

# Energy Analysis of a Prototype of Power Generating Unit Using Sliding Plates

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**ABSTRACT:** Today, our whole lifestyle is dependent on electricity. But we know that the resources to generate electricity are limited, and this has led to the energy crisis. To attend this problem, we have made a system that can extract power which is wasted in form of friction. It can be observed that the number of vehicles on the roads and highways have been constantly increasing; which has escalated the traffic rates and consequently the energy produced by the traction between the road and the vehicle tyres. In this paper, the desolate energy incurred by the traction force of the tyres of a vehicle is converted into usable form of electrical energy. A prototype model is developed for generating electricity through the sliding plate mechanism. The vehicle is made to move over the sliding mild steel plate, the translation of which causes a rotation of the sprocket. This rotation is transferred to the shaft of the DC (Direct Current) stepper motor through several mechanisms. The rotation of motor shaft generates electricity, which then can be used to operate traffic lights or any low load equipment. In this way, the non-usable energy from the road tyres friction is converted into a productive form. This paper also clearly explains the working principle of the design system, its practical implementation, and advantages.

**KEYWORDS:** Energy, Speed Breaker Power Generation, Sliding Plate Mechanism, Electro Motive Force, Friction force, Road Power Generation.

## I. INTRODUCTION

Electricity is one of the most widely used forms of Energy. With the increasing population and the development of electric vehicles, the demand of electricity is rapidly increasing. According to the study [3], the power requirement of India in 2017 was 306 GW and is estimated to rise up to 575 GW in 2027. In India total energy shortage is 9 % with peak shortage at 15.2 %. To address this challenge, a novel method of generating electricity using traction force between the roads and the wheels of the passenger vehicles is undergoing research. The number of vehicles on the road is increasing rapidly. It was found in a study conducted in India [7], that the number of registered motor vehicles per 1000 population was 53 in 2001, which increased to 167 in 2015. Figure 1 shows the number of registered vehicles in some of the leading states in India. If we can convert some of the kinetic energy of these vehicles into the rotational motion of generator then we can produce significant amount of electricity, which is the main concept of the project.

## II. RELATED WORK

Mohamadet. al [6] presented different types of SBPG (Speed Breaker Power Generation). The results showed that electrical power up to 45 W was generated when a mass of 80 kg is applied to SBPG system. Extrapolation of results confirmed around 0.56 kW per day can be produced when vehicles with different masses pass through the bumps. AshwinChandwani et.al [8] suggested a mechanism to generate electricity from the wasted kinetic energy of vehicles. It contains a flip plate, gear mechanism, flywheel, and finally a generator coupled at the end so that the rotational motion

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of the flywheel is used to rotate the shaft of the generator, thus producing electricity. AnuragPandey et.al [5] also generated electricity through a flip-plate mechanism. The electricity was stored to the lead 12-volt battery. Electricity stored in battery can be used to activate light, fan, etc. Noor Fatima et.al [10] attempted to convert kinetic energy of vehicle using a moving plate on the road. It takes the stroke motion of the vehicle and converts it into rotary motion by crank mechanism, thus running the generator and producing electricity. Sylvester W. Makumi et.al [9] discussed a new rack and pinion mechanism with MMR (Mechanical Motion Rectifier). J.D Jaymin et.al [4] suggested power generation from speed breakers by air compression.

In this paper, authors have presented a modified sliding plate mechanism to generate electricity. The adjustments made in this new model increased the power generation capacity of the system and hence improved the conversion efficiency. Through preliminary experiment we calculated the power output from the prototype and extrapolated the results for actual scenario. Also, various benefits in application of this system over its counterparts are discussed in this paper.

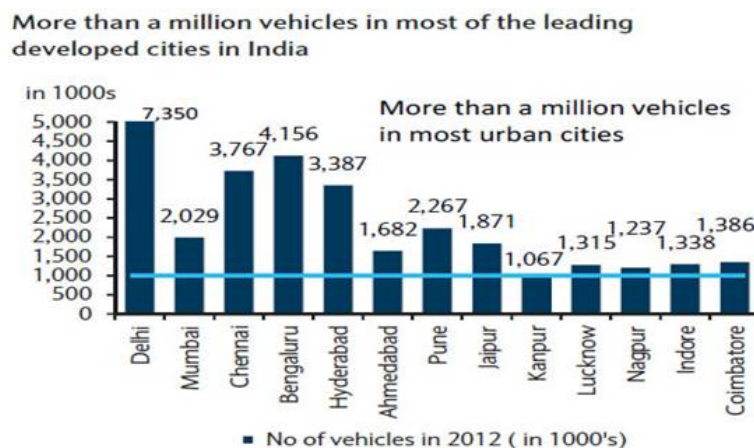


Fig1: Statistics showing number of vehicles in leading developed cities of India.

### III. EXPERIMENTAL SETUP

In this setup two sliding plates (fixed plate and the moving plate) are mounted on the frame which is further kept in road surface and these plates are followed by the sliding plate mechanism arrangement. One of the sliding plates is fixed to the frame and the other plate moves on the roller in the guide ways. Larger sprocket is attached to the shaft which is welded to the moving plate as shown in the figure. The larger sprocket is mounted on the shaft which is attached the frame with the help of roller bearing so as to convert the sliding motion of the plate to the rotary motion. When the vehicle moving at higher speed passes over the sliding plate, then because of the traction force between the tire of the vehicle and the sliding plate the sliding plate moves in the guide direction provide. The motion of the plate is in the same direction as of the moving vehicle also once moved in forward direction the sliding plate retraces its original position with the help of the spring attached to the other end of the plate.

The setup was first made in CAD (Computer Aided Design) modelling software PRO-E. Fig. 3 is the final CAD model of our design and also the space acquired by this model is very less and power generated by this model is greater as the metal plates only undergoes linear motion. The above arrangement can be easily accommodated in a box and can be easily placed inside the ground. Also we have used the support from the base of the frame and not from the sheet metal, this helps in reducing and balancing the weight of the whole system, and also power transmitted by the metal plate to

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the sprocket is uniform and we have used chain drive here for the connection of the sprockets instead of ratchet and pawl.

Table 1  
Specifications of the Major components used during fabrication.

COMPONENT	SPECIFICATION
Metal plate	102 cm X 62 cm, Mild Steel Plate
Sprocket	Teeth = 44, Pitch Circle Diameter = 18 cm
Freewheel	Teeth = 18, Pitch Circle Diameter = 7.5 cm
Shaft	Diameter = 2 cm, Length = 500 cm
Stepper Motor	500 rpm DC motor
Helical Spring	Spring Constant, k = 520 N/m
LED light	3 V, 0.06 W

## IV. METHODOLOGY

The system utilizes the traction force between the wheel and the sliding plate to generate electricity. When the plates reciprocates then the same motion is transferred to the larger sprocket with the help of shaft arrangement as shown in the figure ,thereby converting the reciprocating motion to the rotary motion, this rotary motion is then transferred to the smaller sprocket with the help of the chain drive hence the smaller sprocket also rotates, the rotary motion of the smaller sprocket is transferred to the attached shaft which is mounted on the roller bearing, this rotary motion of the shaft is then transferred to the stepper motor with the help of the gear and belt drive arrangement and then the power is produced, here the bipolar stepper motor is used attached with the three pin led hence the power is produced when the shaft rotates either in clockwise direction or the anticlockwise direction

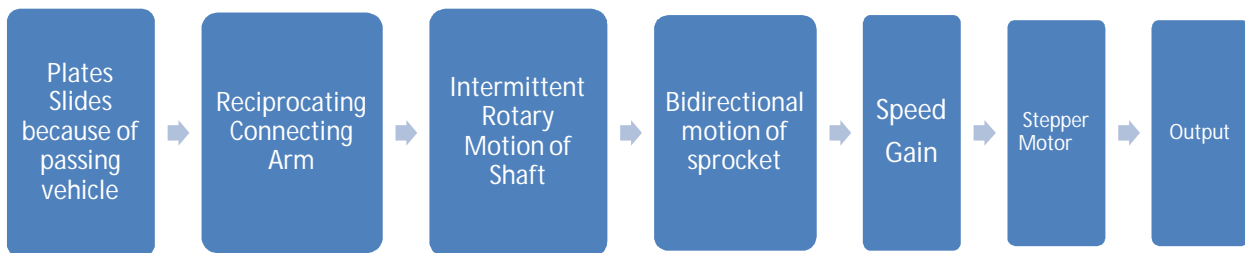


Fig 2: Outline of the working of experimental setup

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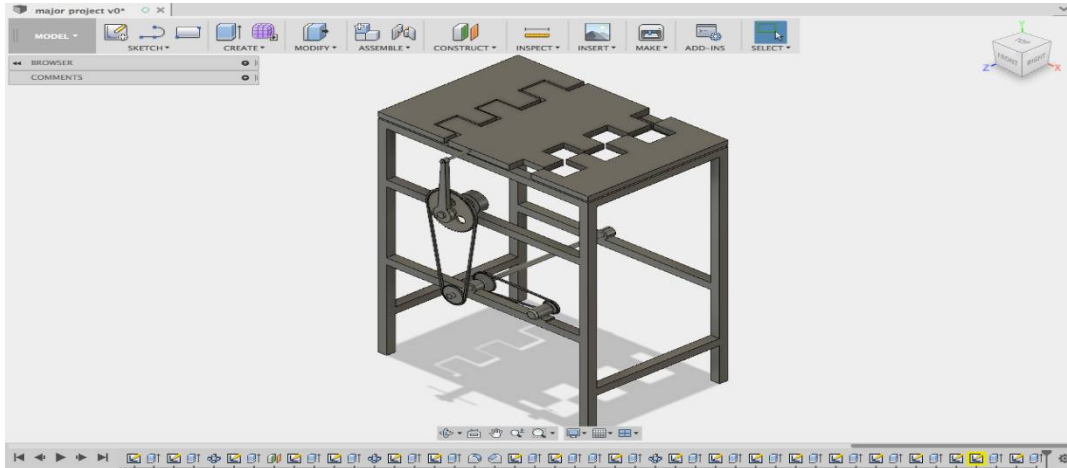


Fig 3: CAD model of sliding plate mechanism.

Fig. 4 shows different views of our fabricated model of sliding plate mechanism for generation of electricity. Different operations involved in fabrication are cutting, arc welding, and grinding.



Fig 4: Different Views of the fabricated model of the mechanism.

Here the bipolar stepper motor is used (attached with the three pin led) hence the power is produced when the shaft rotates either in clockwise direction or the anticlockwise direction. This increases the power generation by a factor of two.

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## V. RESULT

When the plate is moved from the stationary position to the next extreme position, the LED (Light Emitting Diode) bulb of power rating 0.06 Watt lightens. Using a Multimeter, we measured a 0.03 amp and 15 v current outputs from the motor. In terms of power, we get 0.45W of electric power. After being pushed by the wheel, the plate returns to its original position which again produces electricity of 0.9W. Therefore, by moving one wheel of the vehicle over the plate we generate 0.9W of power.

If we analyse the situation, we will find that most of the times two wheels of a vehicle will pass over the plate and we get 1.8W of EMF (Electro Motive Force) from passing of a single vehicle over a single unit of this system. According to a survey conducted by MSRDC (Maharashtra State Road Development Corporation), as many as 90,000 vehicles pass through the Pune-Mumbai express highway. Considering 30,000 vehicles pass each day through a place anywhere in India. This gives us 54000 W or 54 kW of electric power in a day by using sliding-plate mechanism. Therefore, by installing a single unit of sliding plate mechanism we can generate up to 0.9 kW/h of power.

To calculate the efficiency of this system, we find the work done by the wheel of the vehicle on the plate. Friction force on the plate is given by Eq. (1)

$$F = \mu mg \quad (1)$$

where,  $F$ =Force in (N);  $\mu$ = Coefficient of friction;  $m$  = Mass in (kg);  $g$  = acceleration due to gravity in ( $m/s^2$ )  
Taking the average mass of a vehicle to be 1500 kg, and assuming equal distribution of mass to all the four wheels, we can say that mass on one wheel would be 375 kg. Assume kinetic friction coefficient as 0.02 for mild steel.

And finally work done by the wheel is represented by Eq. (2). Distance between the plates is 5 cm or 0.05 m.

$$W = F * D \quad (2)$$

where,  $W$  = Work done in (J/s);  $D$ = Distance in (m)

By calculation, we get the work done by the wheel on plate to be 3.68W. From previous data, the motion of one wheel over the plate generates 0.9W. So, the efficiency of the sliding plate mechanism is 24.46%.

## VI. ADVANTAGES OF SLIDING PLATE MECHANISM

1. Generation of power without polluting the environment.
2. Eco-friendly and reliable source of power production.
3. Simple Construction and easy maintenance.
4. No consumption of any fossil fuel which is non – renewable source.
5. Utilizes the otherwise wasted energy from the vehicles.
6. Can be installed on any kind of road surface.
7. The more the frequency of the vehicles passing over it, greater will be the electricity generation.

## VII. APPLICATIONS

1. This Technique can be used in all highways.
2. The Power is generated when the vehicles pass through it, which in turn can be stored in battery of vehicle or can be used to run the charging ports in vehicles.
3. This Power can be used in the following :
  - Road Signals

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- Sign Boards on the roads.
- Lightning of the bus stop.
- Lighting of the check post on the highway.
- Lightening Street Lights.

## VIII. CONCLUSION

In this project, we have discussed a sliding plate mechanism for RPG (Road Power Generation). It has been shown that this type of system utilizes very small place and can be installed anywhere, unlike SBPG system which cannot be installed everywhere. We have achieved a power output of 1.8 W through the sliding plate mechanism. The power output can be increased by arranging several machines in series and/or by using a generator with higher capacity. The efficiency of the system was found to be about 24.46%. However, this can be improved by increasing the distance by which plate moves and efficiency of mechanical gear and pulleys. The power generated by this machine can then be stored in batteries for use. This makes it convenient since power can be supplied even if there are no vehicles passing over the sliding plate.

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