other sources such as using the bumper to generate kinetic energy, which can be converted into electrical energy. This study designed a generator mechanic that will be mounted on the bumper construction to generate electricity for the purposes of traffic lights at the crossroads. The Mechanical generator is composed of springs, levers, sprockets, chains, flywheel and customize power generator. Through the rotation of the flywheel, we can earned 9 Volt DC voltage and electrical current of 5.89 Ampere. This achievement can be used to charge the accumulator which can be used to power the traffic lights, and to charge the accumulator capacity of 6 Ah, the generator works in the charging time for 1.01 hours.

1. Introduction

For many years, the urban transport planners have attempted to reduce congestion. In most cases, such studies is recommended to overcome congestion by improving conditions of traffic light at the intersection of crossroad. in this case, employing speed bumps in order to slow traffic has been a choice to generate the kinetic energy that can be convert to the electrical power for traffic light. actually, speed bumps are proven effective in slowing average traffic speed, but they also have drawbacks that must be considered.

The innovation of speed bumps that capable to generate electricity is called the green speed bump. Speed bump or Police Trap is a tool that serves to limit the speed by raising the road surface. In Indonesia, elevated roads is the form of additional asphalt or cement which installed on the road crossings to decelerate vehicle.

Among all the energy that related to human activities in urban environment, traffic is one of the most energy-expensive, and, furthermore, it is characterized by great waste. "Power bumps" are innovative energy harvesting devices that reduces the speed of vehicles by converting the wasted kinetic energy into electricity. For obvious reasons of energy balance, those devices cannot be installed randomly on the road network but should be implemented in decelerating sites only, such as urban road crossings, where the standard passive speed bumps are usually installed. Whenever this condition is verified, power bumps allow us to achieve the optimal combination of improved road safety.



The number and variations of vehicles traveling through highways in Medan City were obtained from Sundari Hindriyani research around Sisingamangaraja, William Iskandar, and Krakatau Road shown in Table 1. As follows [2].

Table 1. Vehicle Volume on some roads in Medan City [1]

Location	Type of Vehicles	Amount
Sisingamangaraja Str.	Motor bike	64%
	Cars	74%
	Truck	50%
	Bus	45%
	Rickshaw	46%
	Bicycle	20%
	Public transport car	0,50%
William Iskandar Str,	Motor bike	65%
	Cars	80%
	Truck	30%
	Bus	40%
	Rickshaw	35%
	Bicycle	10%
	Public transport car	20%
Krakatau Str.	Motor bike	30%
	Cars	50%
	Truck	10%
	Bus	25%
	Rickshaw	10%
	Bicycle	5%
	Public transport car	

These vehicle which loads in Table 2 will be used to analyse the loads assigned to the generating device. The Load trend is formed from statistical calculation with the addition of polynomial average road load character of vehicles passing in the road. The formed load graph will be related to the frequency patterns and variations of vehicles passing on the highway, resulting a trend that illustrates the pattern of increase and decrease of expense based on the variation and frequency of passing vehicles.

Table 2. Variations in Vehicle Load on the Road

Vehicle type	Vehicle load	On the Road load	Frequency
Motor bike	87kg – 170kg	60kg – 100kg	30% - 65%
Public car	1000kg – 2500kg	1500kg -3000k	50% - 80%
Mobil Bus	3500kg – 15000kg	5000kg – 25000kg	25% - 45%
Truck	12000kg – 40000kg	12000kg – 43000kg	30% - 50%
bicycles	5kg – 20kg	50kg – 100kg	5% - 20%
Rickshaw	100kg– 120kg	120kg – 200kg	10% - 46%
Special Vehicle	100kg – 40000kg	100kg – 43000kg	1% - 10%

There are three forces acting on the tire: (a) The normal or vertical force (F_z), caused by the weight of the vehicle, and the vertical inertia-oriented force, (b) the longitudinal force (F_x), which is generally due to inertial forces Acceleration or braking and may also be caused by longitudinal components of the vehicle centrifugal force, (c) lateral forces, caused by the centrifugal force of the vehicle.



Figure 1. Dynamics of the Moving Wheel

The rolling wheel of Fig. 1 is the stress occurring on the wheels that not in steady state conditions, resulting in a contact slip (κ') and deformation (u) which is also not constant. In this model, u and κ' tend to be small. Thus, the relationship between F_x and u and u to κ' becomes a linear function:

$$F_x = C_{Fx} \cdot u = C_{F\kappa} \cdot \kappa', \quad C_{Fx} = \left(\frac{\partial F_x}{\partial u} \right)_{u=0}, \quad C_{F\kappa} = \left(\frac{\partial F_x}{\partial \kappa'} \right)_{\kappa'=0}$$

$$u = \sigma_{\kappa} \cdot \kappa', \quad \sigma_{\kappa} = \left(\frac{\partial F_x}{\partial \kappa'} \right)_{\kappa'=0} / \left(\frac{\partial F_x}{\partial u} \right)_{u=0} = C_{F\kappa} / C_{Fx} \quad (1)$$

Deformation (u) is expressed according to the following equation:

$$\frac{du}{dt} + \left(\frac{1}{\sigma_{\kappa}} \right) \cdot |V_x| u = -V_{sx} \quad (2)$$

Slip κ' follows σ_{κ} and u , so the drive wheel has a damping rate of: $|V_x| / \sigma_{\kappa}$.

Obviously the target is how to generate better quality for the traffic flow to pass through the intersection that maximizes the flow of traffic and eliminates the queue. The intersection between the various movements, requiring a good transport network planning system as an effort to minimize the time delay.

2. Design Stages

The research was conducted by designing the structure of the power station building that utilizes the mechanical energy of the modified speed bump. The electrical generator transmitted from mechanical generator that utilizes the motion energy of a modified speed bump.

The design process of speed bump power generator Fig. 2 is done in several stages. The first stage is to survey the energy needs of traffic lights. The second stage is the selection of components that can convert motion energy or mechanical energy into electrical energy. The third stage is to build a model generator simulation. The fourth stage is analysing the component parameters and the installation of generator components. And the fifth stage is analysing the test results of generator that is built.

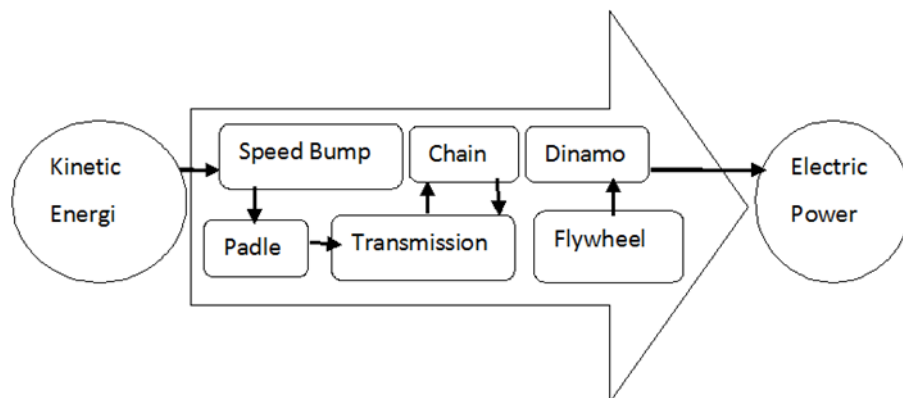


Figure 2. Mechanical to Electrical Power transmission

The electric generator technical data is taken from the commercial DC power generator which is used with specifications speed Rate 2750 RPM, current Rate 18.7 A, Output power 350 W and Voltage 24 VDC. This generator is driven by a chain and the drive sprocket that connected directly to the flywheel shaft and the mechanical generator sprocket. The flywheel function is to increase the inertia load that will connect the mechanical generator and the electric generator. The mechanical generator consists of a little sprocket on the flywheel, Chain and pedal Sprocket. The pedal lever will be connected to the connecting lever between the speed bump and the mechanic generator. The spring is driven by the load which is received by the speed bump cover (the spring is connected fix with the speed bump cover).

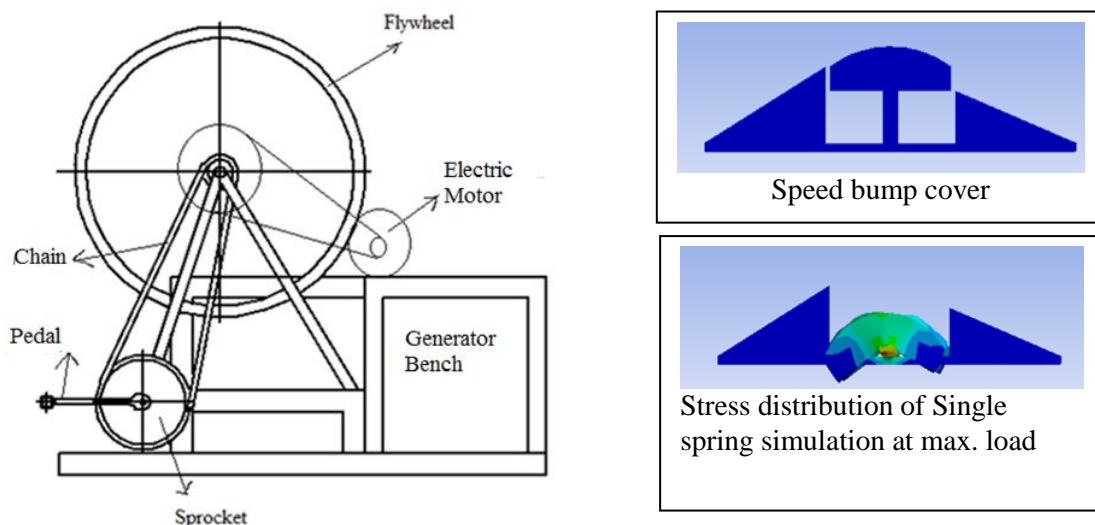


Figure 3. Model of Power Generator

Table 3. Traffic Lighting Power Requirements

LED Color	Power Consumption	Operation time	Load
Red	15 Watt	8,9 hour	133,5 Wh
Yellow	15 Watt	8,9 hour	133,5 Wh
Green	12 Watt	8,9 hour	106,8 Wh
Total Load			373,8 Wh

The load study was conducted on a traffic light or Traffic Light (TL) at one of the four intersections in Medan City. Lighted traffic time red-yellow-green in a day for 17.75 hours from 05.45 WIB to 23.00 WIB. Table 3 indicated the load used in the design of this research is the traffic light 3 colours (R-Y-G).

Calculated dimensions of gears, sprockets, and flywheels are designed to produce a power of 45 watt from a compressive force at a speed bump of a minimum of 500 N and a maximum of 900 N. The design dimensions for gears, sprockets, and flywheels are the length of pedal 180 mm, radius of Front sprocket 95 mm, Radius of Rear sprocket 35 mm, radius of Fly wheel 260 mm, Fly wheel sprocket radius 70 mm and radius of dynamo shaft 10 mm.

In the design of speed bump power will used battery or accumulator with a capacity of 6 Ah and with a voltage of 12 Volt DC. To be able to fully fill, the accumulator must be tested against the current generated by the electric generator. The charging time of the battery or accumulator is the result of the battery current or accumulator current sharing with the current generated by the electric generator.

3. Prototyping, Measurement & Function Test

To measure applied incoming and outgoing loads in which the force is imposed by the vehicle that passing through the road to the spring of speed bump, need to know that the acceleration of spring motion identify from the flywheel. So, to be able to measure the flywheel round required tachometer.

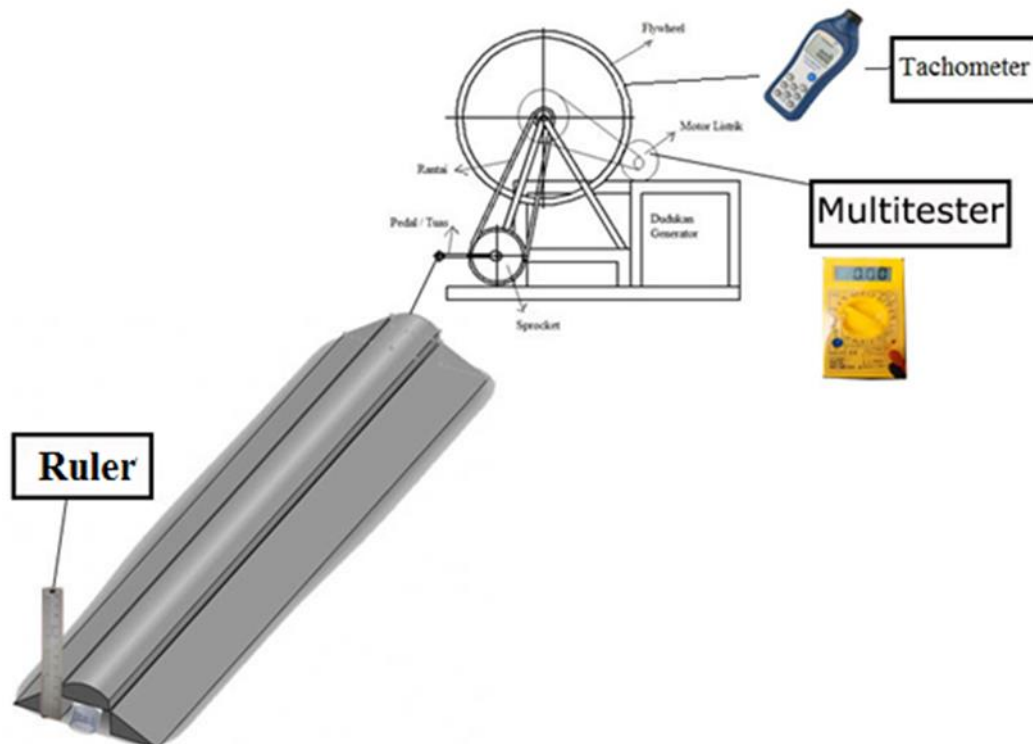


Figure 4. Mechanical generator to accumulate dynamic load of speed bump

The test is done on the generator by giving the stepping force to the speed bump lever. Figure 4 show that the Speed bump moves down due to the load and moves up due to the restoring force of the spring. This causes a deflection on the spring as measured using a slide ruler. The deflection on the spring causes the lever to move and rotate the gears and be transmitted on the flywheel. The rotation on the flywheel is measured by a Tachometer gauge to obtain rotation per minute of the flywheel spinning. The crazy flywheel is transmitted by a chain to an electric motor that will generate electrical energy in the form of voltage and electric current. Voltage and electric current are measured using Multimeters.



Figure 5. Experimental test of Power Speed bump

The test is done by using human load with mass of 50 kg yielding round 39,9 rpm obtained by 5.1 volt voltage and electric current 4,6 Ampere. Testing is also done by using human load and motorcycle with a mass of 110 kg resulting 69.5 rpm rotation obtained voltage 8.9 volts and electric current 5.0 Ampere. Testing is also done by using the human load and the car with a mass of 750 kg to produce 99 rpm rotation obtained voltage of 11.5 volts and 8 ampere electric current.

Table 4. Mechanical Generator and Electrical Generator Measurement

Mechanical Generator		Electrical Generator				
Factorial Variables		Experimental Variable				
Weight (Kg)	Load (N)	Deflection (mm)	Rotation (rpm)	Voltage (V)	Current (A)	Power (Watt)
50 (M)	490.5	20	39.9	5.1	4.6	23.46
74 (M)	725.94	22	60.1	6.9	5.3	36.57
90 (M)	882.9	23	66.7	8.0	5.0	40.0
110 (M+S)	1079.1	24	69.5	8.9	5.5	48.95
155 (M+S)	1520.55	24	69.7	8.5	5.5	46.75
200 (M+S)	1962	25	74.4	9.1	6.0	54.6
300 (M+S)	2943	25	74.4	9.0	5.8	52.2
500 (M+S)	4905	28	85.3	10.6	6.9	73.14
750 (M+C)	7357.5	30	99.0	11.5	8.0	92.0
780 (M+C)	7651.8	30	99.2	11.5	8.2	94.3
1000 (M+C)	9810	30	100.2	11.3	9.8	110.74
1030 (M+C)	10104.3	30	100.2	11.5	10.0	115.0

M = human, S = Motor bike, C = Car.

The full accumulator achievement time can be calculated by dividing the current capacity of the battery with the output current of the electric motor. If an accumulator or battery with 6Ah of voltage 12 VDC is used, the calculation of the time required to fill the accumulator shown in figure 6.

Within 1.3 hours can fill the full accumulator so it can be used for traffic lights. And if the given load is larger as in the 1030 kg mass measurement yielding a 10 A current, it takes only 0.6 hours to fully charge the accumulator.

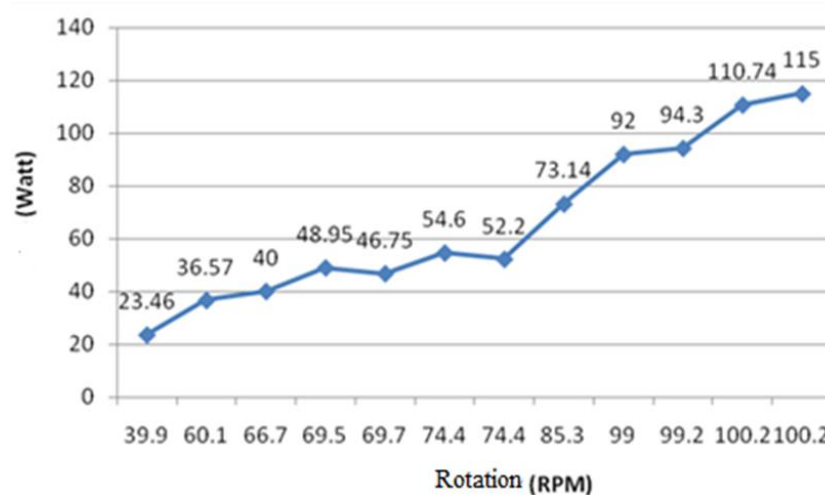


Figure 6. Speed Rotation and Power Test

4. Conclusion

Based on the results of research and testing of power bump power generator, it is obtained that using 490.5 N load produces a voltage of 5.1 Volt DC and current of 4.6 Ampere. While the maximum testing load of 10104.3 N produces a voltage of 11.5 Volts DC and a current of 10 Ampere. And to be used on accumulator charging takes 0.6 hours to 1.3 hours of charging to full.

The magnitude of the voltage and current occurs is influenced by the various loads used so that the flywheel rotational speed changes and affects the rotation of the dynamo shaft which will generate the electricity.

The use of alternatives in renewable energy sources strongly supports the provision of energy needs. By utilizing the modified speed bump mechanism to obtain mechanical energy which is then converted through generator into electrical energy that can be used for various purposes.

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