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Design and Development of Magnetorheologial Damper

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ABSTRACT
Magneto-rheological suspensions, or MR suspensions, are a type of magneto-rheological suspension. MR suspension is a vibration-controlling intelligent suspension that is utilized in automobiles. MR fluids are a type of smart material that changes its rheological behavior dramatically when exposed to an electric or magnetic field. The key advantages of MR suspensions are that they require extremely little control power, are simple to build, respond quickly to control signals, and have very few moving parts. In the last two decades, magnetic resonance suspension (MR suspension) has gotten a lot of attention as a promising technique for semi-activecontrol.
Keywords: Dampers, Seismic dampers, Dissipation, Structure, Friction dampers, Viscous dampers, Yielding dampers, Magnetic dampers and tuned mass dampers

I. INTRODUCTION

Magnetorheological (MR) fluids are materials that modify their rheological behaviour dramatically when exposed to a magnetic field. In the absence of a magnetic field, an MR fluid is a free-flowing liquid, but in the presence of a strong magnetic field, its viscosity can be increased by more than two orders of magnitude in milliseconds, giving it solid-like properties. Shear yield stress can be used to describe the strength of an MR fluid. Magnetorheological (MR) fluids are materials that modify their rheological behavior dramatically when exposed to a magnetic field. In the absence of a magnetic field, an MR fluid is a free-flowing liquid, but in the presence of a strong magnetic field, its viscosity can be increased by more than two orders of magnitude in milliseconds, giving it solid-like properties. Shear yield stress can be used to describe the strength of an MR fluid.

Figure 1 Comparison of MR suspension with standard suspension

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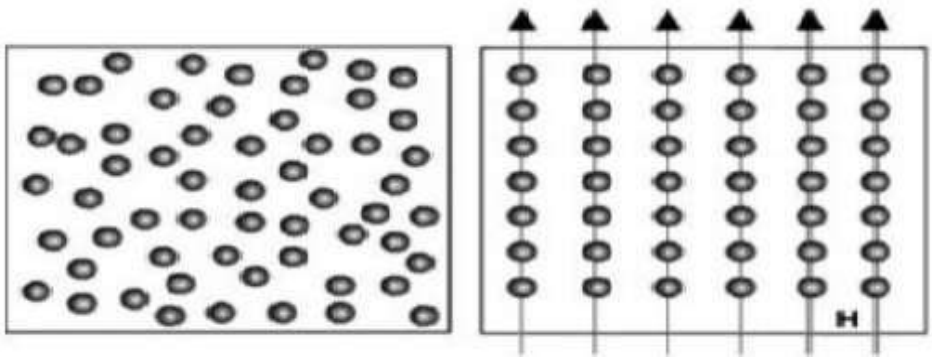
Semi-active suspension systems, such as MR suspensions, have piqued the interest of suspension designers and researchers for these reasons. Furthermore, as the need for enjoyable and safe vehicle rides grows, intelligent suspension will become more frequently used in both regular vehicles and engineering automobiles, resulting in a larger market for MR suspension.

1.1 Magneto-rheologicalFluid

MR fluids are a type of smart fluid that changes its rheological properties (elasticity, plasticity, or viscosity) when exposed to a magnetic field. Soft particles with a diameter of 1–5 mm are suspended in a particular carrier liquid such as water, mineral oil, synthetic oil, or glycol in MR fluids. When a fluid is subjected to an external magnetic field, the suspended particles in the fluid form chains, and the suspension takes on the appearance of a semi-solid material due to the rise in apparent viscosity. An MR fluid behaves like a non-Newtonian fluid with controlled viscosity in a magnetic field.
Figure 2 MR effect

Figure 2 MR effect



When the magnetic field is removed, the suspension transforms into a Newtonian fluid in a matter of milliseconds, and the transition between the two phases is highly reversible, giving MR fluids the unique property of magnetic field controllability. In a few moments, the chains develop, causing roughly 50 kPa of yield stress depending on the kind of MR fluid, and the casing provides a resistance to fluid flow.

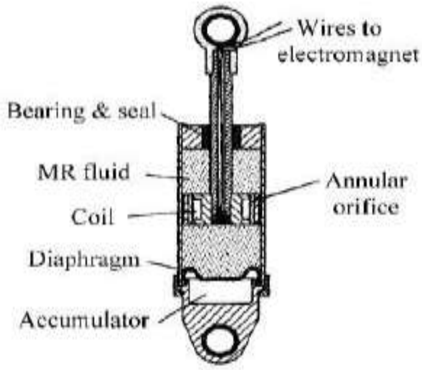
1.2 Magneto-rheologicalSuspensions

1.3 Problem Statement

In normal Telescopic shock observer, the stiffness of shock absorber cannot be changed according to road so this is the main problem in existing all shock absorber whether it is Telescopic

These devices generally operate in the valve mode. Typically, a MR suspension consists of a hydraulic cylinder, magnetic coils and MR fluid offering design simplicity. In addition to field controllability and design simplicity, MR suspensions have many other advantages such as they (i) require relatively very low power input, (ii) produce high yield stress up to 100 kPa, (iii) can be stably operated in a wide range of temperature (−40–150 ◦C) and (iv) MR fluids are not toxic and are insensitive to impurities

spring or below it may be any kind but you cannot change its stiffness now for transport vehicle heavy luggage vehicle military vehicles that travel on road and off road so there need the shock observer according to their road condition which cannot be



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done in any kind. So, we have introduced our Mr. fluid best smart shock absorber whose stiffness can be changed according to road condition if the vehicleisrunningonoffroadsilencerstiffnessrequired willbemoresosmartMr.fluid smartshockabsorbercanchange its stiffness if the Roadies plane off road so here we required soft stiffness shock absorber for Mr. fluid can change it either.

1.4 Objective

The suspension system is an integral part of an automobile which not only supports the vehicle body andseparates the vehicle body from tires but also gives better ride comfort and safety to the passengers. Therefore, the objective of the project is Performance Analysis of MR suspension for better ride comfort of thevehicle.

- To replace the spring by MRfluid
- To achieve highsafety
- It is efficientsystem
- To generate magnetic flux density within MRfluid

1.5 Methodology

Methodology for making MR-Fluid:

CI particles (80% by wt.) were mixed with oleic acid (0.25% by wt) for 30 minutes at 400 R.P.M in the stirrer. After that white grease (0.25% by wt.) was poured and mixed for 30 minutes at 400 R.P.M in the same stirrer. Then servo medium e.g.,paraffinoil(19.5%bywt.)waspoured insmallamountsgradually (4%bywt)after every30minutesand mixedfor 3 hrs. at 450 R.P.M in the samestirrer.

1.6 Working

The working of MR fluid shock absorber is first you have to prepare the MR fluid because the standard fluid available in market is very costly. The preparation of MR fluid is given above. now this prepared MR fluid will be filled in cylinder, normal Piston cylinder has no clearance even they have gas kit in between them but here we are keeping 1 mm clearance show the all MR fluid will pass through this one mm clearance now in normal condition when the road is plain or good we required soft shock absorber so here only 6 volt supply will be passed through Piston coil that is electromagnet because only 6 volt is applied the resistance for MR fluid passing between Piston and cylinder is very less that's why we will get soft shock absorber, now suppose the vehicle is travelling on off road hard road so here the voltage supplied will be more and the resistance for MR fluid will be more because high magnetic field will be developed between Piston and cylinder so the result is we will get hard shock absorber. In this manner the stiffness of shock absorber can be changed. Design of Machine

In this attempt to design a special purpose machine a very careful approach needs to be adopted, the total design work has been divided into two parts mainly;

- System design
- Mechanicaldesign

System design mainly concerns with the various physical constraints and ergonomics, space requirements, arrangement ofvariouscomponentsonthemainframeofmachineno. ofcontrolspositionofthesecontrolseaseofmaintenanc escope of further improvement; height of m/c from groundetc.

1.7 Literature Review

The authors reviewed the design, modelling, and types of MR Dampers and suspension systems in the literature review in order to provide ride comfort, road holding qualities, vehicle handling, and road stability. Different forms of MR suspension models were also investigated in order to precisely forecast the actual behaviour of the genuine MR suspension. The MR suspension model's parameter optimization was also investigated, and the model's ideal parameters were discovered. The writers employed a variety of controllers to provide riders with a more comfortable trip. Researchers employed a quarter car model, which is one of the best and easiest ways to analyse vehicle ride comfort with a two-degree-of-freedom system, and analysed the vehicle's performance using sinusoidal, bump, and random road profiles. HILS was also used to conduct an experimental investigation of the MR suspension (Hardware in loop simulation).

Application Of Magneto-rheological Fluid In Industrial Shock Absorbers, Andrzej Milecki, Miko" Aj Hauke, 2012, discussed: Magnetorheological (MR) fluid is a type of fluid that may be used to regulate the stopping of moving objects, such as trains. The proposed technique allows the braking force to be adjusted (via an electronic controller) according to the kinetic energy of the moving object. An overview of passive shock absorbers is presented in this publication. Following that, a semi-active shock absorber with MR fluid is offered as a design concept. The ideal breaking process happens when the breaking force remains consistent throughout the whole stroke of the absorber, according to theory.

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Passive shock absorbers, which are currently in use, do not provide this assurance. Because the braking force of these absorbers varies, the stopping procedure is less than ideal. As a result, there is room for improvement. Semi-active devices, often known as "intelligent" devices, have recently been proposed for vibration and oscillation dampening. The parameters of these devices, such as the movement opposite force, may be altered continually with very little energy. Electrorheological (ER) or magnetorheological (MR) fluids are used. These fluids have a lot of potential in industrial applications, such as stopping moving pieces on production lines. MR devices are more powerful than traditional electrorheological solutions and may be operated directly from low-voltage power supplies, which is why MR fluids are used so frequently.

In Design, fabrication and evaluation of MR suspension by A. Ashfak, a. Saheed, k. K. Abdul Rasheed, and j. Abdul Jaleel, International Journal Of Mechanical, Aerospace, Industrial, Mechatronic And Manufacturing engineering vol:3, no:5, 2009. This paper presents the design, fabrication and evaluation of magneto-rheological suspension. semi-active control devices have received significant attention in recent years because they offer the adaptability of active control devices without requiring the associated large power sources. magneto-rheological (MR) suspensions are semi- active control devices that use MR fluids to produce controllable suspensions. they potentially offer highly reliable operation and can be viewed as fail-safe in that they become passive suspensions if the control hardware malfunction. the advantage of MR suspensions over conventional suspensions are that they are simple in construction, compromise between high frequency isolation and natural frequency isolation, they offer semi-active control, use very little power, have very quick response, has few moving parts, have a relax tolerances and direct interfacing with electronics. magneto- rheological (MR) fluids are controllable fluidsbelonging.

1.8 CAD Models

Figure3Assembly **Figure 4 CutSection**

Figure 5 Piston Figure 6 Main frameCylinder

1.9 MachineDesign

MACHINE DESIGN is a subject that deals with the art of designing structural machines. A machine is a collection of resistant bodies with successfully constrained relative motions that is used for converting various types of energy into mechanical energy or transmitting and upgrading existing designs to convert and regulate motions with or without transmitting power. It is the practical application of machinery in machine and building design and construction. A solid understanding of applied science is required to design simple components satisfactorily. Furthermore, material strength and characteristics, including some metrological aspects, are critical. Knowing the velocity also necessitates knowledge of machine theory and other branches of applied mechanics. The mechanics of machinery are concerned with the acceleration and inertia force of the many linkages in motion.

Properties of steel C45

Weldability: Due to the medium-high carbon content it can be welded with some precautions.

Hardenability: It has a low hardenability in water or oil; fit for surface hardening that gives this steel grade a high hardness of the hardened shell.

Weldability Machinability

Easily available in all section Cheapest in all metals

Cutting ability

Material = C 45 (mild steel)

Take fos2

σt = σb = 540/fos = 270 N/mm2 σs = 0.5σt

= 0.5 x 270

= 135 N/mm2

1.10 DesignCalculation

Area x Pressure = Force Output F = P X A

Let us design the cylinder for 100 kg weight = 981N 981 = P x πr2

P = 981/ π242

P = 0.54 N/mm2.

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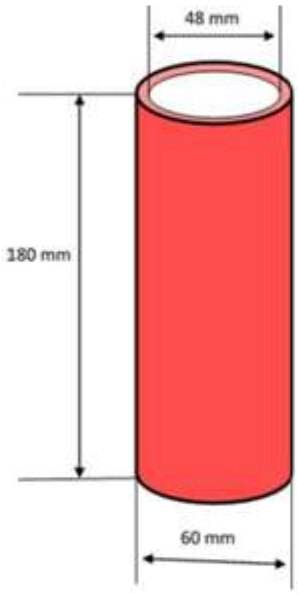

Figure 7 Cylinder dimension

1.11 Design ofCylinder

Now for thickness of cylinder wall of cylinder, Hooks law –

Hooke's law is a law of physics that states that the force (F) needed to extend or compress a spring by some distance (x) scales linearly with respect to that distance—that is, Fs = kx, where k is a constant factor characteristic of the spring (i.e., its stiffness), and x is small compared to the total possible deformation of the spring.

We have, t = pd/2 σtensile where p = internal pressure= 0.54N/mm2, & d = diameter of cylinder=48 mm selected, σtensile = permissible stress.

Considering factor of safety as 4.

We get permissible stress = ultimate stress/factor of safety σtensile = 135 N/mm2

Inputting this value in the thickness formula, We get, t = 0.54 x 48/2 x 135

= 25.92/270= 0.416 mm.

t = 0.09 mm (say)

but standard available cylinder in the market is 6 mm thick, so our design is safe. Outer Dia. of cylinder = 48 + (2 x 6) = 60 mm

The minimum outside dia of cylinder is 60 mm

1.12 Design of handlelink

W = maximum force applied = 981 N = 491 N (Since we are using 2 links)

M = W x L

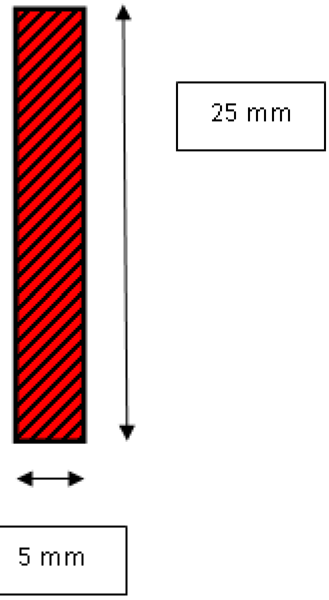

Figure 8 Cut-Section of Handle Link

M = 491 x 765/4 = 93903.75 N-mm

And section modules = Z = 1/6 bh2

Z = 1/6 x 5x252 Z = 1/6 x 3125

Z = 520.83 mm3.

Now using the relation,

Fb = M / Z

Fb = 93903/ 520 = 180.29 N/mm2

Induced stress is less then allowable so design is safe AISI 4140 Alloy Steel (UNS G41400)

Introduction Alloy steels are designated by AISI four digit numbers. They comprise different kinds of steels having composition exceeding the limitations of B, C, Mn, Mo, Ni, Si, Cr, and Va set for carbon steels. AISI 4140 alloy steel is chromium, molybdenum, manganese containing low alloy steel. It has high fatigue strength, abrasion and impact resistance, toughness, and torsional strength. The following datasheet gives an overview of AISI 4140 alloy steel.

Chemical Composition The following table shows the chemical composition of AISI 4140 alloy steel

M = WL/4 = 981 × 290/4

= 71122.5 N-mm Z= π(D 4 – d 4) /D x 32

Z=167.55mm

σb (induced)= M/Z = 7122.5/167.5 = 424.5 N/mm²

As induced bending stress is less then allowable bending stress i.e., 655 N/mm2 design is safe.

1.13 Buckling Analysis

Figure 9 Cut-Section of Piston Rod

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Buckling Analysis is an FEA routine that can solve all the difficult buckling problems that cannot be solved by hand calculations.

Meshing Information –

Mesh type	Solid Mesh
Mesher Used	Standard mesh
Mesh Element	Tetra (Automesh)
Automatic Mesh Transition	Off
Element Size	4 mm
Mesh Quality Plot	High

Boundary conditions –

Boundary condition	The Maximum Pressure which is induced when the damper is at its maximum stiffness condition.
Force	981 N upper surface of piston rod
Fixed support	At the eye of the cylinder

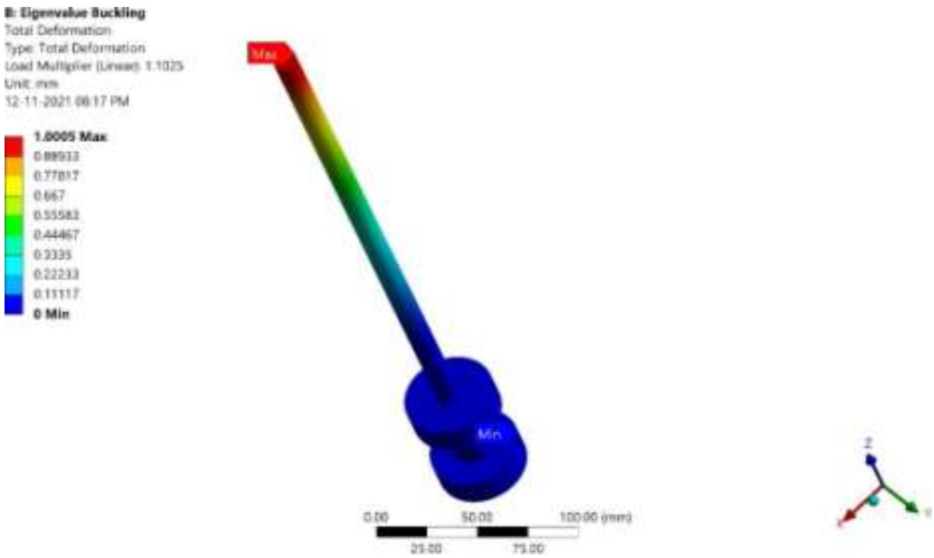

Figure 10 Buckling Deformation

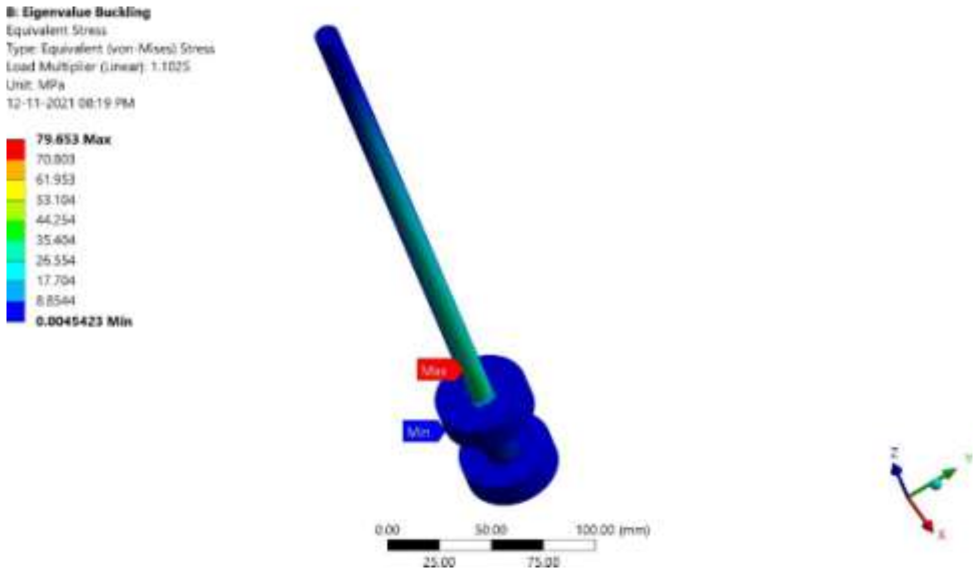

Figure 11 Buckling Stress

1.14 Images of Actual MR fluid andcomponents

II. CONCLUSION

- In the previous decade, MR fluids and MR fluid devices have evolved significantly, and some commercialproducts have been developed.
- The largest industrialized countries, including the United States, Belarus, France, Germany, and Japan, have been developing this approach competitively.
- The preparation of high-performance MR fluids and the design of MR fluid devices in structures are crucial for MR fluid technology.

As can be observed, the MR fluid devices discussed in this lecture will continue to be the focus of substantial research and applications in a variety of fields, as previously stated.

1.15 Advantages

1. The yield stress in the fluid isgreater.
2. In comparison to ER fluids, the devices are simpler to fabricate, have lower power requirements for control, and havea faster responsetime.
3. A MR suspension's squeeze mode offers several advantages, including a straightforward structure, clear efficacy,and quick response.
4. The fluids also benefit from the use of low-voltage power supply ranging from 2 to 25V, with currents ranging from1 to 2A and power ratings ranging from 2 to50W.

2.3 Application

1. Heavy industry uses these suspensions for heavy motor damping, operator seat/cab damping in construction trucks, and other applications.
2. TheArmyResearchOfficeintheUnitedStatesisactivelyfinancingresearchintotheuseofMRfluidtoimprovebody armor. Dynamic MR shock absorbers and/or suspensions are also used in HMMWVs and other all-terrainvehicles.
3. It was utilized to make the corrective lens for the Hubble SpaceTelescope.
4. In the case of a collision, magnetorheological suspensions are being developed for use in military andcommercial helicopter cockpit seats as safety mechanisms. They would be used to reduce the amount of stress imparted to a passenger's spinal column, lowering the risk of lasting harm in the event of acollision.
5. Semi-active human prosthetic legs use magnetorheological suspensions. The shock delivered to the patient'sleg when jumping is reduced by a suspension in the prostheticleg.

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