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# Active Suspension System Using Emf and Piezo Sensor

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**ABSTRACT**–
Inthispaper,anewtypeofpiezoelectricharvester forvehiclesuspensionsystemsisusedasacurrentsourcefor electromagnetic suspension and addresses the current problems of power source, weight and cost in current technologies. Hence, a modified damper was developed for the electromagnetic and the energy conversion component. Therefore, influence of factors such as vehicle speed, the parameters of the harvester, and the forces ofelectromagnets isdiscussed.

## I. INTRODUCTION

Ongoing energy problems such as oil shortages and problems such as pollution have become major challenges in the automotive industry. Thus, the interest in regaining the energy lost through vibration during vehicle travel is growing rapidly. -e the current state of energy harvesting that is trying to convert lost energy into available energy is not focused on the car but in parts instead. Energy harvesting technology has a huge impact on the current automotive industry by improving energy efficiency and fuel economy. The same technology is widely used in the collection of solar, wind, water, thermal, and mechanical energy. In cars, lost heat, braking force, and vibration power are the most targeted energy harvesters.

Among current energy harvesters, magnetic field harvesters are widely used in automotive suspension systems to harvest vibrational energy due to the efficiency of power conversion, compact design, reaction speed, and tight control. Electromagnetic energy harvesters can be divided primarily into two types: direct electric harvesters and rotating electric harvesters. -e A rotating power harvester is known for providing better power conversion and a more compact structure than consecutive power harvesters by converting direct movement into rotational movement by mechanical or hydraulic transmission.

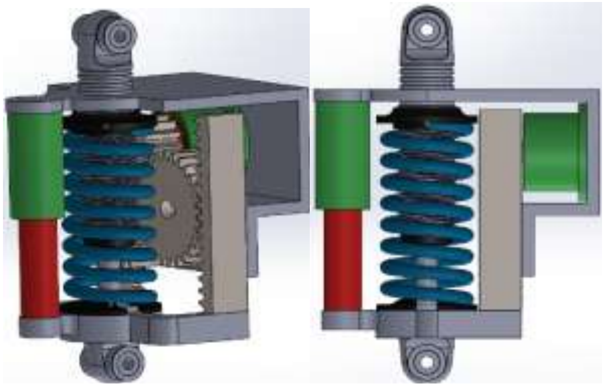
## II. OBJECTIVES

This particular active suspension system is based on a concept where electric current generating Piezo produces appropriate amount of power. Thus, enough to generate emf in a linear induction motor resulting in specific Damping and Rebound function according to the user's choice and terrain conditions. Also touching out on various smaller aspects of its working and the required parameters.

1. It should have a wide band of gravity limit.
2. To get the right Piezo, present the combined size and maximum current results.
3. Finding the correct oil / liquid that changes its density according to the passing power.
4. Trying to make a complete plan by size.
5. It should have very few moving parts, leading to low maintenance and unusual chances of repair.
6. A small amount of energy loss is reported, which makes it very effective.
7. The total cost of the program should be Less.
8. It can replace any existing suspension system from older generations.
9. The concept should be useful for any other applications too, with the exception of automotive.
10. The construction / production process is expected to have a high carbon neutrality.

11. Attempts to establish an integrated control unit for multiple channels when in use.

**THEORY**
A. Design of Machine



In our attempt to design a special purpose machine wehaveadoptedaverycarefulapproach;thetotaldesign work has been divided into two partsmainly;

a) System design

b) Mechanicaldesign

System design mainly concerns with the various physicalconstraintsandergonomics,spacerequirements, arrangementofvariouscomponentsonthemainframeof machine no of controls position of these controls ease of maintenancescopeoffurtherimprovement;heightofm/c from groundetc.

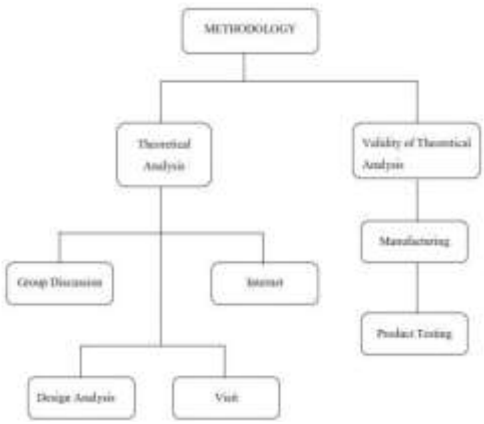
In Mechanical design the components are categorized in two parts.

a) Design parts

b) Parts to bepurchased.

For design parts detail design is done and dimensions thus obtained are compared to next highest dimension which are readily available in market this simplifies the assembly as well as post production servicingwork.Thevarioustolerancesonworkpiecesare specified in the manufacturingdrawings. The process charts are prepared & passed on to the manufacturing stage. The parts are to be purchased directlyarespecified&selectedfromstandardcatalogues.

Methodology can properly refer to the theoretical analysis of the methods appropriate to a field of study or to the body of methods and principles particular to a branchofknowledge.Therearemanymethodsuseinthis project such as internet references, interviewinglecturers and technicians and the most important is group discussion.




B. Energy Harvesting from Vehicle Suspension System by Piezoelectric Harvester

[14]A new Piezo electricity harvester device with high potency was designed for gathering vibration energy from the suspension throughout vehicle travel. A corresponding mathematical model was developed to calculate the output charge and voltage from the magnetically excited Piezo electricity piece. -is dual-mass 2-DOF suspension dynamics model was established by introducing mass and an applied force to the

energy conversion elements. Numerical simulation results from this electricity harvester model show that the RMS of the generated power will increase with a rise within the length and thicknesses of the electricity patch and also the magnetic block, the driving speed of the vehicle, the residual denseness of the magnet, and also the road roughness. additionally, the RMS redoubled with a decrease within the area between the stator coil ring and also the rotator ring and also the dimension of the electricity patch and also the magnetic block. [6]
It was found that a sensible configuration of this style was shown to produce an influence up to
332.4e analysis conferred during this work provides a brand-new technique of economical and sensible energy gathering from suspension systems, thereby up the energy potency of the vehicle. [2]
When a typical passenger car is driven at a speed of 97 km/h on a good road surface, the potential for harvested power can reach between 100 and 400 W.
When an off-road vehicle travels on a road of class D at a speed of 80 km/h, the generated electric power can reach as high as 2048 W. [4]

C. Advances in Active SuspensionSystem

Active suspension system offers wide range of options in terms of handling, comfort and overall flexibility. This particular report acknowledges broader understanding regarding it and looks at the new developments and analysis for the same. Even though consideration of modern developments the power requirement is seen to be sky-rocketing.

Due to easy availability of various components and basic structure, hydraulic actuators have therefore been far chosen to be used in active suspensions. Recently, due to lower power consumptions, electromagnetic actuators also they have higher bandwidth abilities. Active suspension systems have the ability to engrave the road profile which considered as capable of reckoning huge advancements in ride and handling performance, in addition of system robust to vehicle parameter fluctuations. Regarding this, looking-ahead preview control is being actively developed by motorcar manufacturers. The dynamic model uses adaptive control approach as a control method that is appropriate for this type of suspension phenomenon.

D. Design and simulation automobile active suspension system.

Mostly, suspension system that generally applied on the vehicle is a passive suspension system in which its spring stiffness and dumping value is constant. In the passive system it dumping system has not yet gives an optimum performance where its vibration amplitude levels are still larger and the time required to terminate the vibration is quite longer. To solve this problem, a semi- active suspension or active suspension system can be used. Unfortunately, this type of suspension system requires greater energy and acquires small economy, so then the semi- active suspension become a better option to keep the ride comfort and handling of the car according to any of road condition thrown at it.

The objectives of this research are as follows:
a) To design an active suspension.
b) To simulate the appropriate rack and pinion parameters; gear ratios and damper rate

D.A Regenerative Active Suspension System

Active magneride automotive suspension systems have been under development for very long time and with recent introductions of various past discovery and optimization in field. A suspension system can be considered “active” with a self-sustained power source is used to acknowledge its characteristics. A regenerative piezo concept can minimize the power requirement for the active system. It uses piezo to create charge, which releases basic amount of necessary energy to power the linear induction motor system. Discussed later on.

This paper overviews the system configuration, describes the power and energy-saving features of the system, and discusses possible piezo configurations and control strategies for same.

D. Constructing Control System for Active Suspension System

PIDcontrollerincludinghydraulicdynamics hasbeen designedforabasic carmodelofapassengercarto have a good ride comfort and road holding balance.-It is also found that active suspension system improves ride comfort even at variable frequency. -For step inputtheof0.08m,thesprungmassdisplacementhas been reduced by 25 % which show sprungmassaccelerationreduced by 89.93% and improvement inridecomfort. The suspension travel is been decreased by74.64%andtireimbalancehasreducedby89.73%.
For the general application in vehicles, the proposed active suspension structure faces unparallel challenges including the cost factor plus the required space in wheel aby area and power consumption required in the whole process. For the

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power consumption problem. This power consumption is lowest when system is least active, as when driving on a smooth road. During, rough roads and steep handling situations, on other hand; put more of a demand on the structure and system itself. The piezo component works harder and because power requirements have increased [1].

E. Vibration control of vehicle active suspension systemusinganewrobustneuralnetworkcontrol system

Inthispaper, an idea of a neuralnetwork-basedcontrolsystemfor whole vehicle active suspension system parameters has been thought off. The full vehicle model is considered general degree of freedom understanding the real-world conditions. The performance is compared to both the PID controller and the proposed RNN control system for random road uneven surface profiles. The proposed NN based control system is consisted of a robust feedback controller and feedforward neural network predictive controller. From the simulation results, it is seen that using the associated control system with feedback controller and a basic neural network controller monitoring road profile tracking performance can be achieved for uneven road roughness. It confirms theeffectivenessandrobustnessoftheproposedRNN controlsystem.

F. Material selection &methodology:

Material Selection

The exact selection of materials for the different part of a machine is the primary objective of any development of a machine. For an engineer it is must that they must be acquainted with the outcomes, considering the manufacturing process and thermal properties of any materials. The Choice of material for manufacturing purposes depends upon the following factors: [3]

1. Mechanical properties of material.
2. Suitability of materials for the working condition in service.
3. Availability of the materials.
4. The cost of materials
5. Physical and chemical properties of material.

The ability of the material to resist mechanical forces and load defines the mechanical properties of any system. Following aspects are discuss below:

A. Strength B. Elasticity
C. Stress D. Plasticity
E. Stress F. Ductility
G. Brittleness H. Malleability
I. Toughness J. Resilience

When a part is subjected constant stresses at dreading high thermal conditions for extended period of time, it will undergo a composite and permanent deformation called state referred to as creep. These properties are considered while designing IC engines, boilers and turbines.

Hardness

It is a very important property of the metals and has a synonymous paradigm. It acquires variably different properties such as resistance to wear and drastic deformations. It also means the ability of the metal to slit another metal. The hardness is usually expressed in numbers, which is dependent on the method of analyzation in the test.

The hardness of a metal may be determined by the following test.

1. Brinell hardness test
2. Rockwell hardness test
3. Diamond pyramid test

In engineering practices, the machine parts are subjected to multiple forces, which might be caused due to any of thefollowing situation.

1. Energytransmitted
2. Weight ofmachine
3. Fictionalresistance
4. Inertia of reciprocatingparts
5. Change intemperature
6. Imbalance ofparts in motion

The selection of the materials depends upon the various types of stresses that are faced during an operation. Further, variable type of loads effects the following selection of material.

Selection of the material depends upon factor of safety, as of depends upon the following factors.

1. Reliabilities ofproperties.
2. Reliability of applied load.
3. The possibility as to exact mode offailure.
4. The extent of simplifyingassumptions.
5. The extent oflocalized.
6. The scope of initial stresses set during manufacturing.
7. The loss of life if failureoccurs.
8. The magnitude of loss of property if failureoccurs.

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Theoretical aspects of the work

In the following study the finite element method is analyzed using Engineering software Ansys as a commercial CAD and FE program, Solidworks, Catia v.5, and fusion 360. The following wordings contain few of the fundamentalsappliedtheoriesprovidedthatthe reader has a basic knowledge regarding basic structural mechanics, machine components, and finite elementmethods.

Finite element method

Finite element method (FEM) is a method for estimated solutions of differential equations.Thedomainofinterestbifurcatedintofinite elements on which the solution is indefinite by polynomials. The finer the partition (Mesh) is, the more exact of a solution.

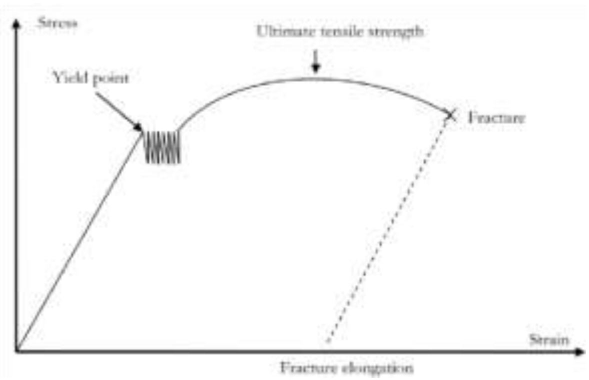


Figure02. Relationship Between Stress & Strain

ANSYS

ANSYS is a commercial, purposed analysis software used by engineers, which has been in inception past since 1970s. It can be used in various applications for example to study the thermal transfers, fluid flow, magnetic fields, acoustics/vibrations and last but not least structural component analysis.

Bilinear stress-strain curve

In reference of the license version applied, ANSYStender a bilinear approximation of the stress-strain relationship as in figure 2.9. The bilinearstress-strain curve requires two input values, tangentmodulus and yield strength.Theyieldstrengthisthevaluewhen plastics compulsion occurs and the tangent modulus is the slope in stress-strain curve afteryielding.

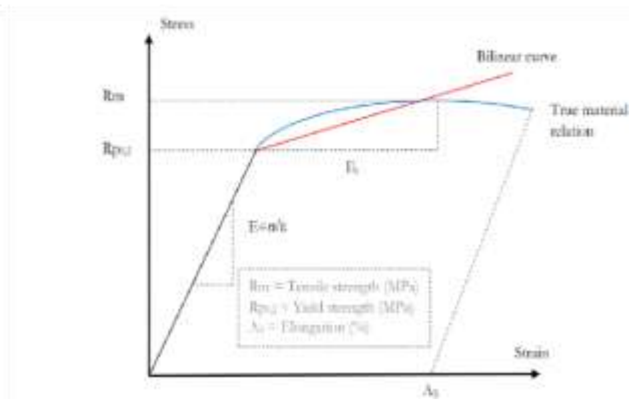


Figure03. Relationship Between Stress & strain

Meshing controls

ANSYS offers various tools to manipulate the meshing procedure. The mesh densities of the whole model can be controlled by global settings from a relevant center in three steps: coarse, medium or fine.

System Design

In system design we mainly focus on the following parameter.

Arrangement of various component

Viewing the situation and space restriction the

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components should be arranged such that there is easy withdrawal or servicing is possible moreover every component should be fairly visible & none of it should be disguised every possible space is utilized for the component arrangement.

Components of system
As already stated, system should be compact enough so that it can be accommodated in a small space. All the moving parts should be perfectly closed & compact.

Chances of failure
The losses suffered by owner in case of failure of a component are essentialcriteria of design. Factor of safetywhiledoingthemechanicaldesigniskepthigh so that there are no chances of failure there over periodic maintenance is required to keep the m/c troublefree.

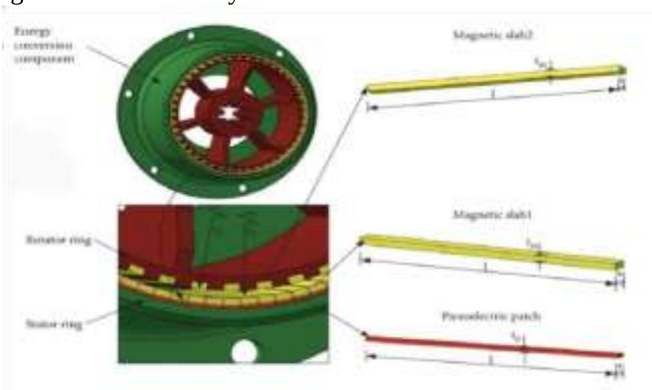
Servicing facility
The layout of components should be such that easy servicing is possible especially those components which required frequent servicing can be easily disassembled.

Weight of machine
Theoverallweightofm/cdependsupontheselectionof material components as well as dimension of components. A higher weighted m/c is not easy for transportation & in case of major break down it becomes difficult torepair.

Mechanical Design
Mechanical design phase is essential from the view of designer as whole success of the project relies on the correct deign analysis of theproblem. Many preliminary alternatives are eliminated during this phase. Designer should have knowledge about physical properties of material, stresses, deformation, and failure. For theories and wear analysis, we should identify the external and internal forces acting on the machineparts.

These forces may be classified as;
a) Dead weightforces
b) Friction forces
c) Inertiaforces
d) Centrifugalforces
e) Forces generated during power transmissionetc.

Designershouldcalculatetheseforcesveryaccurately by using design equations. If one does not have sufficient information to calculate them, he should make certain practical hypotheses based on similar conditions which will almost assure the functional needs.Assumptionsmustalwaysbeonthesaferside.



I. Outcomes:
Can be used for various applications also other than automobiles

Provides good balance between Ride and Handling Overall system should be user friendly to understand and repair Good robust automated control system.Good energy recovery from the shocks produced.

Advantages:
1. Road handlingquality improve.
2. Reduces body-roll of the vehicle.
3. No need of external power source.

Dis-advantages:
1. Increases size of system.
2. Won't be compact enough for small scale application/automotive.
3. Requires separate sensors like conventional active suspension for controlling body roll.

**Linear Induction Motor Theory:**
A linear induction motor is asynchronous

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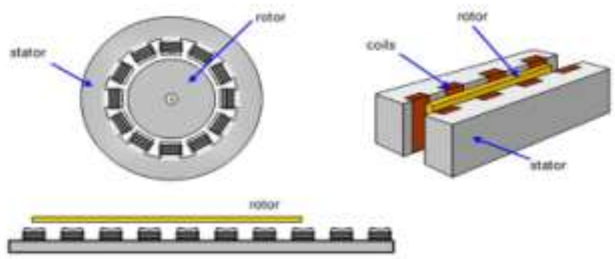
motor, that works on alternating current and principles of induction motor which are designed to produce motion in straight line. Linear induction motor has characteristically primary and secondary length. Conventional induction motor generates motion in rotary fashion. Linear ones produce in a linear fashion and generates end effect.

Few linear induction motors are employed for generating rotations of large diameters whereas use of a continuous primary would be fairly expensive.




**Why Use Induction Motor**

Ideal for applications that require rapid movement of large payloads.

Can achieve speeds in excess of 1800 inches per second (45 m/s) and acc. in the range of 3 to 4 g's.

Forces in the range of 720 lbs (3200 N) at a 3% duty cycle

Multiple motors can be used in synchronization

Linear inductions motors run on a three-phase power supply unit instead of usual and also support very high speed. However, there are end-effects that reduce the motor's force, and it is often not possible to fit a gearbox to counteract force and speed. So, in such cases the linear induction motor is slightly less efficient.

Still, linear induction motors can give out levitation effect. Therefore, they can be used for contact less force applying application, where low maintenance and low duty cycle effects are required. [13]

**CONSTRUCTION**

Linear induction motor is a flat magnet core (laminated) with transverse slots that are often straight with coils placed into the slots, with each phase giving an alternate polarity so that the different phases overlap in physical spectrum.

The secondary is a sheet of aluminum, often which is an iron backing plate. Some Linear induction motor are double sided with one primary on either side of the secondary, and, in this particular scenario, no iron backing is required.

Two types of linear motor exist:

Primary, where the coils are truncated shorter than the secondary, and

Secondary, where the conductive plate is smaller.

Short secondary Linear induction motor are certainly wounded as in parallel connections between coils of the same phase, whereas short ones are mostly wounded in series.

The primaries of transverse flux in linear induction motors have a series of bipolar(s) situated transversely side-by-side having opposite winding directions. These poles are made either with a suitably cut laminated backing plate or a series of transverse U-cores. [15]

**LIM OPERATION**

A linear electric motor consists of a flat magnetic core with transverse slots with coils laid into the slots, with each phase giving an alternating polarity so that the different phases physically overlap.

The stator part is fixed, and rotor will be associated to the variable motion of the damper.

The minimum power output harvested from the piezo component is between 100W-400W. It can reach as high as 2000W.

LIM requires three phase AC input.

Convertor used for 1 phase to 3 phase conversion

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requires 240V input.

**PRINCIPLES**

In usual electric motor design, the force is generated by a linearly moving magnetic field prospering on conductors in the field. Any conductor, be it a loop, a coil, or simply a piece of plate metal, that is placed in this field later possess eddy currents induced in it therefore creating an reverse magnetic field in consideration with Lenz's law. Thus, two opposing fields henceforth repel each other, creating motion as the magnetic field sneaks through the metal piece.

$n_s=2f_s/p$

were,

fs is supply frequency (Hz),

p is the number of poles,

ns is the synchronous speed of the magnetic field (rev./sec)

The travelling field pattern has a velocity of:

〗 $v2f_r=2tf_s$

where vs is velocity of the linear travelling field in m/s, and t is the pole pitch.

For a slip of s, the speed of the secondary in a linear motor is given by

〗 $v_r=(1-s)v_s$

**Forces Induced**

Usually, three types of forces are taken in consideration:

End Effect- Unlike usual circular induction motor, a linear induction motor projects 'end effects'. These end effects consist of losses in efficiency and performance that are expected to be caused due to magnetic energy being passed away and veined out at the end of the relative movement of the primary and secondary.

Thrust- Drive force generally shows relative slip, modulated at the ends

Levitation- Unlike rotary motor, Linear induction motion shows levitation effect or forces, this is zero slip in nature. Though levitation doesn't occur on iron backing plate used in secondarones.

**Performance**

Due to its general design linear induction motor doesn't requires need of any specific gearbox, or any similar drive train, were in usual case these also poses their own loses. Which linear induction motor gets away with. Also, linear induction motor can provide a motion-based application which can be controlled by motion control system, bandwidth modulator

**Single Phase to Three Phase Static Power Converter:**

The single phase to three phase converter is used to power the linear induction motor. The design of a single phase to three phase power converters by using static phase conversion technique will be presented in this paper. The power converter can convert the single phase 220~240 VAC supply to balanced three phase 220~240 VAC to power the three phase AC motor. The design standards which include the suitable selection of appropriate capacitors sizing, motor ratings and other relevant components also will be experimentally verified on laboratory prototype converter.

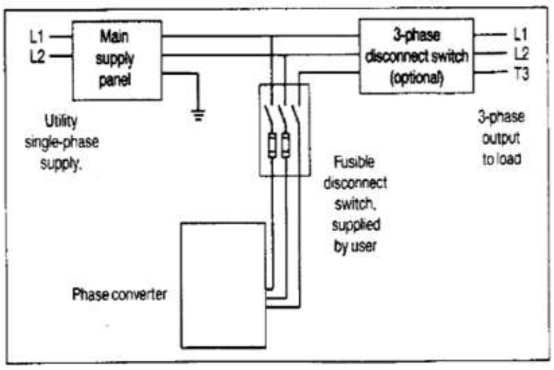



Fig. 1. Basic system of single phase to three phase power converter

DC TO AC CONVERSION

A power inverter may be a power device or circuitry that changes direct current (DC) to alternating current (AC). The resulting AC frequency obtained depends on the actual device employed. Inverters do contradictory of "converters" which were originally large electromechanical devices converting AC to DC. The input voltage, output voltage

and frequency, and overall power handling rely upon the design of the precise device or circuitry. The inverter doesn't
produce any power; the voltage is provided by the DC source. A power inverter is often entirely electronic or could also be
a mixture of mechanical effects (such as a rotary apparatus) and electronic circuitry. Static inverters don't use moving parts
within the conversion process. Power inverters are primarily utilized in electric power applications where high currents and
voltages are present; circuits that perform an equivalent function for electronic signals, which usually have very low currents
and voltages, are called oscillators. Circuits that perform the other function, converting AC to DC, are called rectifiers.

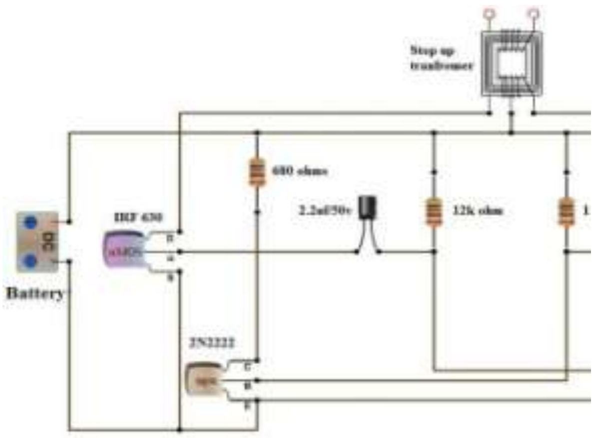
• 12 V DC, for smaller consumer and commercial inverters that typically run from a chargeable 12 V lead acid battery or automotive wall socket.[3]

• 24, 36 and 48 V DC, which are common standards for home energy systems.

• 200 to 400 V DC, when power is from photovoltaic solar panels.

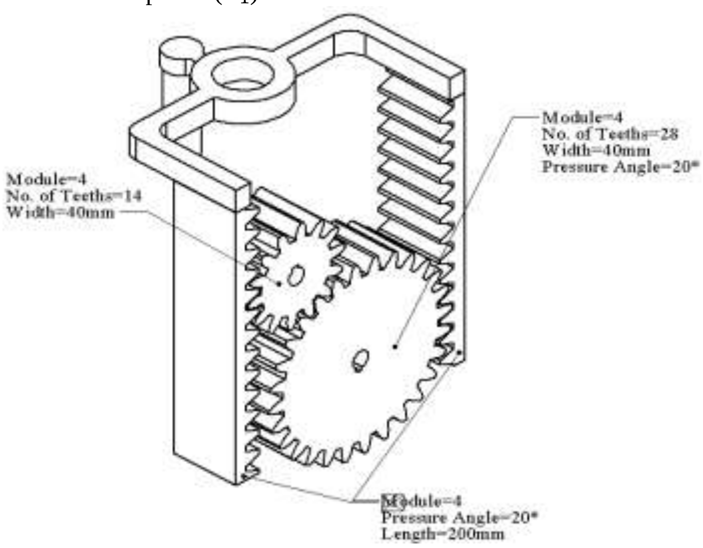
• 300 to 450 V DC, when power is from electric vehicle battery packs in vehicle-to-grid systems.

• hundreds of thousands of volts, where the inverter is an element of a high-voltage DC power transmission.




**GEAR MECHANISM**

- Gears mechanisms are used to transmit rotary motion from the damper to the piezo component.
- Rack and pinion are used for this transmission.
- Minimum number of teeth on pinion($Z_1$) for practical use is 14 according to DB.
- To calculate optimum design for the rack and pinion mechanism, we had to calculate factor of safety (FOS) for the wear and bending strength.[19][20]



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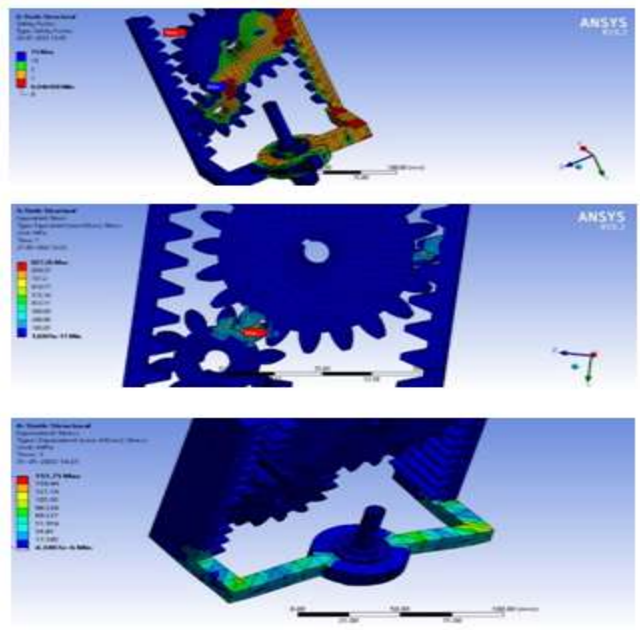
**Factors Affecting Gear Mechanism**

- Gear geometry
- Material properties
- Effective load
- Service and velocity factor




**GEAR GEOMETRY PARAMETERS:**

- **m =4** (from choice 1), kept low to reduce pinion diameter.
- Gear ratio **i = 2**
- **20 deg full depth involute system**
- **Zp =14** (to avoid interference)
- **b (face width) = 40mm** (considering space required for bearing and retaining rings to fit within 100mm).

| Gear Geometry Parameters | | |
|---|---|---|
| m | 4 | |
| zp | 14 | mm |
| zg | 28 | mm |
| alpha | 20 | deg |
| b | 40 | mm |

GEAR MATERIALS: Materials were considered according to cost, availability, surface hardness, and strength to meet the FOS (bending and wear).[16][17]

| Material | UTS ($MPa$) | BHN | Approximate. Cost (Rs/kg) | Youngs Modulus (MPa) | Density (kg/m3) |
|---|---|---|---|---|---|
| Alloy | 500 | 143 | 70 | 206000 | 8000 |

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| | | | | | |
|---|---|---|---|---|---|
| Steel 30C8 | | | | | |
| Nylon 6 | 96 | 100 | 150 | 2250 | 1490 |
| Structural steel | 400–550 | 200 | 54 | 200000 | 7850 |

Nylon offers following advantages:
• Reduced weight and lower inertia due to the lower density of the material
• Ability to absorb shock and vibration due to the elasticity of the material.
• Reduced noise.
• Low coefficient of friction
• Self-lubricating in most cases.
• Corrosion resistance
Low maintenance
• Low manufacturing cost*
• Elimination of machining operations; capability of fabrication with inserts and integral designs.
• Tolerances often less critical than for metal gears, due in part to their greater resilience. [20]

Though cost of nylon is high, it is desirable to use nylon given the constraint on weight (< 5kg) and the need of a portable mechanism. Nylon gears can be less expensive to produce than metal gears. As there is usually no need for secondary finishing, plastic gears typically represent a 50% to 90% saving relative to stamped or machined metal gears, according to Plastics Technology.[19]

After determinism gear geometry parameters, iterations were done on spreadsheet to find suitable gear material satisfying the FOS (bending and wear)>1. Load factor Cs = 1.1 was assumed from DDHB T17.19

• Beam strength of tooth gear $Sb = mb\sigma bY$
o Sb = beam strength of gear tooth (N)
o $\sigma b$ = permissible bending stress (MPa or N/mm2)
o Y = Lewis's form factor
o $\sigma b$ = (1/3)$*Sut$ (MPa or N/mm2)
o $Sut$= Ultimate Tensile Strength (MPa or N/mm2)

• Wear strength of gear tooth $Sw = bQdp$K
Sw = wear strength of the gear tooth (N)
Q= ratio factor
$dp$= pitch circle diameter of pinion (mm)
K = load – stress factor (MPa or N/mm2)
= 0.16*(BHN/100)^2 for steel with $\alpha = 20°$

$$K = \frac{\sigma_c^2 \sin\alpha \cos\alpha(1/E_p + 1/E_g)}{1.4}$$

Ep = modulus of elasticity of pinion materials (MPa or N/mm)
Eg = modulus of elasticity of wheel materials (MPa or N/mm2)
• According to G. Niemann, Sigma c = 0.27(BHN) kgf/mm2 = 0.27(9.81) (BHN) N/mm2
• $M\_t = (60*10\text{^}6*kW)/ (2*\pi*n\_p)$
• $Pt = (2*Mt)/ dp$
• $d = (z*mn)/cos\varphi$
• $v = ((\pi*d*n))/ (60*10\text{^}3)$
• $C\_v = 3/(3+v)$
• Velocity method $\boldsymbol{Peff} = (\boldsymbol{Cs}*\boldsymbol{Pt})/\boldsymbol{Cv}$
From the determined values of gear geometry, following parameters were obtained:

| | | |
|---|---|---|
| np | 47.74648293 | rpm |
| ng | 23.87324146 | rpm |
| dp | 56 | mm |
| dg | 112 | mm |
| Mt_p | 29154.51895 | Nmm |
| Mt_g | 58309.0379 | Nmm |

- Nylon gears offer large weight reduction compared to steel gears.
- While both materials offer FOS>1, giving preference to higher FOS (wear) of nylon due to low Youngs modulus, nylon is selected.
- Velocity consideration for the linear motion of the rack required for the calculation above is done by literature review for the motion of damper in application of forces.
- Value 0.14m/s is the average velocity of the damper which we have considered for the rack connected to it.

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**FINAL DESIGN:**

| | | |
|---|---|---|
| m | 4 | mm |
| zp | 14 | |
| zg | 28 | |
| alpha | 20 | deg |
| B | 40 | mm |
| np | 68.20926133 | rpm |
| ng | 34.10463066 | rpm |
| P | 56 | mm |
| dg | 112 | mm |
| Mt_p | 29154.51895 | Nmm |
| Mt_g | 58309.0379 | Nmm |
| *FOS(wear)* | *35.6421099* | |
| *FOS(ben)* | *1.408791271* | |

## III. CONCLUSION:

Whenwestartedouttheresearchprogram,we figured out that an ordinary suspension system considering leaf suspension system, coil suspension system and hydraulic suspension system are not viable enoughto provide a perfect balance between ride handling and comfort as one aspect gets more leverage in any one of aspect to be focused. Ifany.

Thisiswhenweconsideranactivesuspension system to be a feasible solution for the desired outcome for thestudy.Hence,weconsideranelectromagnetbasedactivesuspensionsystemeitherwayreferencedasthe Magneridesuspension.

Across the research patten we studied about various components and design aspects that are practical enough to provide supreme balance between ride, handling and comfort. Where the electromagnet mainly controls the positioning and rebound of dampers according to the ride setting. These electromagnets are control by actuators, piezo which converts the vibrations into signals where as these electromagnets are charged by the same vibrational frequency of a piezo.

The excess vibrational frequency by the piezocreates charge which if not used can be stored back in the battery backups for future energizing hence making Magneridesuspensionoptionapracticableanswerfor growing electric vehicle marketevolution.

## REFERENCES:

[1] C. Ergun, S. Yilmaz, E. Ozdemir, O.Gul, and O. Kalenderli, “Piezoelectric materials and application areas,” in Proceedings of the Denizli International Materials Conference, Pamukkale, Turkey, November 2006.

[2] X. Han, W. Zeng, and Z.Han,“Investigation of the comprehensive performance of turbine stator cascades with heating endwall fences,” Energy, vol. 174, pp. 1188–1199, 2019.

[3] M. K. A. Ali, H. Xianjun, M. A. A. Abdelkareem, M. Gulzar, and A. H. Elsheikh, “Novel approach of the graphene nanolubricant for energy saving via anti-friction/wearin automobile engines,” Tribology International, vol. 124, pp. 209–229, 2018.

[4] H. Wang, A. Jasim, and X. Chen, “Energy harvesting technologies in roadway andbridgefor different applications—a comprehensive review,” Applied Energy, vol. 212, pp. 1083– 1094, 2018.

[5] M. K. A. Ali, P. Fuming, H. A. Younus et al., “Fuel economy in gasoline engines using Al2O3/TiO2 nanomaterials asnanolubricant additives,” Applied Energy, vol. 211, pp. 461– 478, 2018.

[6] Y. Zhang, K. Guo, D. Wang, C. Chen,and X. Li, “Energy conversion mechanism and regenerative potential of vehicle suspensions,” Energy, vol. 119, pp. 961–970, 2017.

[7] L. Pugi, M. Pagliai, A. Nocentini,G. Lutzemberger, and A. Pretto,“Design of a

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 2 Feb 2022, pp: 1459-1471 www.ijaem.net ISSN: 2395-5252

hydraulic servo-actuation fed by a regenerative braking system," Applied Energy, vol. 187, pp. 96–115, 2017.

[8] C. Wei and X. Jing, "A comprehensive review on vibration energy harvesting: modelling and realization," Renewableand Sustainable Energy Reviews, vol. 74, pp. 1–18, 2017.

[9] B. Heißing and M. Ersoy, Chassis Handbook (Fundamentals, Driving Dynamics, Components, Mechatronics, Perspectives), Mercedes Druck, Berlin, Germany,2011.

[10] Z. Zhang, X. Zhang, W. Chen et al., "A high-efficiency energy regenerative shock absorber using supercapacitors for renewable energy applications in range extended electric vehicle," Applied Energy, vol. 178, pp. 177– 188,2016.

[11] Z. Zhang, X. Zhang, Y. Rasim, C.Wang, B. Du, and Y. Yuan, "Design, modelling and practical tests on a high-voltage kinetic energy harvesting (EH) system for a renewable road tunnel based on linear alternators," Applied Energy, vol. 164, pp. 152–161, 2016.

[12] L. Zuo and P. S. Zhang, "Energy harvesting, ride comfort, and road handling of regenerative vehicle suspensions," Journal of Vibration and Acoustics, vol. 135, no. 1, article 011002,2013.

[13] J. Fairbanks, "Vehicular thermoelectrics: the new green technology," in Proceedings of the :ermo electric applications workshop, Coronado, CA, USA, January2011.

[14] M. A. A. Abdelkareem, L. Xu, M. K.A. Ali et al., "Vibration energy harvesting in automotive suspension system: adetailed review," Applied Energy, vol. 229, pp. 672–699, 2018

[15] P. Li, L. Zuo, J. Lu, and L.Xu, "Electromagnetic regenerative suspension system for ground vehicles," in Proceedings of the IEEE International Conference on Systems, Man, and Cybernetics (SMC), pp. 2513–2518, San Diego, CA, USA, October 2014.

[16]: Design of Rack and Pinion Steering System for an All-Terrain Vehicle 1Gaurav P. Keer, 2Sanket S. Keer, 3Sandesh S. Jogdand, 4Saurabh S. Dalvi, 5V. Murali Mohan 1,2,3,4Students, Finolex Academy of Management & Technology, Ratnagiri 415639,

[17] Associate Professor, Finolex Academy of Management and Technology, Ratnagiri 415639.

[18] Design Methodology and Manufacturing of Rack and Pinion for All Terrain Vehicle Aksh Patel, Nandan Bhatt, Mayur BapuRawade Department of mechanical engineering Lj institute of engineering and technology ahmedabad, India

[19] [ISs Design and Analysis of Steering Gear and Intermediate Shaft Steering System Thin Zar Thein Hlaing, HtayHtay Win, MyintThein

[20] Developing a Virtual Prototype of a Rack and Pinion Steering System Naresh Kamble and S.K. Saha*

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