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Design and Analysis of Power Generating Speed Breaker

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Abstract: ***Energy is the primary need for the survival of all organisms in the universe. Everything that happens in the surrounding area is the expression of the flow of energy in one of the forms but in this fast-moving world population is increasing day by day and conventional energy sources are decreasing.***
The extensive use of energy resulted in the energy crisis in a few years. Therefore to overcome this problem we need to implement the techniques of optimal utilisation of conventional sources for the conservation of energy.
This project includes how to utilise the energy which is wasted when the vehicle passes over the speed breaker. There are four mechanisms to generate electricity through speed breakers via, Rack and Pinion mechanism, etc.

I. INTRODUCTION

In the present scenario, power becomes the major need for human life. Energy is an important input in all the sectors of any country's economy. An energy crisis is due to two reasons, firstly the population of the world has increased rapidly, and secondly, the standard of living of human beings has increased. India is the country, which majorly suffers from a lack of sufficient power generation.
The availability of regular conventional fossil fuels will be the main source of power generation, but there is a fear that they will get exhausted eventually by the next few decades.
Therefore, we have to investigate other types of renewable sources, which produce electricity without using any commercial fossil fuels, which are not producing any harmful products. There are already existing such systems using renewable energy such as (solar wind), OTEC (ocean thermal energy conversions), etc...for power generation.
The latest technology which is used to generate the power by such renewable energy is called "POWER HUMP". A large amount of energy is wasted at the speed breaker through friction, every time a vehicle passes over it. So electricity can be generated using the vehicle weight (potential energy) as input. So this is a small step to try to improve this situation. In this method in general potential energy is converted into electrical energy.
Speed breaker POWER GENERATOR Convertersbasically a new concept of non-conventional energy generation

A. Working Principle

This device works on the principle of conversion of mechanical energy into electrical energy. It is an electro-mechanical energy-generating machine.
This machine converts reciprocating motion to rotary motion. The rotational power is stored in the flywheel & the flywheel rotates dynamo, which generates electricity. We put our machine underneath the speed breaker installing different units. All the units are connected to the common shaft using gears.
The head of the rack is brought up to level beneath the speed breaker surface. When the vehicle moves on the speed breaker, the rack will be pushed down. The rack is attached with a freewheel-type pinion that rotates in one direction only.
The rack & pinion arrangement converts reciprocating motion into rotary motion. This rotary motion is further magnified using reciprocating motion into rotary motion gear drive. The output of the pulley is attached to a flywheel which stores kinetic energy and transfers it to a dynamo which generates electricity at zero cost. A "generator" and "motor" are essentially the same things: what you call it depends on whether electricity is going into the unit or coming out of it. A generator produces electricity. In a generator, something causes the shaft and armature to spin. This generated power is used for various applications.

B. Motivation

An energy crisis is any significant bottleneck in the supply of energy resources to an economy. Industrial development and population growth have led to a surge in the global demand for energy in recent years. There is a current global need for clean and renewable energy sources. Fossil fuels are non-renewable and require finite resources, which are dwindling because of high cost and environmentally damaging retrieval techniques. So, the need for cheap and obtainable resources is greatly needed.

Now the question arises why only the speed breaker is used and not the rough road or plane road where the kinetic energy of the vehicle is more than what is getting on the speed breaker for the answer to this question let"s look at one example: A car or any heavy vehicle is coming with a speed of 100 mph on the road and passing over this roller which is fitted at the level of the road then this roller is gaining the speed nearly somewhere 90 mph (due to losses). So now suppose a bicycle is coming with a speed of 20 mph and is going to pass this roller (which is moving at a speed of 90 mph) due to this difference in the speed there will be a collision that is the main reason for using this concept on the speed breaker.

C. Project Definition

This device converts the Potential energy of the vehicles into electric energy. This happens when a vehicle passes over our system(power generating speed breaker), and a reciprocating rack and pinion mechanism is set under the speed breaker.

D. Objective

1) To select an alternate source for the generation of electricity for lighting the streets.
2) To design, develop, and perform the evaluation of the mechanical setup of the project work.
3) To generate electricity at a low price.
4) Eco-friendly system.

Using wasted kinetic and potential energy of the vehicle at a speed breaker.

II. LITERATURE REVIEW

A. Review On Electricity Generation using Speed Breaker,2018.{1}

In this paper, they represent the three types of mechanisms that we can use for power generation from speed breakers. The three mechanisms are 1)Roller Mechanism, 2)Rack and Pinion Mechanism and 3) spring coil mechanism. They designed a speed breaker as per the government standard, The material used in the construction of speed breakers is steel. The speed breaker's shape is trapezoidal or parabolic. the specification for Road Humps, As per Indian Road Congress are -. Height: 10-12 cm; Width: 3.5 meters; and the Length is the same as the road width. They also designed spring, assuming the spring deflection of 0.1M. From this paper, we understood that we can use different types of mechanisms, And understood how to design the component.

B. Introducing Speed Breakers as a Power Generating Unit for Minor Needs,2013.{2}

In this paper, the roller mechanism is used to generate electricity from speed breakers by converting vehicle kinetic energy to mechanical energy. As the vehicle passes over the speed breaker wasted kinetic energy can be converted into the rotational motion of the roller to generate electricity, this is the main concept of this research. A roller having some kind of grip is placed between the speed-breaker. So when a vehicle passes over the breaker, it rotates the roller. This movement of the roller is used to rotate the shaft of the DC generator with the help of a chain drive using 1:4 speed ratios. As the shaft of the DC generator rotates, it produces electricity. The outcome of this paper was that heavy vehicles generate more power as compared to light-weight vehicles.

C. Generation of Electricity Through Speed Breaker Mechanism,2012.{3}

In this paper, the chain and sprocket mechanism is used for power calculation. The working of the chain and sprocket mechanism is similar to the rack and pinion mechanism. When the vehicle comes on the speed breaker because of its weight the top portion of the speed breaker moves downwards and the shaft consisting of the U portion rotates in a particular direction. Due to this rotation of the shaft, the sprocket will rotate and the rotational energy from one shaft is transferred to the other shaft with the help of a chain drive mechanism. This rotates the gear on the bottom shaft, which in turn will help to rotate the gear placed on the motor. This rotation of the gear starts the generator and generates electricity. The outcome of this paper is

1) The power generated from the roller mechanism is less compared to the chain and sprocket mechanism.
2) The working principle of the chain and sprocket mechanism is simple as compared to the roller mechanism.

D. Design and Fabrication of Power generation System using Speed Breaker,2014.{4}

In this paper, the crankshaft mechanism is used for power generating from a speed breaker. They did the design and fabrication of all the components which are used in this project. The working principle of this is, that the reciprocating motion of the speed-breaker is converted into rotary motion using the connecting rod and crankshaft arrangement. The axis of the crankshaft is coupled with the larger gear. The gear arrangement is made up of two gears. One of larger size and the other of smaller size. Both the gears are connected and are meshed directly which serves in transmitting power from the larger gear to the smaller pinion. As the power is transmitted from the larger gear to the smaller pinion, the speed that is available at the larger gear is relatively multiplied at the rotation of the smaller pinion. The outcome of this paper is

1) In this mechanism more power is generated as the load increases.
2) Dc Current is the most effective type of power that can be produced.

E. Design and Construction of a Speed Bump Power Generator,2017. {5}

In this paper, The rack and pinion mechanism are used for power generation. The components which are used in this project are gear, compression spring, LED metres, digital metre, chain and sprocket, shaft, and bearing. When a vehicle moves on the speed breaker, the rack will be pushed downward. The rack is attached with a freewheel-type pinion that rotates in one direction only. The rack & pinion arrangement converts reciprocating motion into rotary motion. And this rotary motion goes to the generator or motor. They calculated the maximum power output of 1.95Kw at 2028(RPM).

F. Electrical Power Generation Through Speed Breakers,2015.{6}

In this paper, the rack and pinion mechanism is used with a hydraulic press to increase the force. In a hydraulic press, a small force applied on a column of liquid is converted into a much greater force available to another column of liquid. It is an application of Pascal's law. In their proposed system it converts the force 4 times from small piston to large piston when the pressure is created on the speed breaker.

In this mechanism, they get the power output of 8.58w, they assume the approximate weight of the vehicle was 350kg. The approximate power generation from this system is 12.35kw for 24 hours. The outcome of this paper is we can use a hydraulic press to increase the force on the rack and pinion. And understood the types of parameters required for power output calculation.

G. Generation Of Electricity Using Speed Breaker By Application Of Rack And Pinion,2018.{7}

In this paper also, The rack and pinion mechanism is used. Their project was a simulation-type project. In their research paper, they did a literature survey of 22 research papers. The outcome of this paper is that the rack and pinion mechanism is a more suitable and compact mechanism to enhance efficiency as compared to the other mechanisms. This rack and pinion mechanism can be designed for heavy vehicles, thus increasing input torque and ultimately output of the generator will also increase.

H. A Revolutionary Technique of Power Generation Through Speed Breaker Power Generators,2013.{8}

In this paper, the rack and pinion and chain drive mechanism is used. The working principle of this mechanism is very similar to the rack and pinion mechanism. In this mechanism, When the vehicle comes on the speed breaker because of its weight the top portion of the speed breaker moves downwards and the shaft consisting of the U portion rotates in a particular direction. Due to this rotation of the shaft, the sprocket will rotate and the rotational energy from one shaft is transferred to the other shaft with the help of chain drive mechanism. This rotates the gear on the bottom shaft, which in turn will help to rotate the gear placed on the motor. This rotation of the gear starts the generator and generates electricity. A single design of power generation is not suitable for all the road conditions. We can introduce different designs as per the road condition.

I. Design and Fabrication of Speed Bump Power Generation System,2019.{9}

In this paper, The SBPGS(speed breaker power generation system) is used. This system consists of two basic parts: Mechanical Speed Bump (MSB) and Energy Storage System (ESS). They did calculations as per the GVWR(Gross Vehicle Weight Rating). In GVWR the vehicles range from light-weight vehicles(taxi/rickshaw) to heavy-weight vehicles(Heavy Truck 6-Axles). They used a MATLAB program code consistent with this performance was developed for evaluating the actual performance of their system, from which an average weight of 10.91kN acting on the tires of vehicles plying our roadways, generates 32.52W of electrical power. The outcome from this research paper is that this System is designed to function as a road safety device and power generation system.

J. Speed Breaker Power Generation,2019.{10}

In this paper, they proposed various mechanisms which we can use for power generation. The mechanisms are the Spring coil mechanism, Rack- Pinion mechanism, Crank-shaft mechanism, and Roller mechanism. They used a rack and pinion mechanism with a motor because it generates more power as compared to other mechanisms. They Used a small motor to increase the rpm of the gear thus resulting in the increase in power output from the generator. They designed all the components considering the weight of 200kg. The outcome of this paper is that we can use a small motor to increase the RPM.

K. Power Generating Speed Breakers: A New Approach,2019.[11]

In this paper, the flywheel is used with a rack and pinion mechanism. In their system they used a flywheel to store the energy i.e the output they got from the rack and pinion mechanism. They calculated the power output considering criteria 1)Voltage generated VS Speed of the vehicle and 2)Voltage generated VS Load of vehicle. In the first case, the speed of the vehicle ranges from 10-40km/h and the voltage generated ranges between 9-5 volts respectively. In the second case, the load of the vehicle ranges from 360kg-500kg, and the voltage generated ranges between 8-12 volts respectively. The outcome of this paper is as the load increases on the system the power output will also increase.

III. METHODOLOGY

A. Acquisition Of Data

Research papers have been the main source of data acquisition for our project. Various research papers published about power generating speed breakers were found.

The most common source for these papers was Google Scholar. We found all related research papers, as well as journal articles related to our topic, and all of them were downloaded and studied by all members thoroughly.

B. Design and Calculations

The design of the entire model is to be done in 3D CAD software. For this one, we have picked Solidworks to use. The entire model will be created on this as well material for various parts will be selected.

Each component will be designed separately and then assembled together in the final product. This is for the purpose of manufacturing the various parts separately and having them assembled at the site of the actual installation.

Various calculations have been performed as well as assumptions were made on some of the dimensions of the parts to have them suit the design. More about the dimensions and calculations of parts will be elaborated in the design section.

The entire model is to be analysed properly in an analysis software to confirm the structural integrity of the system as well as analyse the various loads which will be acting on it. The design has to be deemed safe and structurally solid as well as meet safety standards of the road.

With all these criteria in mind, we are to design our project.

IV. DESIGN

A. Various Mechanisms Availables

Power can be produced from conventional and non-conventional energy sources. Speed breaker power generator converters are a new concept of non-conventional energy generation. There are various mechanisms available to generate power from speed breakers. They are as follows:

1) Roller Mechanism

In a roller mechanism, a roller is placed in between a speed breaker (rotational bump shaft) which is connected to a DC motor shaft. The speed breakers provide some kind of grip so that whenever the vehicle passes over a speed breaker it rotates the roller. This movement of the roller is used to rotate the shaft of the DC motor. Rotating bump rotates DC motor (which is used as a generator). As the roller rotates the shaft of the DC motor, it produces electricity. Hence, kinetic energy through a rotation of a motor gets converted into its equivalent electrical energy. [1]

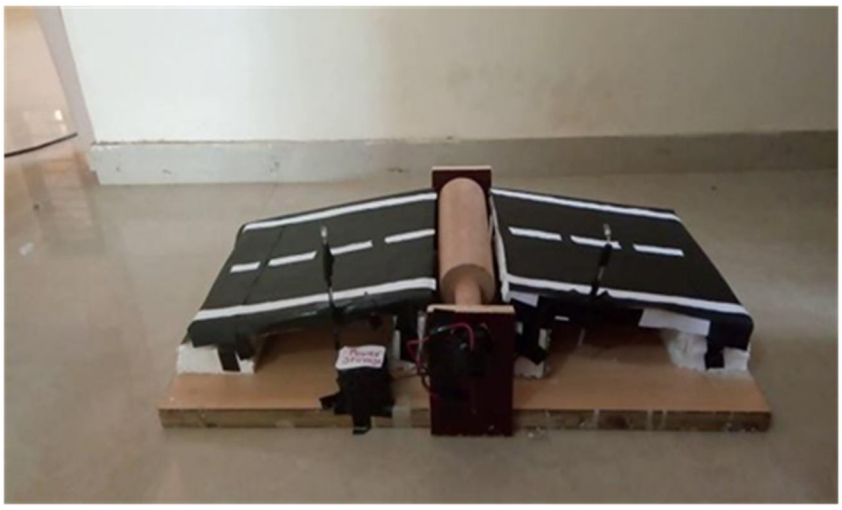

Fig 1 Roller Mechanism [1]

2) Rack and Pinion Mechanism

- Rack and Pinion using Chain Drive
- Rack and Pinion Using Hydraulic Press
- Rack and pinion using spring system

The rack and pinion mechanism uses gear that converts the reciprocating motion of the speed-breaker into rotary motion. The circular gear is the pinion that is connected to the lower part and the linear gear is the rack that is connected to the speed breaker. They interact through teeth in both the gears when the vehicle passes over the speed breaker the linear gear i.e. rack moves towards the downward direction and gives movement to the circular gear i.e. pinion. A circular gear rotates in a clockwise direction. This pinion or small gear is coupled to the larger gear. So as the larger gear rotates at the multiplied speed of the pinion, the smaller gear following the larger gear still multiplies the speed to more intensity. Hence, although the speed due to the rotary motion achieved at the pinion is less, as the power is transmitted to gears, finally the speed is multiplied to a higher speed.

➢ *Rack and Pinion using Chain Drive*

In this mechanism, the axis of the pinion attached to the sprocket mechanism arrangement is made by using two sprockets, one is larger and the other is in a smaller size. When a vehicle passes over the breaker, the rack is pushed in a downward direction which gives rotation to a pinion which is connected with a sprocket arrangement which is connected via a chain, which transmits energy from the larger sprocket to the smaller sprocket. Energy from the larger sprocket transmitted to the smaller sprocket is the speed that is available at the larger one which is relatively multiplied at the rotation of the smaller sprocket. The smaller sprocket shaft is connected to the shaft of the DC motor, when the smaller sprocket rotates, it rotates the DC motor shaft via a gear assembly. [1]

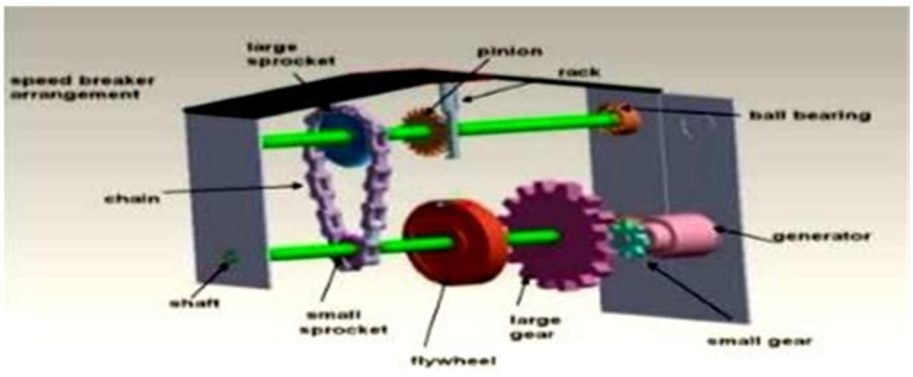

Fig 2 Rack And Pinion With Chain Drive Mechanism [1]

➢ *Rack and Pinion Using Hydraulic Press*

In this system When the vehicle load is acted upon the speed breaker is transmitted to rack and pinion arrangements. Because of the weight of the vehicle, the top portion of the speed breaker moves downwards. In the pressure rod, one side is attached to the bottom of the speed breaker and another side to the small piston of a hydraulic press. The hydraulic press converts the force 4 times from a small piston to a large piston. In a hydraulic press, a small force applied to a column of liquid is converted into a much greater force available to another column of liquid. It is an application of Pascal's law. [6]

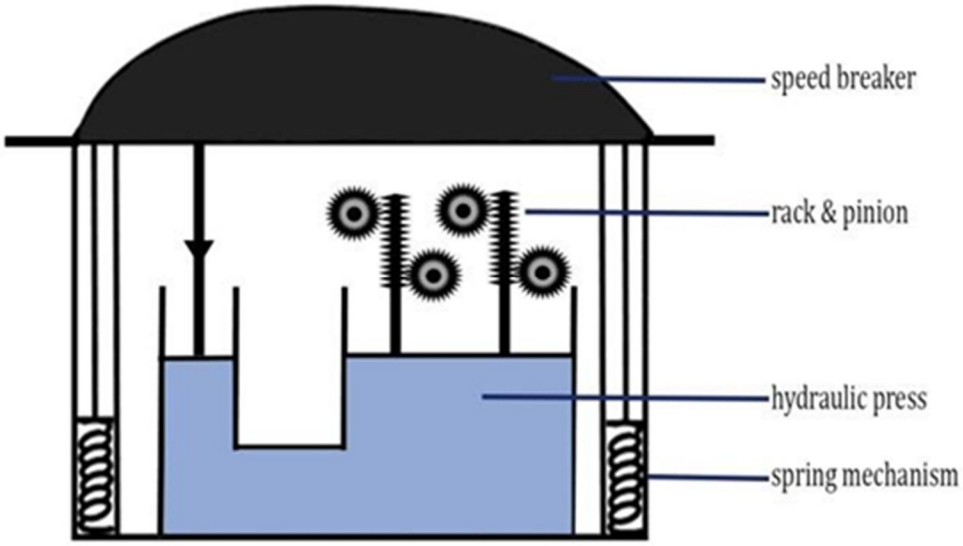

Fig 3 Rack And Pinion With Hydraulic Press [6]

➢ *Rack and Pinion using Spring System*

In this system when a vehicle passes over the MSB(Mechanical Speed Bump), the tyres exert force on the SBC(Speed Bump Cover), the SBC then depresses, the springs attached to the SBC compresses and the rack that is also attached to the SBC moves downward in translational motion. When the two springs are compressed to their maximum, the rack reaches the motion limit and stops moving, and then the four suspension springs placed beneath the speed bump cover support the impact of the tyres over the MSB. The two compression springs which are arranged in parallel then rebound to their original position by a restoring force the springs developed during compression.[9]

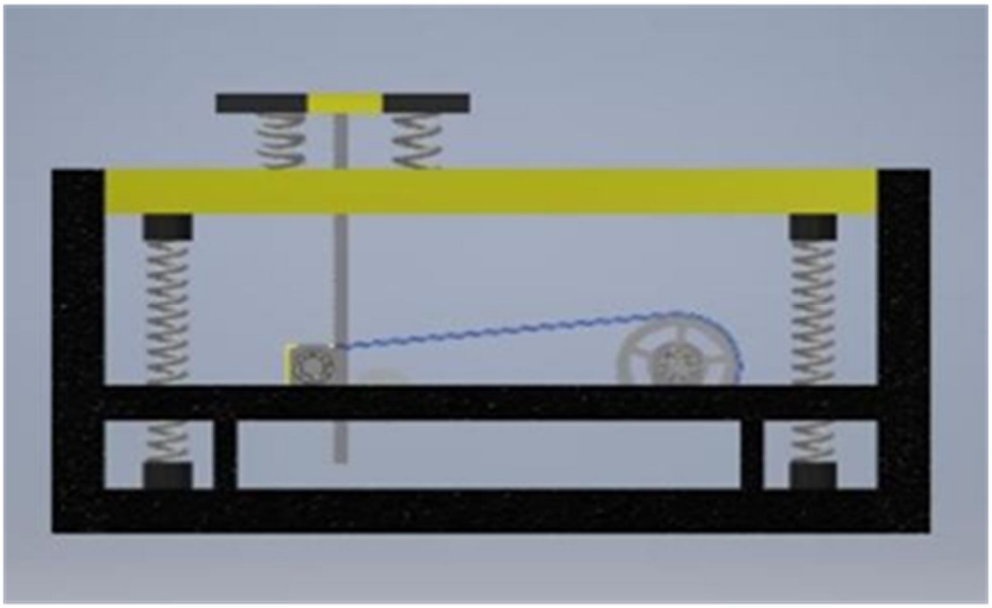

Fig 4 Rack And Pinion With Spring System [9]

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B. Mechanism Selected

1) Reciprocating Rack And pinion

Intended as a substitute for the crank. Reciprocating the rectilinear motion of the double rack gives a continuous rotary motion to the centre gear. The teeth on the rack act upon those of the two semi-circular toothed sectors, and the spur-gears attached to the sectors operate upon the centre gear. We selected this mechanism because it is more efficient than other mechanisms, and energy loss in this mechanism is very less compared to the other mechanism. In this mechanism, power will generate continuously i.e when the rack travels upward and downward.

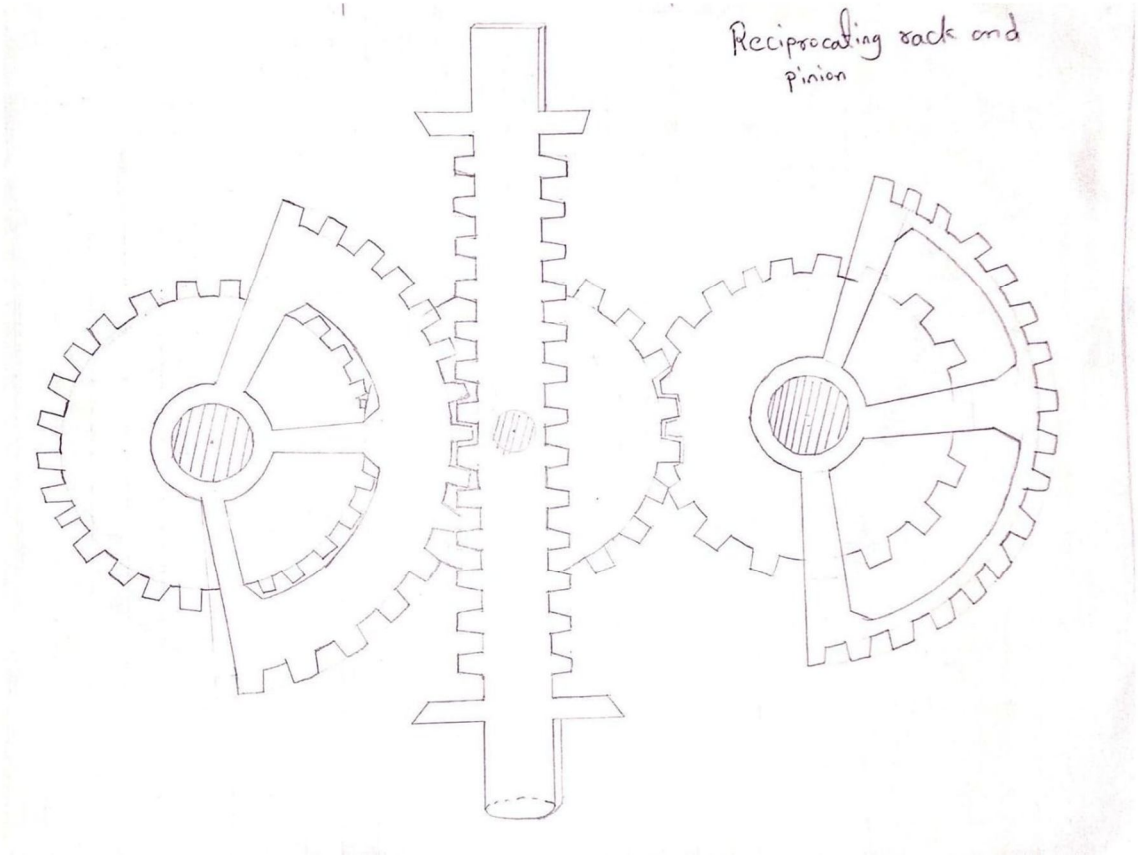

Fig 5 Reciprocating Rack And Pinion Mechanism

C. Components

1) Bump (speed breaker)

This is the bump of the speed breaker which will be on top of the road. This is a normal speed breaker that will be used to slow down the cars. This whole bump will be pushed down which will cause the springs attached to it to be compressed.

Fig 6 Bump CAD Model

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➢ Specifications

•Dimensions: 1000*500*100
•Material: Polyvinyl Chloride(PVC)
•Ultimate Tensile Stress: 52 N/mm2

➢ Feature

•1 metre long allows for more flexibility and a wider range of applications.
•Can stack units till the width of the road.

2) Top Part

The top part is where the bump is placed on and it is where the springs are attached to on the bottom side. It has sections of rods on the side for smooth motion of the part as well as to provide extra stability to the system so that it doesn't collide to any one side as a result of dynamic loading.

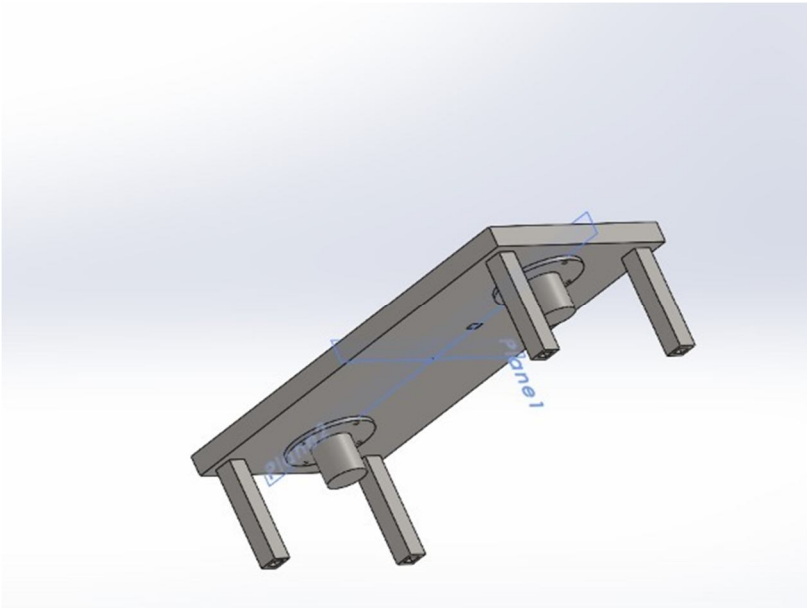

Fig 7 Top Part

3) Base

The Base is the bottom of the system, where all the components are placed. It holds the gear casing, bottom of the spring and mainly the generator.

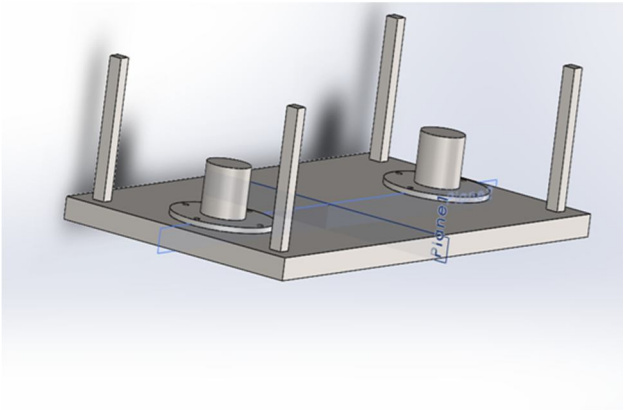

Fig 8 Base CAD Model

➢ Specifications

•Dimensions: 1000*500
•Material: Cast Iron
•Ultimate Tensile Stress: 450N/mm^2
•Yield Stress: 2.206e+08
•Deformation: 1.6004e-08m

➢ Features

Used as the base for spring, gear casing as well as the generator.

4) Reciprocating Rack and Pinion

In this reciprocating rack and pinion mechanism, we have one rack connected to two half gears (pinions). One gear is connected and rotates when the rack is moving downwards and disconnects when the rack reaches the bottom position. When the rack is moving upwards, it connects to the other gear and hence the rotational motion is ever present in the system.
We have 3 additional gears connected at the back of the system. Two of these gears connected at both the ends are used to keep the motion of the half gears continued when they are disconnected from the rack. The gear at the centre is used to transfer the pure rotational motion into the shaft.

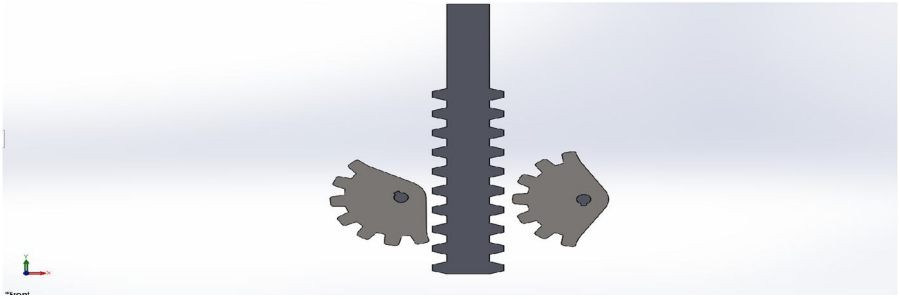

Fig 9 Reciprocating Rack And Pinion CAD Model

5) Springs

Springs are attached at both ends to other components. When these components move apart, the spring tries to bring them together again. Extension springs absorb and store energy as well as create a resistance to a pulling force.

Springs are used in our project for the following reasons

a) To apply force
b) To control vibrations
c) To control motion
d) To reduce impact i.e. as Shock absorbers.

➢ Specifications

- Free Length: 370mm
- Compressed Length: 270mm
- Deflection: 100mm
- Number of turns: 15
- Coil Diameter: 13mm
- Spring Radius: 39mm
- Material: Patented Cold Drawn Steel Wire
- Ultimate Tensile Strength: 1090 N/mm
- Stiffness of One Spring: k1= k2=7.1 N/mm
- Total Stiffness: k1 + k2 = 14.2N/mm

(Since both springs are in parallel)

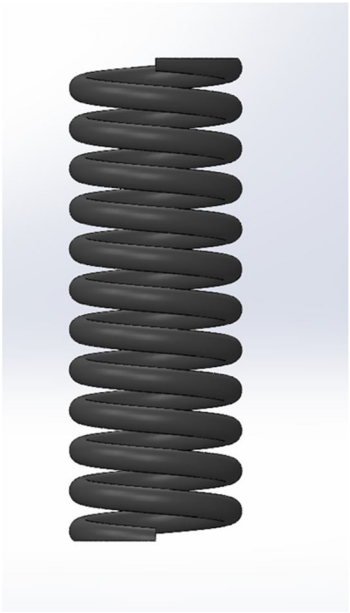

Fig 10 Spring CAD Model

6) Shaft

A shaft is a mechanical component for transmitting torque and rotation, usually used to connect other components of a drive train that cannot be connected directly because of distance or the need to allow for relative movement between them.

The shaft will be used to transfer the rotational motion from the pinion to the generator where it will be used to generate electrical power. The shaft will be the Bridgeway between mechanical power and electrical power.

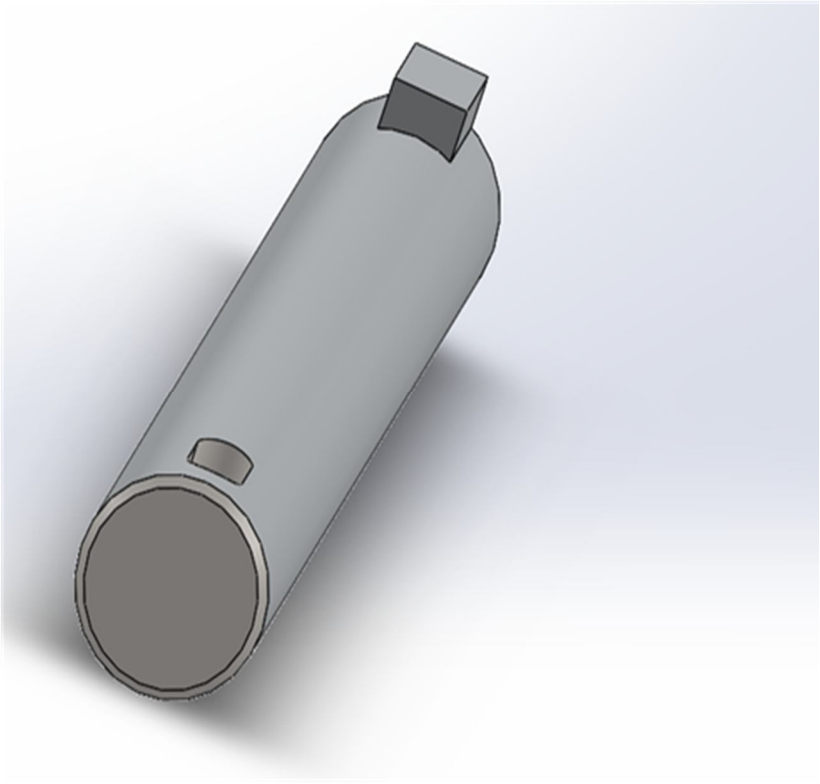

Fig 11 Shaft CAD Model

7) Gears

These three gears are used to transfer the motion from the half gears into the shaft as well as keep the rotational motion of the half gears continued for the other half of the rotation where they are disconnected from the rack.

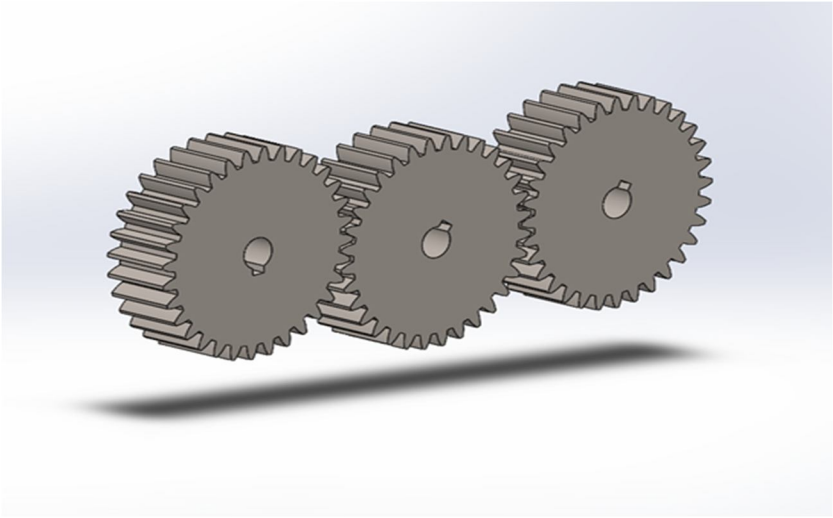

Fig 12 Additional Gears CAD Model

8) Gear Casing

The gear casing is used to hold the gears and the bearings and protect the gears from any external damage.

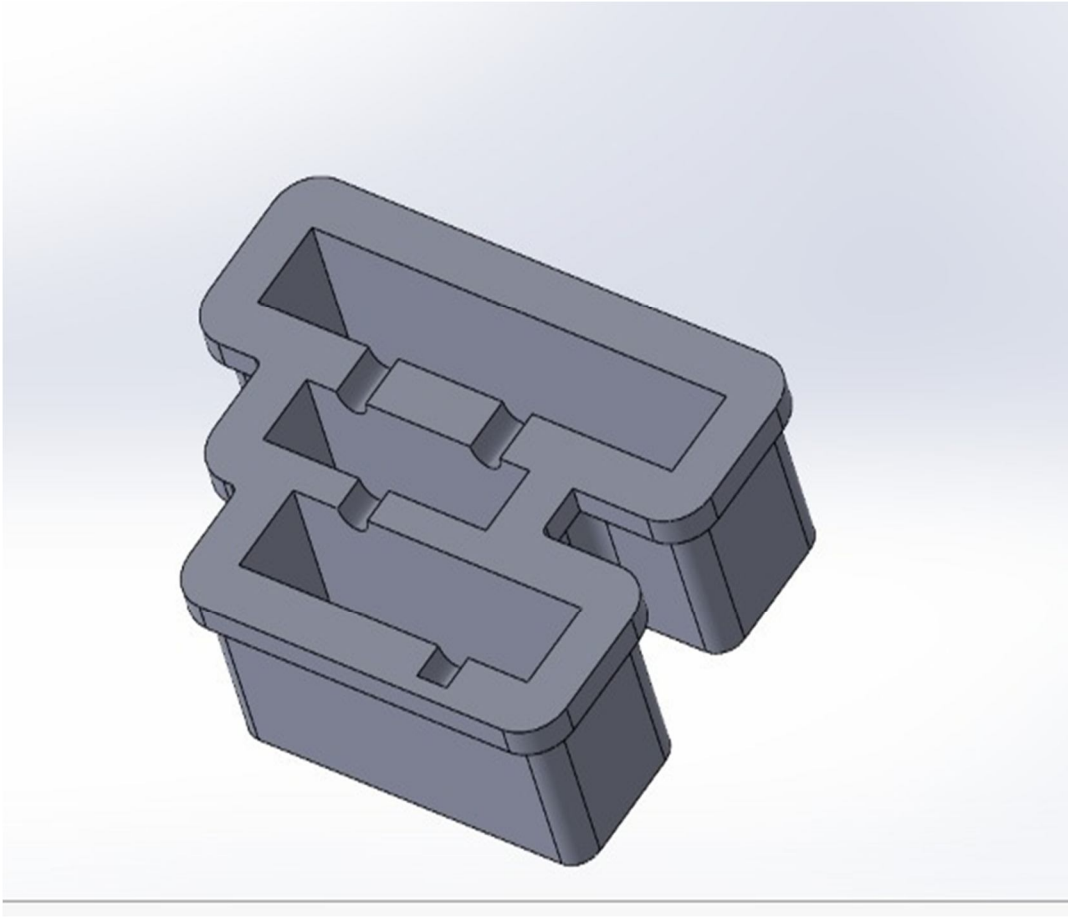

Fig 13 Gear Casing CAD Model

D. Calculations

To design rack and pinion for one revolution of pinion for every 100mm displacement of rack .

No of teeth (Z) = 15

Module (M) = 6

Pitch diameter=Z*M

=15*6 =90mm.

Mounting distance (a) =100mm

Rack pitch height (H) = a-(d/z)

=100-(90/2)

=55mm

Circular pitch of pinion = $(2\pi*(d/z))/Z$

$= (2*\pi*45)/15$

=18.84mm

Linear pitch (of rack) = circular pitch = 18.84mm

Tooth thickness= ½* circular pitch

=1/2*18.84

=9.42mm

Pressure angle (φ)=20

Addendum = module = 6mm

Dedendum = 1.25*6 = 2.5mm

Gear design

No of teeth=15:75

Pitch diameter = z*m

=15*2.5 = 37.5mm

Pitch diameter = 75*2.5 = 187.5mm

Circular pitch = $\frac{2\pi*(37.5/2)}{15}$ =7.85mm

Circular pitch = $\frac{2\pi*(187.5/2)}{75}$ =7.85mm

Tooth thickness = ½*circular pitch

=1/2*7.85

=3.925mm.

Three gears of same pitch diameter are to be made

Pitch diameter of additional gear= $\frac{\text{rack thickness} + (2*\text{radius of pinion})}{2}$

i.e pitch diameter = $\frac{38+(45*2)}{2}$

=64mm.

Module is taken as 2

Number of teeth = pitch diameter/2

=64/2 =32

Circular pitch = $2\pi*(64/2)$

=6.243mm
Since the gear ratio has to kept same
N1:N2:N3::1:1:1
All three gears will be the same

- **Spring design:**

Material = patented and cold drawn steel wire.
Ϭut = 1090N/mm^2
G = 81370N/mm^2
Load = 5 KN
Deflection = 100mm
C =6

Step 1 : calculation of wire diameter.
The permissible shear stress is given by
τ =0.5σut
=0.5*1090 =545N/mm^2
K = 4c-1/4c-4 + 0.615/c.
= 4(6)-1/4(6)-4 + 0615/6
K=1.2525
Now,
τ= k(8*L*C/Πd^2)
= 1.2525(8*5000*6/π*d^2)
545 = 1.2525(48*5000/π*d^2)
d^2=175.65
d=13.25 =13mm

Step 2 : mean coil diameter
D=c*d
= 6*13
=78mm
Step 3 : no of active coil
δ= (8*L*D^3*N)/Gd^4
100=(8*5000*78^3*N)/81370*13^4
N=12.24 =13
N=13.
Solid length of spring =N *D
=15*13 = 195mm.
It is assumed that there will be a gap of 1 mm between consecutive coils.
The total axial gap between the coil will be
(15-1)*1=14mm.
Free length of spring = solid length +total axial gap +δ
= 195+14+100
=309mm
*Pitch of the coil
Pitch = free length / (N-1)
=309/14
=22.07mm.

E. CAD Models (Assembly)

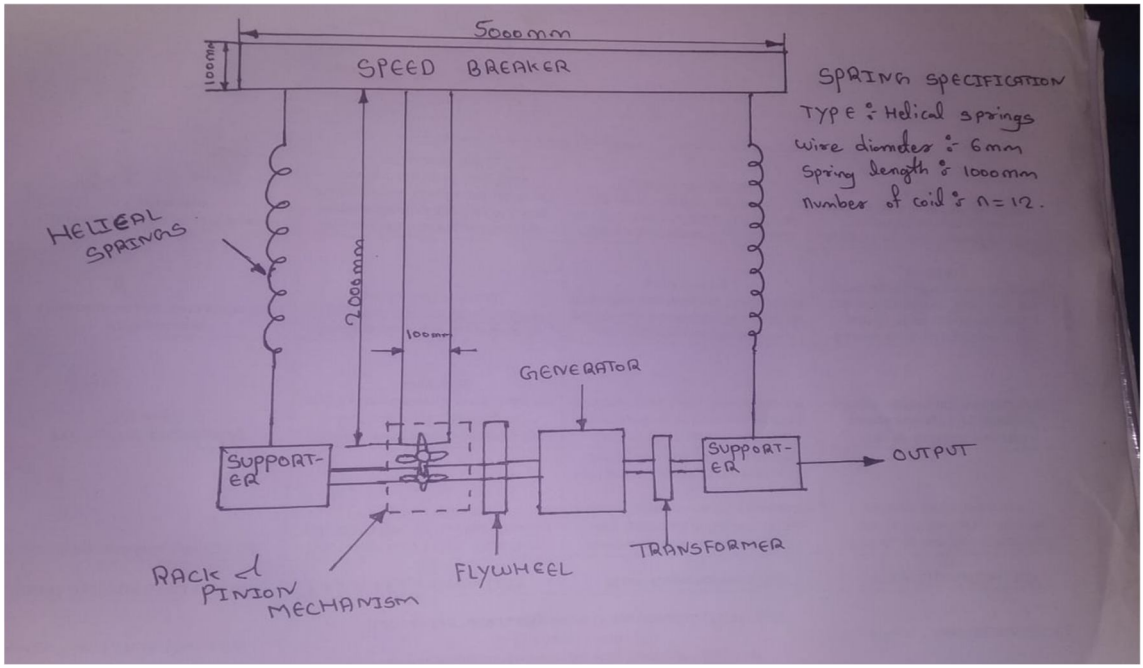

Fig 14 Rough Sketch of model

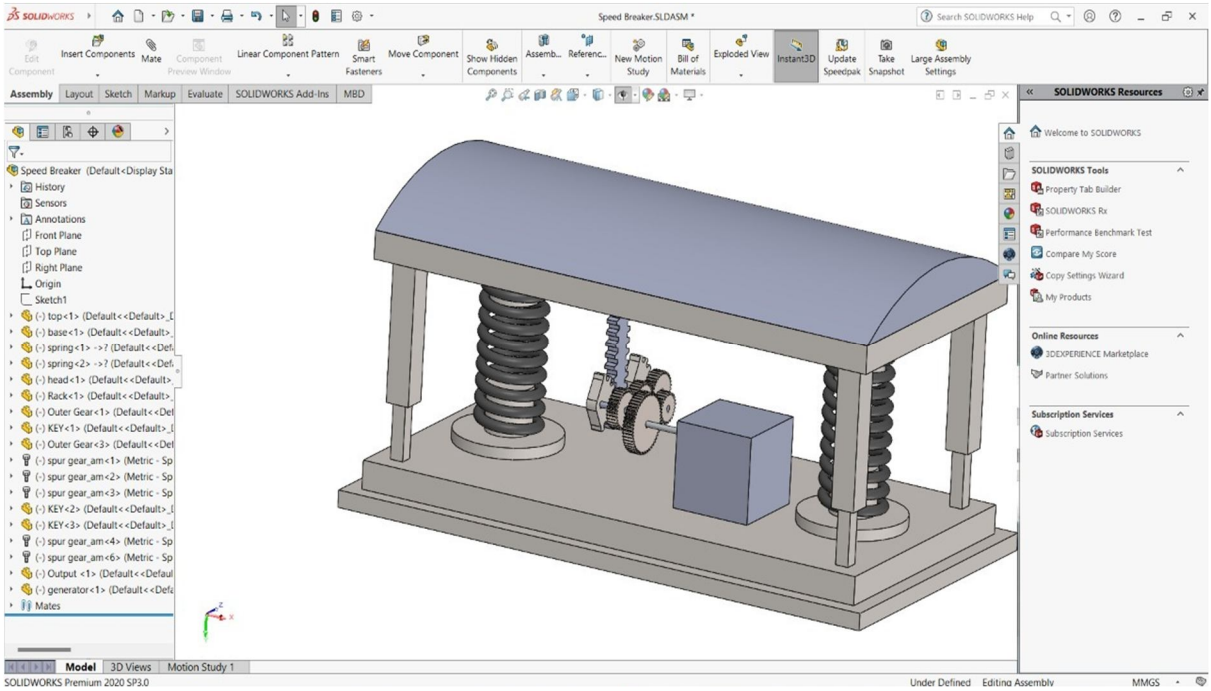

Fig 15 CAD Model Of Assembly

V. ELECTRIC COMPONENTS

The model will make use of a few electrical components, Mainly they are

1) Generator
2) Inverter
3) Battery

A. Generator

The device which converts mechanical energy into electrical energy is called a generator. In our project the output shaft is directly connected to the generator which in turn will generate electrical power This electricity generated will be stored in the battery.

The generator used here is a permanent magnet D.C. generator. The generated voltage is 12 Volt D.C

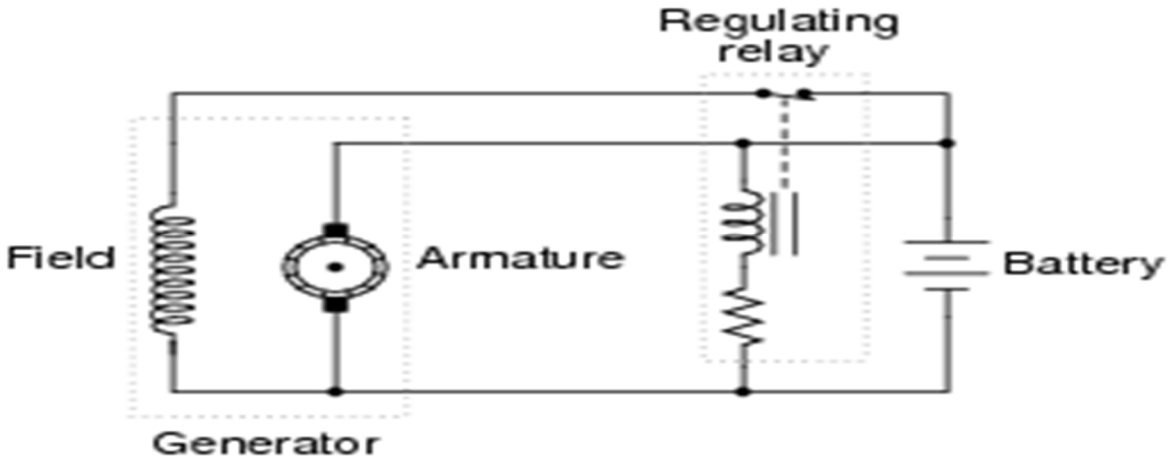

Fig 16 Generator

B. Inverter

The inverter will convert 12-volt D.C generated by our generator to the 220 volt A.C. that will be used globally. By increasing the capacity of the battery and the inverter the total power output can be increased as per requirements

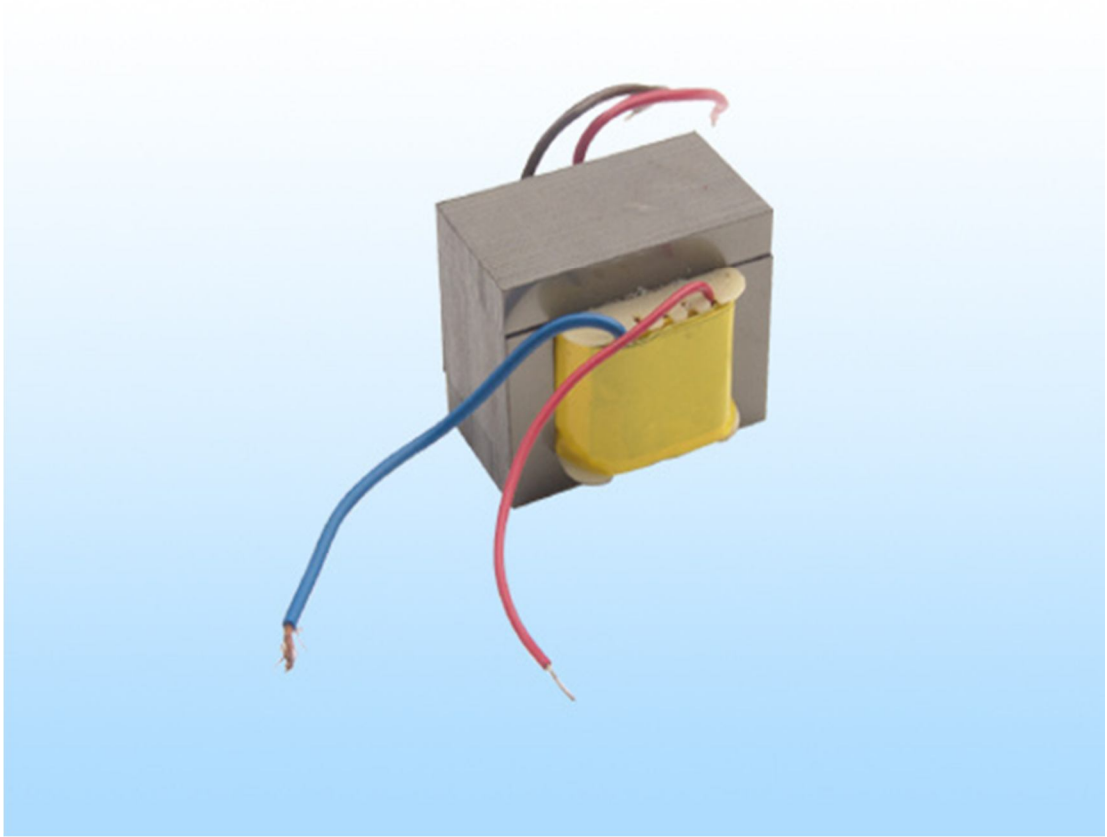

Fig 17: Inverter

C. Battery

The battery is used to store electricity generated by the generator when a vehicle is passed over the speed breaker. The battery is connected to the inverter and then this inverter is used to convert D.C output from the battery to the A.C output that can be used in day-to-day life.

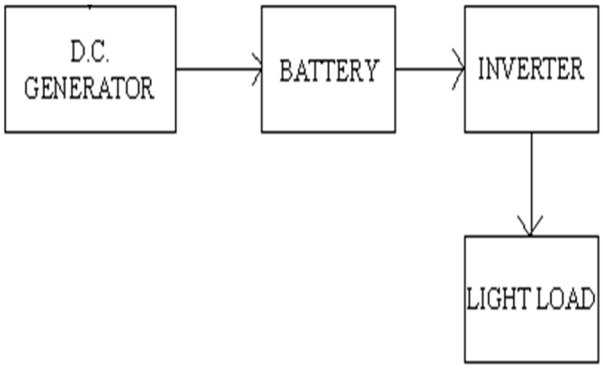

Fig 18: Block Diagram of Power Storing Circuit

VI. RESULTS

A. Analysis

1) Speed Bump: From the analysis we can see that the speed bump which is made of PVC is safe for the weight of a tire of a car. There is some concentration of stress along the sides where the springs are located.

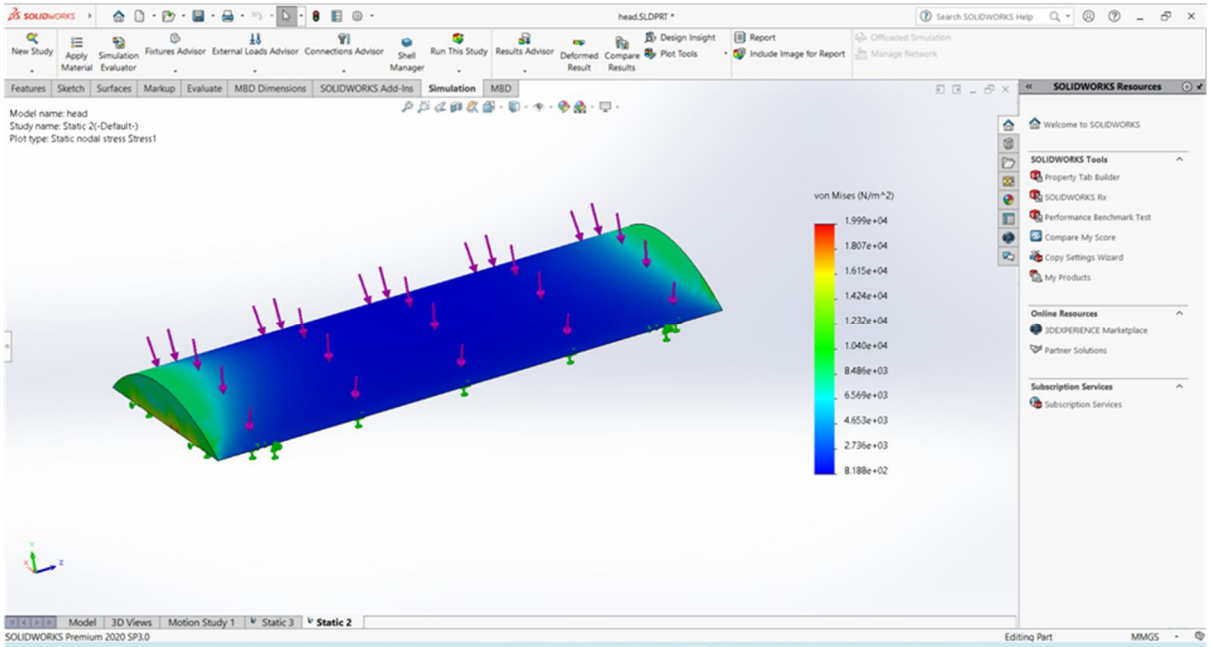

Fig 19: Speed Bump Analysis

Von Mises

Minimum	Maximum	Yield Strength
8.18*10^-4	1.99*10^-2	3.1023*10^1 N/mm2

Table 1: Speed Bump Analysis Results

2) *Top Part:* The top part is where the bump is placed and the top part of the springs are welded onto. From the analysis we can see that some of the stresses are concentrated at the centre as well as around the springs. Overall the design is safe for our considered load.

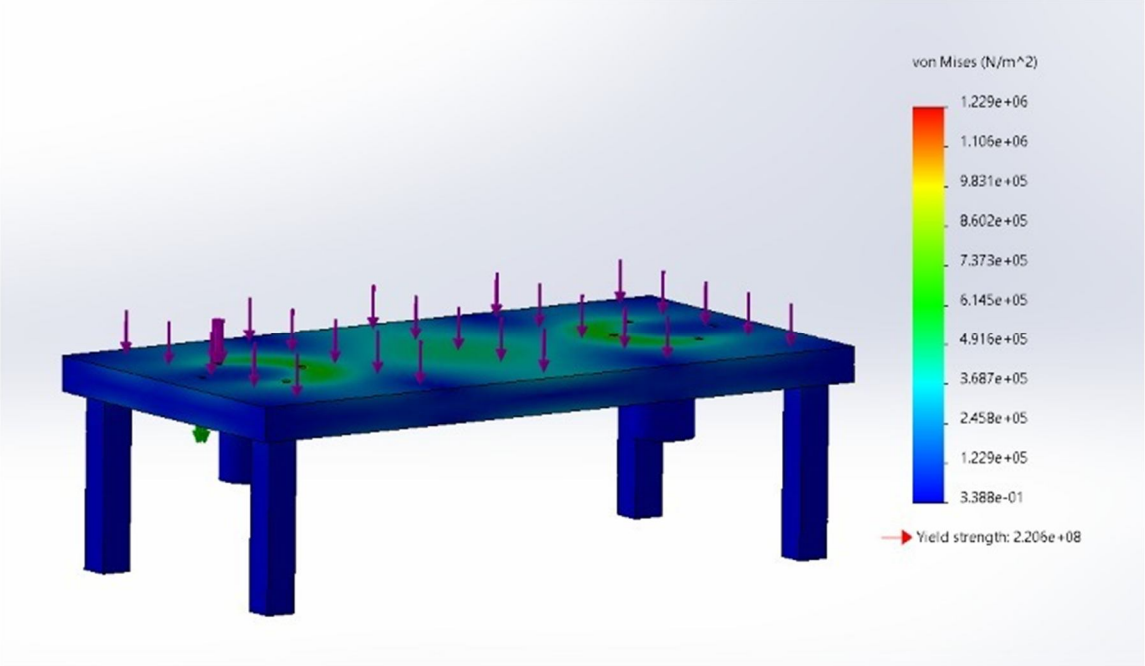

Fig 20: Top Part Analysis

Von Mises

Maximum	Minimum	Yield Strength
1.229	3.388*10^-7	2.206*10^2

Table 2: Top Part Analysis Results

3) *Base:* Most of the stress concentration is towards where the spring is located. The compressed spring is going to exert load on the circular sections. The circular sections are made to hold the spring as well as provide extra stability for dynamic loading of the springs

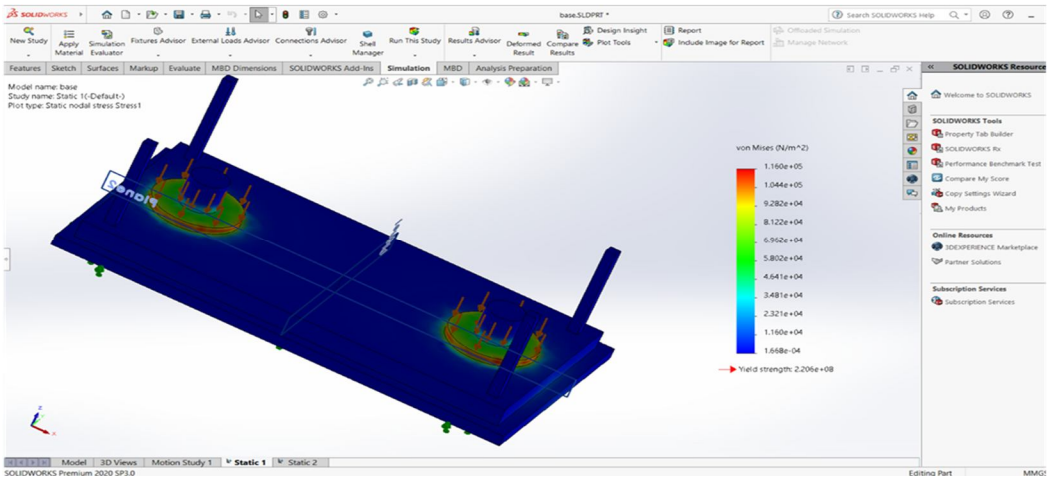

Fig 21: Base Analysis

Von Mises

Maximum	Minimum	Yield Strength
1.160*10^-1	1.668*10^-10	2.206*10^2 N/mm2

Table 3: Base Analysis Results

4) *Springs:* The Springs will be the major load carriers in our system. There are two springs in the system each with a stiffness of 14.2 N/mm. Since the springs are connected in a parallel manner, the stiffness will be added linearly and hence the load deflecting capacity of the system is highly enhanced. From the analysis we can see that out designed spring is relatively safe at all points at our given load, hence the whole system is stable and safe with a factor of safety of 2.

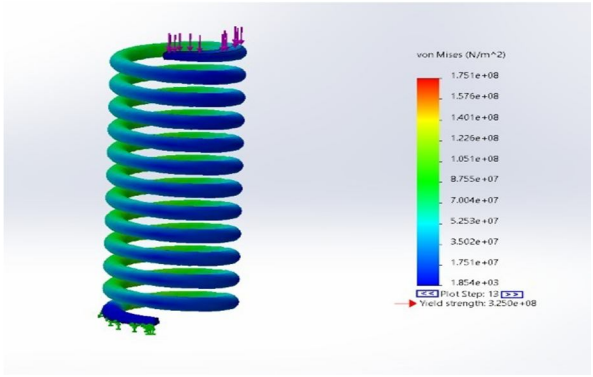

Fig 22: Spring Analysis

Von Mises

Maximum	Minimum	Yield Strength
1.751*10^+2	1.854*10^-3	3.250*10^2N/mm2

Table 4: Spring Analysis Results

B. Power Output Calculation

We calculated the power output as per the Gross Vehicle Weight Rating(Kn). From this standard, we can get the gross vehicle weight and the weight on a single tire. The following table will describe the gross vehicle weight of the different vehicles and the force on the single tire.

Vehicle categories	Gross Vehicle Weight Rating(Kn)	Weight on the tire
Taxi cab	18.85	4.714
Passenger car	18.70	4.675
Sedan car	14.31	3.577
Sports utility vehicle	20.70	5.174
MPV	17.66	4.420
Station wagon	16.42	4.106
Passenger van	21.52	5.380
Cargo van	18.72	4.684

Table 5: Weight of Different Vehicles

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1) Power Output Calculation

Torque Calculations
For a maximum load of 5kN,
The Torque produced on the pinion is given by,

T=FxR/2000 (For a Factor of Safety of 2)

where F is the force and R is the radius of the pinion.
Therefore, T=5000 x 0.9/2000
T= 2.25 N-m
Deflection y= 100mm for 5kN

2) Rpm Calculations

For a deflection of 100mm we get 5 rotations per passing of each wheel.
For a car passing 2 wheels over it, we get 2x5=10 rotations per vehicle.
If a car takes 2 seconds to pass over and we get a new vehicle passing every 3 seconds i.e. one vehicle completely passes over the speed breaker every 5 secs.

Therefore, in a minute 60/5= 12 car passes.
Thus, in a minute we get 12x10=120 rotations

Therefore, we get 120 rpm

Power output produced by the generator will be given by,
Work done=Torque x Displacement of the rack
Work done=5000 x 0.1 = 500 Joules
Power produced = Work done per second
Power produces = 500/60 = 8.33 W
This is the maximum power that can be produced by one unit of our system.

The following table shows the power output from different vehicles when they pass overpower generating speed breakers.

Sr.no	Vehicle categories	Weight of the tyre (kn)	Power output(w)
1	Taxi cap	4.714	7.85
2	Passenger car	4.675	7.79
3	Sedan car	3.557	5.96
4	Sports utility vehicle	5.174	8.62
5	MPV	4.420	7.36
6	Station wagon	4.106	6.84
7	Passenger van	5.380	8.96
8	Passenger cargo	4.684	7.80

Table 6: Power Generated by Different Vehicles

Average Power from all the different vehicles is 7.92 W per minute
Hence the power produced per hour by an average of 10 cars passing is 79.2W
Per day with 5 units is = 79.2 x 10 x 24 = 114kW.

3) Power Output Applications

Streetlights: Street lights use a 60W bulb. If we use 100 Street Lights in a 1km radius with each light running for approx 12 hours, it will consume 72kW of power.
Traffic Signals: Traffic Signals use 15W LED lights. If we operate 20 signals with 3 sections each for 24 hours, it will consume 21kW of power.
LED displays: LED displays consume 144W of power. If we operate 6 LED displays for 24 hours, it will consume 20 kW of power.
Adding all these power usages is about 113kW. Therefore, we can run these devices with our generated power.

VII. REAL LIFE SCENARIOS

A. Advantages

1) Pollution-free power generation.
2) Simple construction.
3) Mature technology.
4) Easy maintenance.
5) No manual work is necessary during generation.
6) Energy is available all year round.
7) No fuel transportation problem.
8) No consumption of any fossil fuel which is a non-renewable source of energy.
9) No external source is needed for power generation.
10) Less floor area.
11) This concept is quite promising due to its good efficiency as well as energy recovery criteria.

B. Drawbacks

1) The System is not designed to handle heavy vehicles such as cargo trucks and passenger buses.
2) Ground water and rainwater can be accumulated in the system.
3) Battery is required to store the power and needs to be maintained.
4) The system requires periodic maintenance.
5) Lots of moving parts.

VIII. SCOPE OF THE PROJECT

The Scope is vast and varying. This model can be used not just on roads but in various other places as well with a slight few modifications.

1) Availability of Free Energy: This mechanism produces free energy without any manual labour or without being dependent on any natural phenomenon such as wind or sun. The energy is available all year round.
2) No Trade-Off: Nothing is being lost or being traded off when producing power using this mechanism. No Fossil Fuels are needed to be burnt or used.
3) Simple Construction: The entire assembly is easy to manufacture as well as assemble. As it has no big parts the transportation of such parts is easy and can be made accessible to even remote areas.

A. Future Applications

1) Traffic/Street Lights: The power generated from this can be used to operate nearby street/traffic lights. It can also be used to light up advertisement signs as well as turn indicators or stop signs.
2) Electric Charging Systems: With the norm of using electric vehicles, there is also an increase in the construction of electric charging systems. This power generating speed breakers can be installed near the charging stations such that the power directly gets sent to the charging stations which in turn can be used to charge the vehicles.

B. Design Improvements

1) Such speed breakers can be designed for heavy vehicles, thus increasing input torque and ultimately output of the generator.
2) More suitable and compact mechanisms to enhance efficiency could be created.
3) As these systems are installed on open roads, water accumulates in heavy rainfall regions which may be a threat to the working of this system. So, a waterproof system can be developed to use this system in heavy rainfall regions also.
4) Multiple Batteries could be connected so that power generated would be stored more efficiently

IX. CONCLUSION

This system is non-conventional, and the way of power generation technique is also echoed friendly. It has the advantage that it does not utilise any external source. By using this system we will be able to reduce the power crisis and load shedding. The stored electricity could satisfy the daily requirement for street lighting. We can also use it for signal systems on the roads, tollbooth, or any other useful work.

This system is very much effective in reducing the power crisis. The utilisation of energy is an indication of the growth of a nation. This research introduces a generation system for

harnessing energy from the speed breaker while keeping the engineering environment in check. It produces electrical energy proportional to traffic density which shows more possibility of collecting large amounts of energy in busy cities.

In this research, a speed breaker is introduced as a small generating unit for minor needs such as streetlights and traffic signals. By adopting this arrangement, the future demands for electricity can be minimised to some extent.

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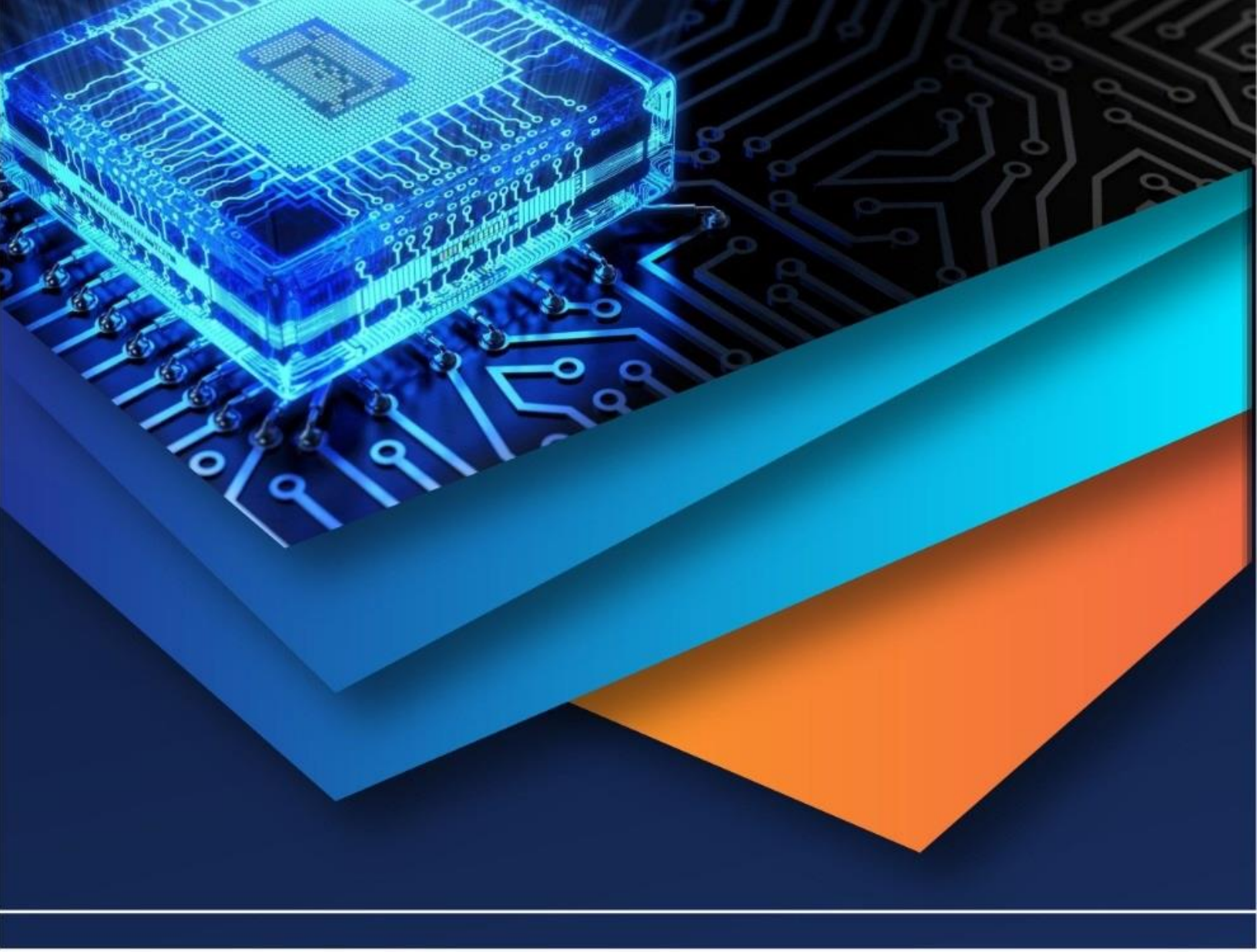

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