STRESS ANALYSIS OF MAGNETIC SUSPENSION SYSTEM.

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ABSTRACT

This paper is a review on design and analysis of magnetic suspension system. The aim of this project is to create a better suspension system in vehicles on rough road conditions, and to enhance traction force between road surfaces. The function of any suspension system is to prevent or reduce sudden shocks and ensure proper and smooth driving. Magnetic suspension system consists of magnets of same polarity which absorb all the bumps. The magnets help to push/pull the car during jerks and sudden shocks, without causing jostling of car thereby resulting in easy and safe driving. This report compares the conventional suspension system with magnetic suspension system, analytically and numerically provides better validation for the use of magnetic suspension system

Keyword: -*Suspension,Magnets, Analysis*

1. INTRODUCTION

Thispaper is a review on design and analysis of magnetic suspension system. The aim of this project is to create a better suspension system in vehicles on rough road conditions, and to enhance traction force between road surfaces. The function of any suspension system is to prevent or reduce sudden shocks and ensure proper and smooth driving. Magnetic suspension system consists of magnets of same polarity which absorb all the bumps. The magnets help to push/pull the car during jerks and sudden shocks, without causing jostling of car thereby resulting in easy and safe driving. This report compares the conventional suspension system with magnetic suspension system, analytically and numerically provides better validation for the use of magnetic suspension system.Hydraulic suspension has its own disadvantages, the hydraulic fluid used causes environmental pollution due to hydraulic leaks and ruptures and tubes. Hydraulic fluid is also toxic.

The comfort and efficiency of a suspension system depends upon the spring stiffness and its life span. Springs with higher stiffness provide a harsh ride and also prevent the vertical travel of the wheels under tough terrain conditions. On the contrary softer springs provide a softer ride but causes unwanted effect on handling and driving of the vehicle like squat, dive of the vehicle. Another disadvantage of soft spring in suspension systems is the building up of high kinetic energy as the springs compress and the subsequent release of this energy when the springs return to their original state. The heavy loaded vehicles are fixed with heavier springs according to its bearing capacity to compensate the load or else it may collapse the vehicle. In extreme conditions, the heavy springs are used for performance applications.

2. LITERATURE REVIEW

Literature Review is implemented to carry out to acquire knowledge and skills needed to complete this project. The main sources that led us built this system are previous projects and various thesis related to this project. And other source is Internet wherein we referred various international journals.Information about various

Reference papers or previously implemented project have been used as a reference which is as discussed below:

In **[1]Babak Ebrahimi, Mir Behrad Khamesee, M. Farid Golnaraghi, 2008**Design and Modeling of a Magnetic Shock Absorber Based on Eddy Current Damping Effect, studied: Eddy currents are generated in a conductor in a time-varying magnetic field. They are induced either by the movement of the conductor in the static field or by changing the strength of the magnetic field, initiating motional and transformer electromotive forces (emfs), respectively.

In **[2]Baratol's. Gysen, Johannes.J.H. Paulides, Jeroen.L.G. Janssen, states** Active Electromagnetic Suspension System for Improved Vehicle Dynamics studied: Due to the change in vehicle concepts to the more electric car, the suspension system becomes ever more important due to changes in the sprung and unsprung masses.

In [3] **Kirk.T. McDonald, Joseph Henry Laboratories, Princeton University, Princeton** discussed When a conductor moves through a non-uniform, external magnetic field, the magnetic flux varies through loops fixed inside the conductor, so an electromotive force is induced around the loops, according to Faraday's law (in the rest frame of the conductor), and eddy currents flow. The Lorentz force on these eddy currents, due to the external magnetic field, opposes the motion, and one speaks of magnetic braking/damping.

In [4] **Zekeriya Parlak, Tahsin Engin, Ismail Çallı, Optimal Design of MR Damper via Finite Element Analyses of Fluid Dynamic and Magnetic Field,** studied: The purpose of the study was to optimize MR damper geometrically in accordance with two objectives, target damper force as 1000N and maximum magnetic flux density.

In [5] **Ammar A. Aldair and Weiji J. Wang**, discussed: To improve the vehicle performance such as ride comfort and road handling, the active suspension system should be used. However, the current active suspension system has a high energy consumption therefore reducing the fuel economy. In this paper the vibration excited by road unevenness is treated as a source of mechanical energy. It is being converted into electrical energy to compensate for the energy consumption by the active suspension. To achieve this task, an electromagnetic active suspension system has been introduced.

In [6] Arindam Pal, Sumit Sharma, and Abhinav Jain discussed: Suspension system is the term that defines the transmissibility of an off-road vehicle. In order to resist the bumps and jerks that usually occur in an off-road track, an integrated approach of design is developed to obtain an optimized geometry which can give the drivers a fun-to-drive 'experience.

3. PROBLEM DEFINITION

As we have earlier mentioned that conventional suspension system uses a spring damper system. Various shocks, unwanted vibrations from rough roads are transmitted to the vehicle. The springs in the suspension absorb the vibrations and get compressed. Sudden bumps and forces of larger magnitude compress the spring to its solid length. After the bump, the spring comes back to its original length.
Frequent compression of the spring to its solid length causes deformation in it, the spring doesn't revert to its original length. Over a period of time, it is noticed that spring loses its elasticity and its free length decreases. This reduces the life of spring also results in a less efficient suspension system.
To overcome this problem, we are modifying the suspension with magnets. Magnets generate a repulsive field that keeps spring to go to its solid length. This repulsive force also helps with the withstanding of vibrations, thus reducing the work on spring. As the spring doesn't compresses entirely, it can stabilize the vehicle much quicker than its conventional counterpart.

4. CONCEPT

Unlike poles of a magnet attract each other and like poles repel each other.When we place two south poles or north poles facing each other and when they are brought closer they are repelled. This same concept is used in magnetic suspension. A set of magnets having like poles are placed in a hollow cylinder. One magnet is fixed at the top of the inner portion of the cylinder, which in turn to the piston. The other one is placed at the bottom.
The top magnet has the North Pole facing down, fixed to the upper part of the suspension. The two magnets are separated by a spring, the lower magnet which is movable has its north pole facing upwards.

Since both magnets have same polarity, a repulsion force is created between the magnets. So, the movable magnet opposes the rod action and moves the top magnet away. By using this type of shock absorber, the suspension will be more effective and impact of vibration will be very less as compared to the conventional counterparts.

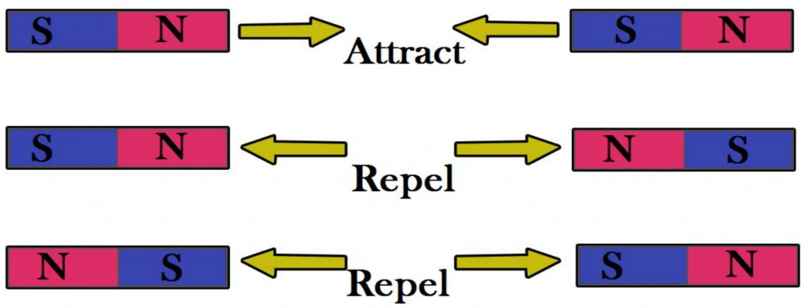

Fig 1: Repulsion and attraction of magnet

5.WORKING

When the vehicle weight increases or vehicle climbs an uneven slope, or rocky roads, the wheel goes upwards and shock absorber is compressed, at this time piston moves downwards. The magnets are brought closer to each other due to the increase of weight. The additional support for the magnets is the spring which was compressed. Thus, vibrations and shocks are absorbed.

When the vehicle returns to original position, the shock absorber expands. The piston moves upwards due to the magnetic flux power of the magnet. The stainless-steel spring provided between the magnets helps in slowly moving the magnets to their original position.

Thus, a magnetic suspension system absorbs the shock, when vehicle moves on an irregular surface.

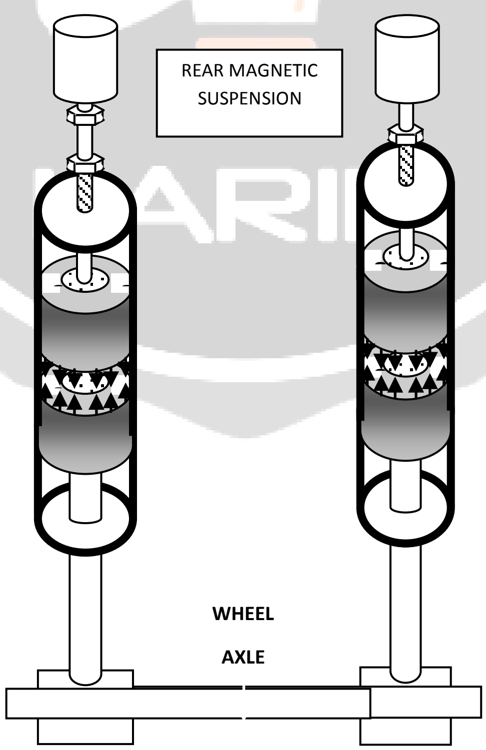

FIG 2: Magnetic Suspension in Automobile

6. MATERIALS USED

The selection of the materials depends upon the various types of stresses that are set up during operation. The material selected should withstand it. Another criterion for selection of metal depend upon the type of load because a machine part resist load more easily than a live load and live load more easily than a shock load.

The Choice of material for engineering purposes depends upon the following factors:

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

Selection of the material also depends upon factor of safety, which in turn depends upon the following factors:

1. Reliabilities of properties
2. Reliability of applied load
3. The certainty as to exact mode of failure
4. The extent of simplifying assumptions
5. The extent of localized
6. The extent of initial stresses set up during manufacturing
7. The extent loss of life if failure occurs
8. The extent of loss of property if failure occurs

The two major materials used in this model is Mild Steel and Neodymium magnet.

6.1 Mild Steel:

Major Reasons to select Mild Steel:

1. Mild steel is readily available in market
2. It is economical to use
3. It is available in standard sizes
4. It has good mechanical properties i.e. it is easily machinable
5. It has moderate factor of safety, because factor of safety results in unnecessary wastage of material and heavy selection. Low factor of safety results in unnecessary risk of failure
6. It has high tensile strength
7. Low co-efficient of thermal expansion

6.1.1 PROPERTIES OF MILD STEEL:

M.S. has a carbon content from 0.15% to 0.30%. They are easily wieldable thus can be hardened only. They are similar to wrought iron in properties. Both ultimate tensile and compressive strength of these steel increases with increasing carbon content. They can be easily gas welded or electric or arc welded. With increase in the carbon percentage weld ability decreases. Mild steel serves the purpose and was hence was selected because of the above purpose.

6.1.2 PHYSICAL PROPERTIES

TABLE 1: Properties of Mild Steel

Mild Steel	
Young's Modulus	2.e+005 MPa
Poisson's Ratio	0.3
Density	7.85e-006 kg/mm^3
Thermal Expansion	1.2e-005 1/°C
Tensile Yield Strength	250. MPa
Compressive Yield Strength	250. MPa
Tensile Ultimate Strength	460. MPa
Compressive Ultimate Strength	0. MPa

6.2 Neodymium magnet

A neodymium magnet or NIB magnet (also, but less specifically, called a rare-earth magnet) is a powerful magnet made of a combination of neodymium, iron, and boron — Nd2Fe14B.
Neodymium magnets are the strongest type of permanent magnet commercially available. They have replaced other types of magnets in many applications in modern products that require strong permanent magnets, such as motors in cordless tools, hard disk drives and magnetic fasteners.
The strength of neodymium magnets is due to several factors:

The most important is that the tetragonal Nd2Fe14B crystal structure has exceptionally high uniaxial magneto crystallineanisotropy.This means a crystal of the material preferentially magnetizes along a specific crystal axis but is very difficult to magnetize in other directions. Like other magnets, the neodymium magnet alloy is composed of microcrystalline grains which are aligned in a powerful magnetic field during manufacture so their magnetic axes all point in the same direction. The resistance of the crystal lattice to turning its direction of magnetization gives the compound a very high coercivity, or resistance to being demagnetized

6.2.1 Physical and Mechanical Properties

TABLE 2: Properties of Neodymium Magnet

Density	8.15e-006 kg mm^3
Coefficient of Thermal Expansion	1.2e-005 C^{-1}
Specific Heat	4.34e+005 mJ kg^{-1} C^{-1}
Thermal Conductivity	6.05e-002 W mm^{-1} C^{-1}
Resistivity	1.7e-004-ohm mm

Compressive Yield Strength	278 MPa
Tensile Yield Strength	278 MPa
Youngs Modulus	2.1e+005 MPa
Poisson's Ratio	0.3
Bulk Modulus	1.75e+005 MPa
Shear Modulus	80769 MPa

7. DESIGN AND ANALYSIS

For anything to be called better, you have to compare with a standard, so the magnetic suspension system is compared to the conventional suspension system analytically. An equal uniform load is applied in both the suspension system and various stress variations, displacement variations are recorded.

A load of 4905N is applied on each suspension, on the movable magnet, the effect of load, and the major differences in conventional as well as magnetic suspension is recorded and tabulated.

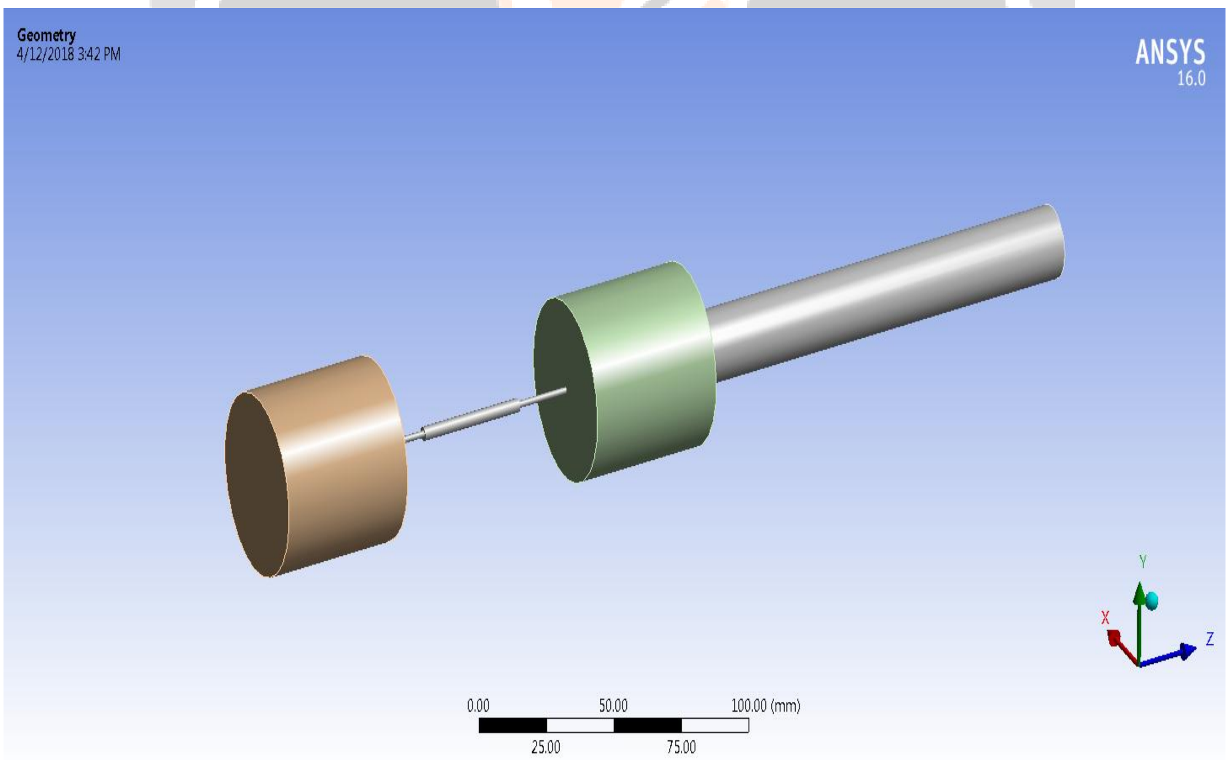

Fig 3: Basic geometry of the suspension system

6.1 Stress Comparison

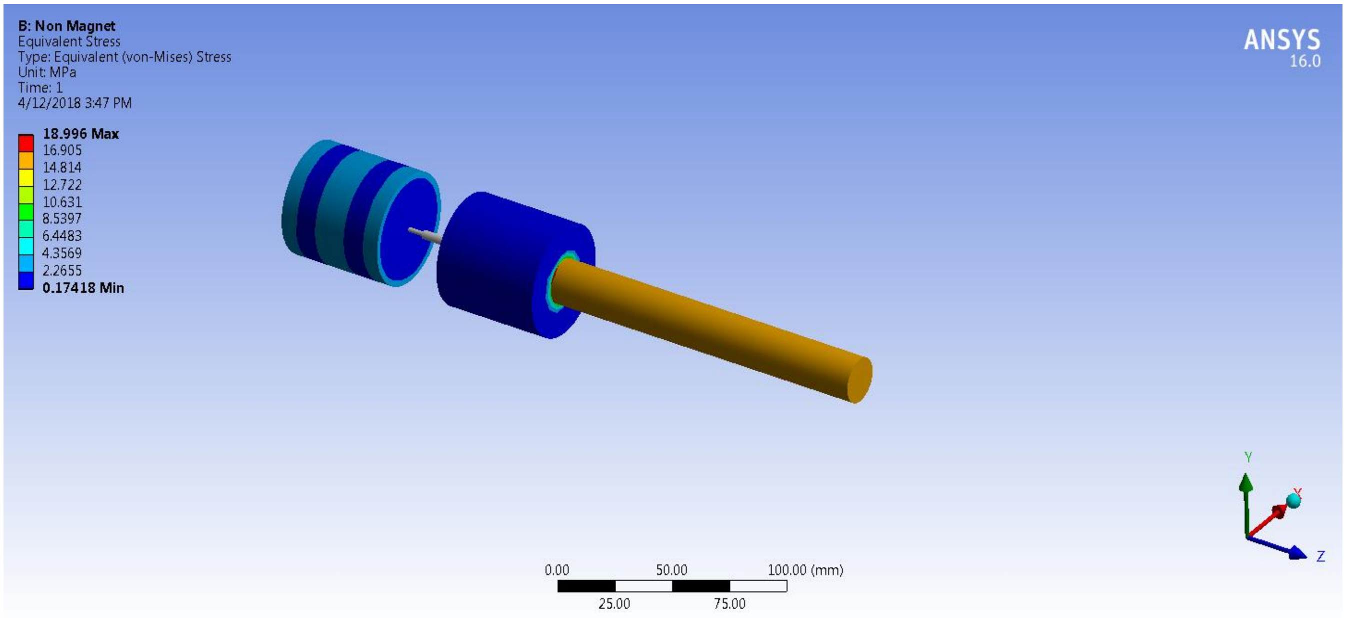

Fig 4: Stress distribution in a normal suspension system.

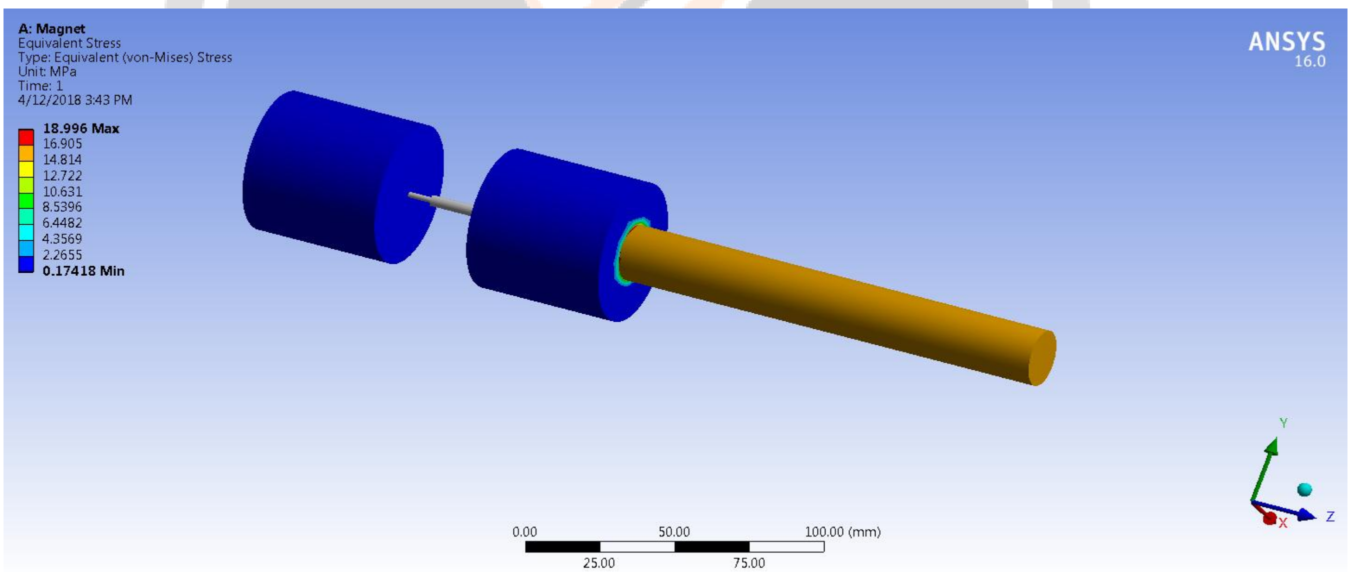

Fig 5: Stress Distribution in Magnetic Suspension System

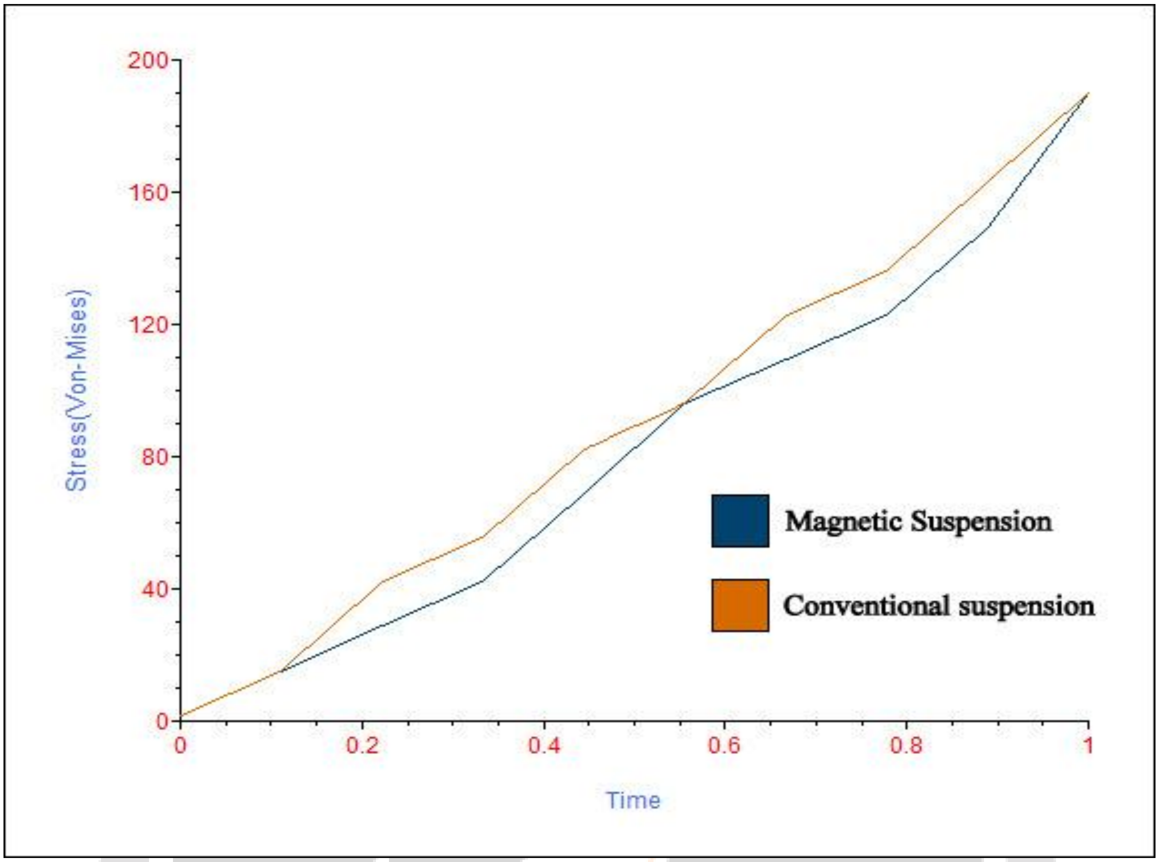

Chart 1: Stress Vs Time Chart for Magnetic and Conventional Suspension.

6.2 Deformation Comparisons

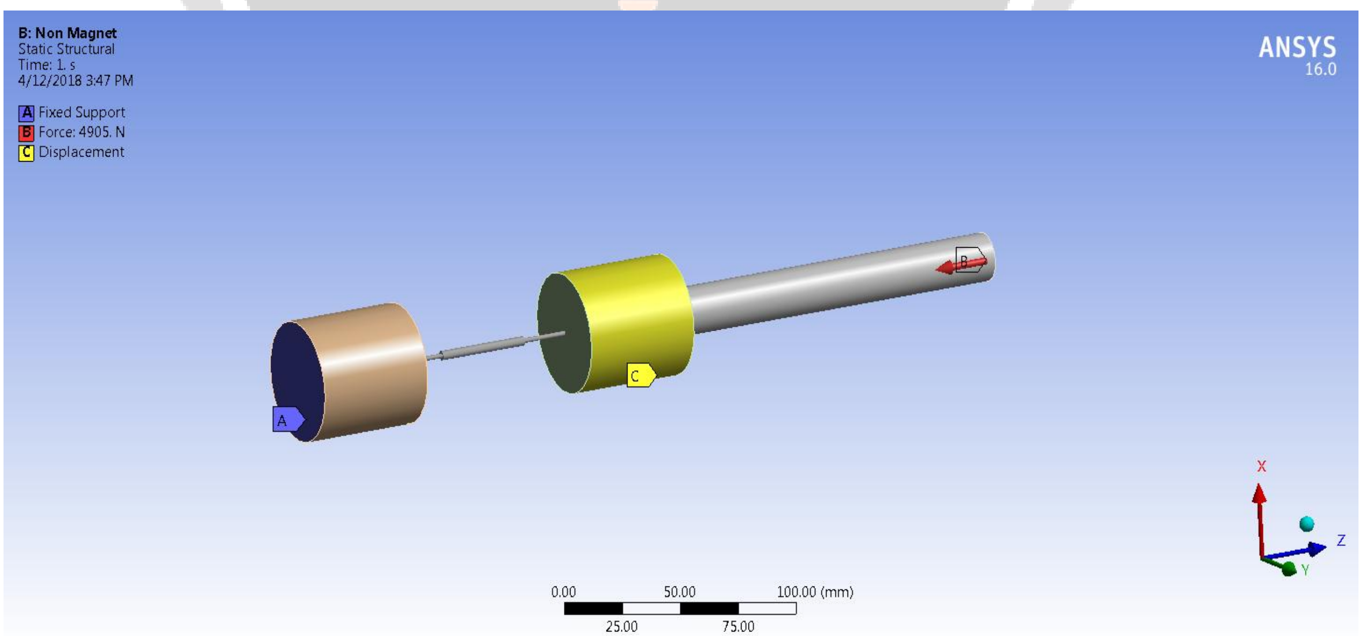

FIG 6: Deformation of Conventional Magnetic Suspension System

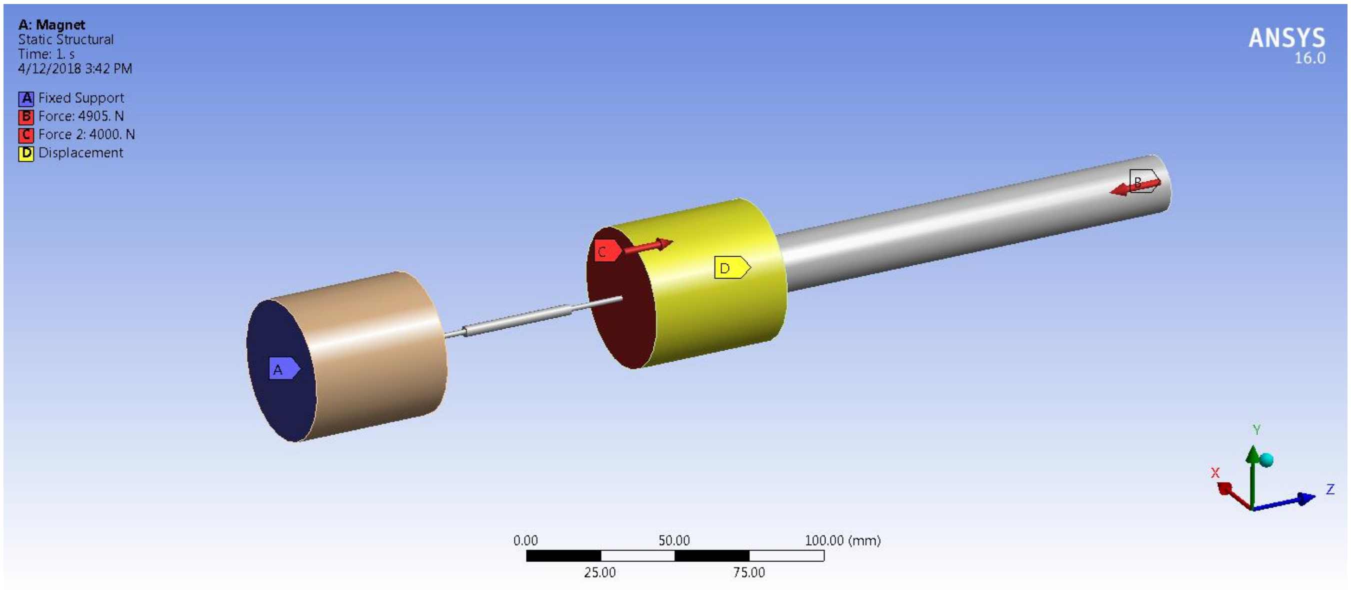

FIG 7: Deformation of Magnetic Suspension System

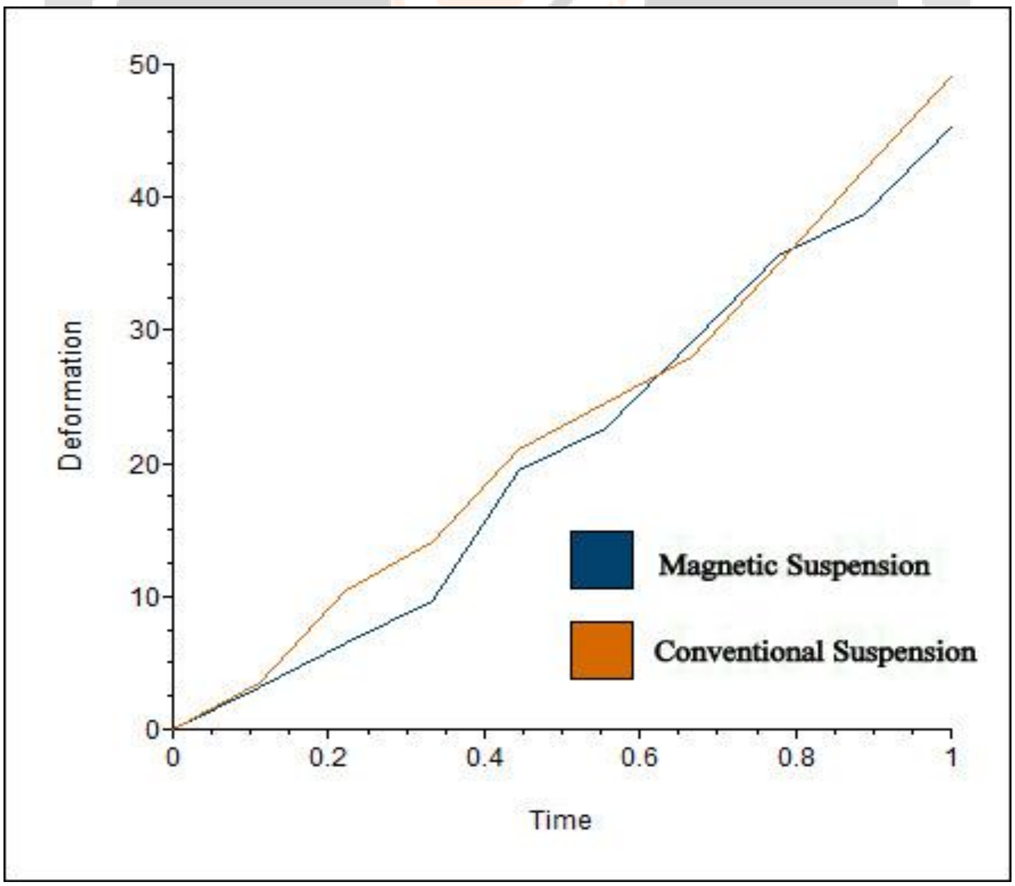

Chart 2: Deformation Vs Time Chart for Magnetic and Conventional Suspension.

TABLE 2: Deformation Results

TYPE	MINIMUM DEFORMATION	MAXIMUM DEFORMATION
MAGNET	0	45.263
CONVENTIONAL	0	49.064

6. CONCLUSION

After careful considerations of various factors, the results from the analysis of magnetic suspension show that, it is far better than its counterpart. The tabulated data and the graphs prove that, magnetic suspension prolongs the life of the system, as well as provides a comfortable and smoother ride to the passenger driving the vehicle. The research is positive and it can be ensured that if a model made, it will work perfectly as designed.

7. ACKNOWLEDGEMENT

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