Semi active suspension system biology essay

Business, Strategy

This chapter describes briefly about the semi-active suspension system and the magnetorheological damper used in the system. A item account stressing the semi-active magnetorheological damper suspension system is explained and an overview on semi-active suspension system available in the market is presented. This chapter besides focuses on the research works done by research workers on semi-active suspension system specifically on the development of magnetorheological damper theoretical account. Gaps in research are identified and justification for the research is presented.

Function of Vehicle Suspension System

A vehicles suspension system, which is located between the wheel axles and the vehicle organic structure frame, has four chief maps. The presence of suspension system allows the vehicle to go over unsmooth surface with minimal up-and-down organic structure motion, depending on the public presentation of the springs and the daze absorbers used.

The suspension system besides allows the vehicle to corner with minimal axial rotation by minimising the inclination of wheels to lose grip with the route surface. This will guarantee uninterrupted buffering action so that route abrasiveness or route daze merely has a minimum consequence on the residents.

Semi-active Suspension System and Magnetorheological Damper

As described in the old chapter, a semi-active suspension system is a system consists of a conventional spring and a variable damping damper (or floor absorber) . The semi-active suspension is much less complex than a to the

full active suspension system and can be produced at a lower cost. In footings of the public presentation, the semi-active suspension system can bring forth route comfort and managing attacks to the public presentation of a to the full active system (Elmadany and Abduljabar, 1991)A semi-active system is a close cringle system where a figure of detectors are required to mensurate vehicle ‘ s attitude. Accelerometers are used for this intent and they are located on the sprung and unsprung multitudes of the vehicle. Semi-active suspension system can be designed to response either in high bandwidth class or low bandwidth class systems. High bandwidth systems are concentrating in bettering suspension ‘ s rattle infinite response (10-12 Hz) and tire hop response (3-4 Hz) .

However bulk of semi-active suspension system are low bandwidth system and merely better the tyre hop frequence (Chen et al. , 2000) . As emphasized antecedently, variable muffling damper or daze absorber is the of import portion, which makes semi-active suspension system differs from conventional inactive suspension system and to the full active suspension system. There are two types of variable muffling damper used in semi-active suspension system ; hydraulicly based damper and magnetorheological (MR) fluid-based damper.

In hydraulicly based damper, the variable damping features are achieved by changing the entire country of valves country within the daze absorber. Ferrari and Maserati are the keenest users of this type of adaptative muffling damper. Mondial T, F355, 456GT, 550M, 360M, Shamal, Quattroporte and 3200GT are among the theoretical accounts that employed this type of

damper. In most of the clip, the damper is in “ soft ” puting to profit drive comfort. In instance the auto goes in action, it is set to “ stiff ” manner for stable handling and minimise organic structure axial rotation. For magnetorheological fluid-based damper, the variable damping features were achieved by magnetising the MR fluid utilizing the wire spiral within the damper.

When the spiral is energized (“ on ” province) , the magnetic field causes the Fe atoms in MR fluid to aline into hempen constructions in the way of the magnetic flux. The strength of the bond between the atoms in the constructions is relative to the strength of the magnetic field. When the spiral is non energized (“ off ” province) , the MR fluid is non magnetized. During this province, the MR fluid will act like a conventional fluid damper. As a consequence, a variable opposition to fluid flows within the damper Piston, which provides a variable damping capableness is generated in the damper. Delphi introduces the first commercialize MR damper in 1998 known as Magneride. It was foremost used by General Motors in the Chevrolet Corvette C5 and Cadillac Seville and STS, and is besides now used in the Ferrari 599, the Audi TT and in some Holden Particular Vehicles theoretical accounts.

2.

4 Research Review on Magnetorheological Fluid Technology

Magnetorheological fluid engineering has existed for more than 50 old ages. Although this engineering was introduced in 1940 ‘ s by Rabinow (Carlson, 2001) , the involvement on using the engineering was really little and shortly died out. The action taken by Lord Corporation in presenting ‘ Motion

Master ‘ which used MR engineering has triggered the involvement among research workers in MR fluid devices. Nowadays, MR fluid engineering is non merely restricted in vehicle ‘ s damper (or floor absorber) it is besides being used in constructing stabilisation during temblor, gun control kick in Naval turret, prosthetic leg and besides in smoothing machine (Poynor, 2001) .

Although the MR fluid engineering has been successfully applied for commercial used, the research on this engineering is still traveling on. Through literature reappraisal on MR engineering research, the research focused can be categorized into 4 classs: Research on MR fluid composing. Research on MR unstable mathematical and numerical simulation mold. Research on design and development of MR devices.

Research on the MR devices control schemes.

Research on MR Fluid Composition

In this class of MR engineering research, the research involvements are on depicting the belongingss of MR fluid, its content and its application. Carlson and Jolly (2000) has defined MR fluid, MR elastomers and MR froths. MR fluid are the liquids (contains iron atoms) whose flow or shear belongingss are easy controlled to enable a assortment of alone torsion transportation or quiver control devices while MR elastomers are no-good stuffs whose stiffness may be controlled to supply tunable or adjustable saddle horses and suspension devices.

It is besides stated that MR froths are governable fluid that contains an absorbent matrix, used to supply a convenient manner of recognizing the benefits of MR fluids in extremely cost sensitive applications. Chen and Yeh (

2002) , studied macroscopic behaviours of MR fluid when exposed to magnetic field. The research focused on the emphasis generated under the magnetic field consequence and the mechanism of energy dissipation. Li et al. , (2002) studied the creep behaviours of magnetorheological fluid under changeless shear emphasis and it was subsequently found out that MR fluids behave as additive viscoelastic organic structures at little emphasiss and changed as the magnetic field increased with increasing changeless emphasiss, nonlinear viscoelastic, and viscoplastic. Simon et al. , (2001) shown the effectual magnetic behaviour of magnetorheological complex as a map of the interparticle distance.

The research focused on the consequence of nonmagnetic bed due to additive added into MR fluid to maintain the Fe atoms in the MR fluid from touching each other. A expression used to foretell the behaviours of MR fluid by sing these effects was proposed.

Research on MR Fluid Dynamic Characterization Modeling

Research workers have proposed assorted patterning methods to qualify the dynamic behaviour of MR fluid devices and the attempt is still continued until today.

The mold of MR fluid devices ‘ dynamic behaviour can be grouped into two ; parametric mold and non-parametric mold.

2. 4. 2. 1 Parametric Modeling

In parametric mold, the dynamic behaviours of MR fluid are represented by mathematical map whose coefficients are determined based on the

experimental information i. e. the parametric quantity values are adjusted until the quantitative consequences match closely with the experimental information.

The following subdivisions are the lists of parametric patterning attack developed by research workers.

a Bingham Model

The Bingham theoretical account is the most common theoretical account used to stand for the dynamic behaviour of MR fluid. An ideal Bingham organic structure behaves as a solid until a minimal output emphasis is exceeded and so exhibits a additive relation between the emphasis and the rate of shear. The shear emphasis developed in the fluid is given by(2. 1)where is the shear rate and is the fictile viscousness of the fluid i. e.

Newtonian viscousness at zero field (Gavin et al. , 1996a) . Stanway et al.

, (1987) proposed a mechanical theoretical account, normally referred to as the Bingham theoretical account, where it combines syrupy and Coulomb clash. In this theoretical account (Figure 2. 1) , the force F generated by the MR device is given by(2. 2)where presents the speed due to the damper excitements, and the damping coefficient and the frictional force are related to the fluid ‘ s viscousness and the field dependent output emphasis severally (Spencer et al. , 1997) .

An illustration of the comparing between the predicted force-velocity feature of MR damper utilizing Bingham theoretical account and the experimental consequence conducted by Spencer et al. , (1997) is shown in Figure 2.

2Figure 2. 1 Bingham ModelFigure 2. 2 Comparison of experimental informations ( ) and predicted of Bingham model ( )

B Extended Bingham Model

Gamota and Filisko (1991) proposed an extension of the Bingham theoretical account to depict the MR fluid behaviour in the pre-yield and in the post-yield part every bit good as the output point. This drawn-out theoretical account consists of a series of three-parameter elements as shown in Figure 2. 3. Figure 2.

3 Extended Bingham ModelThe force generated in this system is given by equation (2. 3) where represents muffling coefficient and is the frictional force in the Bingham theoretical account that history for the fictile viscousness and the output emphasis. The parametric quantities, and are the field dependent parametric quantities (Gamota and Filisko 1991, Spencer et al. , 1997)(2. 3)Figure 2. 4 shows an illustration of comparing between the predicted theoretical account of drawn-out Bingham theoretical account with the experimental information. It can be seen that the drawn-out Bingham theoretical account qualitatively describes the hysteretic response of MR fluid device (Spencer et al.

, 1997) . Figure 2. 4 Comparison of experimental informations ( ) and predicted of drawn-out Bingham theoretical account ( )

degree Celsiuss Three Element Model

Powell (1994) has proposed three-element theoretical account to qualify the behaviour of MR fluid damper. It is a mechanical parallel consisting of a

syrupy damper, a non-linear spring and a frictional component arranged in parallel (Figure 2. 5) .

Figure 2. 5 Three-element theoretical accountThe force generated by the MR device following this theoretical account is given by ;(2. 4)with(2. 5)and(2. 6)where is Coulomb clash force, which is modeled with inactive and dynamic clash coefficients and severally, is the supplanting transmitted to the rheological device, and denotes the speed and the acceleration severally and is the non-linear force of a spring. In the three component theoretical account, the values of the muffling parametric quantities, , , , and every bit good as the elastic parametric quantities and are fitted to the experimental consequences.

An illustration of comparing between the predicted and the ascertained behaviour of MR fluid is shown in Figure 2. 6. Figure 2. 6 Comparison between the predicted (a) and the experimental information (B) of force speed feature for three elements theoretical account

vitamin D Bingmax Model

Makris et al. , (1996a and 1996b) proposed a distinct component theoretical account in order to qualify the behaviour of MR fluid. It consists of a Maxwell component in analogue with a Coulomb clash component as shown in Figure 2.

7Figure 2. 7 Bingmax ModelIn this proposed theoretical account, the generated force is given by(2. 7)where, is the quotient o the damping

invariable and the spring stiffness, K. The notations denotes the lasting clash force.

e Bouc-Wen Model

Spencer et al. , (1997) presented a theoretical account named as the Bouc-Wen theoretical account, used to qualify the behaviour of MR fluid damper. The construct of the theoretical account is based on an attack due to Wen (1976) , where this theoretical account is supposed to reproduce the response of hysteretic systems to random excitements.

Figure 2. 8 shows the mechanical parallel of the Bouc-Wen theoretical account. The force generated from this theoretical account is given by(2.

8)where the hysteretic constituent satisfies(2. 9)By seting the parametric quantity values, , and, it is possible to command the form of the force speed feature of MR fluid damper. The initial supplanting of the spring component (stand foring the collector) is. Figure 2. 8 Bouc-Wen ModelAn illustration of the comparing of this theoretical account with an experimental information is shown in Figure 2. 9. It can be seen that the theoretical account is good suited for numerical simulation, since it is less stiff than the drawn-out Bingham theoretical account.

But as can be seen in Figure 2. 9, this theoretical account can non reproduce the feature in the output part i. e.

for speeds with a little absolute value. Figure 2. 9 Comparison of the Bouc-Wen theoretical account ( ) and the experimental informations ( )

degree Fahrenheits Modified Bouc-Wen Model

To better foretell the response of the MR damper in the output part point, Spencer et al. , (1997) proposed an extension of the Bouc-Wen theoretical account as depicted in Figure 2.

10. The equations for the force in this system is given by(2. 10)where(2.

11)and(2. 12)The hysteretic constituent, histories for the clip history of the response (Dyke et al. , 1997) . The spring and its initial supplanting are for both the extra stiffness and the force beginning produced by the presence of an collector. Figure 2. 10 Modified Bouc-Wen ModelThe notations of, and in equations (2.

10) , (2. 11) and (2. 12) are defined as in equations (2.

13) , (2. 14) and (2. 15) severally.

Equations (2. 13) , (2. 14) and (2.

15) are assumed to depend on the electromotive force applied to the current driver in order to obtain the parametric quantity values in equations (2. 10) , (2. 11) and (2.

12) , which are valid for changing magnetic field strength.(2. 13)(2.

14)(2. 15)where is governed by(2. 16)The parametric quantities, , , , and are invariables where the values are determined from experiment.

An illustration of comparing between the predicted force-velocity of MR damper and the informations collected from the experiment is depicted in

Figure 2. 11. It can be seen from the comparing that the theoretical account is able to accurately reproduce the MR fluid behaviour, even over a wide scope of operating conditions (Spencer et al. , 1997) . More over, its parametric quantity values are independent of the applied electromotive force and need non to be estimated afresh for different field strength. Figure 2. 11 Comparison between modified Bouc-Wen theoretical account ( ) and experimental informations ( )

g Non-linear Viscoelastic-Plastic Model

Kamath and Werely (1997a) has presented viscoelastic-plastic theoretical account, which combines two additive shear flow mechanism with non-linear burdening maps in order to qualify the response of MR fluid damper. Figure 2.

12 Viscoelastic-plastic theoretical account. (a) Viscoelastic mechanism (B) Viscous mechanism. In this theoretical account, the MR fluid ‘ s behaviour in pre-yield part is simulated by the three-parameter elements as depicted in Figure 2. 12 (a) .

The viscoelastic force is generated by(2. 17)where, and denote the parametric damping and stiffness changeless severally, and X is the supplanting transmitted to the damper. In the post-yield part the MR fluid response is represented by(2. 18)where the damping coefficient is related to the evident viscousness of the fluid (Figure 2. 12b) . The passage from the pre-yield to the post-yield government is performed by nonlinearly uniting the viscoelastic and syrupy constituent and to the net force(2.

19)where and are the form map parametric quantities and represented by(2. 20)and,(2. 21)where, and are the non-dimensional speed, output parametric quantity and a smoothing parametric quantity severally. The proposed theoretical account is found to be able to reproduce nonlinear effects of the MR fluid. Furthermore, the proposed theoretical account is besides numerically robust due to the one-dimensionality of the shear flow mechanism (Kamath and Werely 1997a) .

H Augmented Non-Linear Viscoelastic-Plastic Model

Kamath and Werely (1997b) has extended the non-linearity of the viscoelastic-plastic theoretical account mentioned antecedently. In this drawn-out theoretical account, in the pre-yield part, the clash force is weighted by a form map, . The form map was added to let the Coulomb-like effects to be observed at low speeds. Therefore, the force generated in the pre-yield is given by(2. 22)where(2. 23)and is a smoothing factor. The viscoelastic constituent is given by equation (2. 17) .

In order to see the syrupy and inertial mechanism, Kamath and Werely (1997a) introduced the syrupy and inertial mechanism as depicted in Figure 2. 13. The force is given by(2. 24)Figure 2. 13 Inertial mechanism of augmented viscoelastic-plastic theoretical accountBoth of these two shear flow mechanisms are combined by two non-linear burdening maps and giving the non-linear web as depicted in Figure 2. 14Figure 2. 14 Scheme of the augmented viscoelastic-elastic theoretical accountThe entire force F generated by this theoretical account is given by(2.

25)The comparing made between the consequences generated from the theoretical account and the experimental theoretical account is shown in Figure 2. 15. From the comparing, it can be seen that the theoretical account exactly depicts the behavior of the considered MR fluid. The added mechanisms, such as the clash constituent, mostly depend on the design of the considered damper, but they can be manually adjusted by taking suited parametric quantity values (Kamath and Werely, 1997b) . Figure 2. 15 Comparison between simulation and experimental consequences for augmented viscoelastic-plastic theoretical account.

2. 4. 2. 2 Non-Parametric Mold

For non-parametric mold, the patterning method involves experimental informations on a specific magnetorheological device, and used to pattern the dynamic behaviour of MR fluid device. The experiment is by and large being conducted by detecting the device by changing runing status i.

e. supplied current. The informations collected from the experiment are used to foretell the rheological device under random excitements. Below are the lists of the non-parametric theoretical accounts have that been proposed by research workers.

a Chebyshev Polynomial Fit

Ehrgott and Masri (1992) used a Chebyshev multinomial tantrum to come close the force generated by MR device. For fixed magnetic filed strength and fixed exciting frequence, the reconstructing force of the MR device is predicted by an analytical map constructed by Chebychev multinomials(2. 26)where the denote the two dimensional Chebyshev coefficients, and is the

grade of multinomial. The values and are obtained by normalising the supplanting, and the speed that are associated with the external excitement to the internal [-1, 1] .

In the same manner, the force can be determined as a map of speed, and acceleration. Gavin et al. , (1996b) extended this curve suiting method to three dimensions. The reconstructing force of MR fluid damper is related to the supplanting, the speed and the magnetic field strength E by(2. 27)where the denote the Chebyshev coefficients, and and are normalized values.

Figure 2. 16 shows the comparing of the force-velocity characteristic estimated by the Chebyshev multinomials with the experimental consequences conducted by Ehrgott and Masri (1992) . The predicted MR response resembles the corresponding experimental information. However the force secret plan from Ehrgott and Masri (1992) , partially exhibit oscillating behaviors often observed for multinomial insertion. Figure 2. 16 Comparison between the predicted (aˆ¦aˆ¦) and the by experimentation obtained (___) force-velocity feature for a Chebyshev multinomial tantrum.

b Neural Networks

Burton et al. , (1996) studied the public presentation of a multilayer nervous web to foretell the rheological consequence response.

Nervous web consists of several treating unit (nerve cells) whose input are weighted and passed to an activation (signal) map bring forthing one individual end product. The burdening depends on the nerve cells ‘

interconnectednesss and can be adjusted by a sort of larning procedure. The web presented by Burton et al. , (1996) was constructed by an algorithm known as the Dependence Identification Algorithm, which is attributed to Moody and Antsaklis (1996) . Makris et al.

, (1996b) extended the usage of nervous webs in combination with mechanical theoretical accounts reference before. As the latter were assumed to reproduce most of the additive rheological response, the web was trained on a different signal between the response predicted by the parametric theoretical accounts and existent response of the damper. Burton et al. , (1996) found that the public presentation of the nervous web theoretical account of MR damper is better than the element theoretical accounts such as the Bingham Model. When the nervous web is combined with the simple mechanical theoretical account, the web ‘ s anticipation is superior to the consequences achieved with the parametric method entirely.

A comparing between experimental informations and a anticipation obtained from the nervous web combined with the parametric theoretical account is shown in Figure 2. 17. Figure 2. 17 Comparison between the predicted (____) and the by experimentation obtained (— — –) force-velocity feature for a nervous web combined with the Maxwell theoretical account.

2. 4.

3 Research on Design and Development on MR Devicess

Gordaninejad and Kelso, (2000) designed a MR damper to be used on off-high-payload, off-road vehicles. The designed MR damper was tailored to provide for a broad scope of dynamic lading with the capableness to run at a

different recoil and compaction. The design is based on the original daze absorber as the mention. The writer used Bingham theoretical account to plan its MR damper and besides conduct experimental surveies to verify the design. The consequences from the surveies show that the experimental consequences demonstrate good correlativities with the simulation consequences. Ahmedian, (2000) from Advanced Vehicle Dynamics Laboratory, Virginia Tech has applied the MR fluid engineering to plan the MR damper for bike applications. The writer used two attacks in order to analyze the effectivity of MR damper in supplying comfort for the bike users. The first method is by merely retrofitting the MR valves inside the original damper while for the 2nd method the writer made a new design for the bike by sing the relaxation of fiction and assembly.

The writer besides considered the new feature of the designed damper to envelope the original damper. The consequences from this surveies are that, a decently designed MR dampers can supply important dynamic betterment in footings of comfort, as compared with a conventional inactive bike damper. Ahn et al. , (1999) had modified a conventional fluid saddle horse and replaced the original fluid of the mounting with MR fluid. The dynamic behavior of MR fluid when subjected to magnetic field was used to command the fluid flow inside the climb. The behavior of MR fluid was used as a switch to command the gaps of unstable transition of the climb.

A simple control strategy was used to command the operation of the MR fluid and it was found that the application provides a good betterment for the saddle horse ‘ s isolation consequence. Simon and Ahmedian, (1999) studied the consequence of magnetorheological damper as a primary

suspension in bettering drive comfort on heavy truck vehicle. For this intent, a set of governable magnetorheological damper was fabricated. An embedded accountant was used to find the muffling degree for the semi-active suspension based on the skyhook control strategy. Pare ‘ (1998) has studied the effectivity of magnetorheological damper in bettering vehicle ‘ s drive comfort by proving the developed magnetorheological damper on a full graduated table one-fourth auto theoretical account, constructed at the Advanced Vehicle Dynamics Laboratory at Virginia Technology. The writer evaluated the response of the developed damper on the vehicle suspension utilizing different control algorithms viz.

skyhook, groundhook and intercrossed skyhook-groundhook. The comparing between semi-active system and inactive system were besides studied utilizing the developed one-fourth auto rig. Very promising consequences were shown in footings of drive quality betterment that can be produced by the semi-active magnetorheological damper. Poynor (2001) has researched several different applications of magnetorheological fluid engineering. The developed magnetorheological dampers were for automotive suspension system application and for military intents. The dampers developed for the automotive suspension system were mono-tube based damper and hybrid-tube based.

In the military application, the magnetorheological dampers was developed to be used in gun kick system in order to cut down the impact of back-thrust during fire. Another research work on the development of magnetorheological fluid engineering is by Gravatt, (2003) . In his maestro ‘

s thesis, the magnetorheological dampers were developed to be used in ace motorcycle ‘ s suspensions system. The developed MR dampers were designed and fabricated based on the original makers dampers and installed in the super motorcycle ‘ s suspension system. The writer used skyhook control algorithm to command the operation of the developed damper in order to better the super motorcycle ‘ s drive comfort and consequences from the installing are really promising.

2. 4.

4 Research on MR Device Control Strategies

In this subdivision, control schemes that were used to command the operation of magnetorheological damper will be discussed affecting the most common control schemes of semi-active suspension system to the most advanced control schemes that were merely tested via simulation.

2. 4.

4. 1 Basic Control Strategies In Semi-Active Suspension System

This subdivision described the most common control schemes used to command the operation of variable muffling damper in semi-active suspension system. The control schemes are skyhook control schemes, groundhook control schemes and intercrossed skyhook-groundhook control schemes.

a Skyhook Control System

Skyhook control system is the most basic and most common algorithm used in semi-active suspension system for perturbation rejection control.

The algorithm was introduced by Karnopp et al. , (1974) . In skyhook control system, an fanciful damper is inserted between the sprung mass and the stationary sky as shown in Figure 2. 18 as an attempt to cut down or extinguish the gestures of sprung mass when the vehicle is subjected to route inputs such as route abrasiveness or bumps. In kernel, the skyhook constellation adds more damping to the sprung mass and takes off muffling from the unsprung mass. The skyhook constellation is ideal if the primary end is to insulate the sprung mass from base excitements, even at the disbursal of inordinate unsprung mass gesture. The control policy of skyhook system can be summarized as follows: if the merchandise of the sprung mass speed, and comparative speed between the sprung mass and unsprung multitudes, is positive, the semi-active force is relative to the speed of sprung mass.

Else, the semi-active damping force is set to zero. The equation regulating skyhook control is given by: If soIf so (2. 28)Figure 2. 18 Skyhook control system

b Groundhook Control System

Groundhook control system was proposed by Novak and Valasek (1996) in order to extinguish the inordinate unsprung mass gesture and improves tyre force kineticss. In land hook control, an extra fabricated damper is added between the unsprung mass and the land. If in skyhook control system, the betterments are focused in cut downing the sprung mass oscillations and insulate it from the base excitements, the land hook control system is focused in bettering unsprung mass oscillations from base excitements.

Groundhook control system is more suited to be used to command semi-active force in semi-active suspension system for heavy vehicle because the algorithm in Groundhook control improves tire force kineticss which will cut down the consequence of route harm which might perchance do by the heavy vehicle ‘ s suspension system (Valasek and Kortum, 1998a and 1998b) .

The constellation of Groundhook control is shown in Figure 2. 19. The equations regulating Groundhook control are as follows: If soIf so (2.

29)Figure 2. 19 Groundhook control system

hundred Hybrid Skyhook-Groundhook Control System

Hybrid skyhook-groundhook has been proposed by Ahmedian (1997) . The control system which takes benefit both of skyhook and groundhook systems gives the users the ability to stipulate how closely the accountant emulates the skyhook or groundhook. The intercrossed skyhook-groundhook system has two dampers connected to some inertial mention in the sky and in the land as depicted in Figure 2. 20. The intercrossed control scheme is a additive combination of skyhook control system and groundhook control system and can be written asIf soIf so(2. 30)If soIf sowhere and are the skyhook muffling force and groundhook muffling force severally.

The parametric quantities and are the skyhook and groundhook damping invariable. The variable is the comparative ratio between the skyhook and groundhook control, and G is a changeless addition. Figure 2.

20 Hybrid Skyhook-groundhook Control System.

2. 4.

4. 2 Advanced Control Strategies For Semi Active Suspension System

In this subdivision, brief descriptions on options control strategies that are used to command the operations of the variable damper are discussed with most of the control strategies involve complex algorithms.

a Sliding Mode Control

Lam and Liao (2001) and Yokoyama et al. , (2001) studied the application of skiding manner control (SMC) with semi-active magnetorheological damper. The accountant which considers the burden uncertainnesss and the unwanted non-linear belongingss of magnetorheological damper was reported to cut down significantly the sprung mass acceleration. It was besides reported that the usage of SMC with magnetorheological damper besides improves sprung mass extremum response and the root-mean-square values of the studied parametric quantities (i.

e. acceleration, perpendicular supplanting) .

B Fuzzy Logic Control

Fuzzy Logic control is known to be really effectual in perturbation rejection control of semi-active suspension system (Brown and Harris, 1994) . The construct of a fuzzed logic set is introduced by first specifying rank maps.

In order to develop a fuzzy logic system for control application, a functional signifier of the rank map is needed. This rank map describes the grade of certainty that an element belongs to a fuzzed set. There are many forms of rank maps proposed, and the most widely used rank maps are the triangular-

type, trapezoidal-type, Gaussian-type and the singleton rank map. The mathematical signifier of a standard rule-based fuzzy system is given by(2.

31)where and represents the rank map, fuzzed parametric quantity, figure of regulation and end product rank map for i-th regulation severally. The end product of the fuzzy system is used to cipher the coveted damping coefficients for semi-active suspension system (Al-Holou and Shaout, 1994) or to cipher the coveted force required by the active suspension system (Barr and Ray, 1996) . It is reported via numerical surveies that the usage of fuzzed logic are able to better the vehicle theoretical account ' s drive comfort (Sireteanu et al.

, (2001) , Chen et al. , (2001 and 2003) and Zhang et al. , (2004)) . In existent universe application for semi-active suspension system, the execution of fuzzed logic control had been performed by Fang et al. , (1999) , Craft et al. , (2003) and Rui et al. , (2004) and the consequences are really assuring with the accountant could efficaciously cut down sprung mass perpendicular oscillation and better drive comfort and managing stableness.

hundred H Control System

Ha? z control system is known for its hardiness when runing under different environment. It is a control method that considers uncertainnesss, including the theoretical account ' s uncertainnesss, theoretical account parametric quantities and perturbations. H control system of semi-active suspension system with magnetorheological damper has been studied by Du et al. , (2005) . In this survey, the dynamic behaviour of magnetorheological was foremost simulated utilizing a multinomials theoretical account based on the

experiments carried out on the developed magnetorheological damper. Then the magnetorheological damper theoretical account was used in a one-fourth auto theoretical account along with the H control system. The H accountant used the suspension warp and the sprung mass speed as the feedback signals. The strategy was farther studied via numerical simulation under random excitements.

Simulation consequences showed that the designed H accountant could supply good public presentation for the semi-active suspension system.

vitamin D Neural Network Control

Yiming and Xiangying (2004) investigated the public presentation of semi-active suspension system with magnetorheological damper controlled by nervous web accountant. The survey was carried out via simulation theoretical account by utilizing a one-fourth auto theoretical account. Nervous web control of magnetorheological with experimental appraisal utilizing a one-fourth auto trial rig was reported by Chen et Al. (2000) . The consequences from both of these surveies show that the nervous web control system excel in bettering the suspension public presentation.

vitamin E Linear Quadratic Regulator (LQR) Control

The LQR control system for semi-active suspension system has been studied by ElMadany and Abduljabar (1999) utilizing a simple one-fourth auto theoretical account.

Hrovat (1991) studied the strategy on a full auto theoretical account while Krtolica and Hrovat (1992) on a half auto theoretical account. The strength

and advantage of LQR attack is that the elements of the public presentation index can be weighted harmonizing to the interior decorator ‘ s desires or other restraint. With this advantage, an optimum consequence can be achieved when all the standards of public presentation are taken into history (i. e. organic structure acceleration, comparative speed and dynamic tyre burden)

2. 5 Decisions

Through the reappraisal of the magnetorheological fluid engineering, it is clear that research workers are concentrating on analyzing the behaviour of the MR fluid and seek to pattern it via a simulation theoretical account. There are assorted version of simulation theoretical accounts to imitate the dynamic behavior of magnetorheological device that has been proposed.

The researched besides focused on the execution of the magnetorheological fluid engineering affecting the design and development of magnetorheological device to be applied in assorted Fieldss i. e. automotive application. The research workers are besides concentrating their researched on the control strategy to command the operation of magnetorheological device optimally. It is shown from the literature that most of the surveies on magnetorheological damper emphasize on the patterning the dynamic feature of magnetorheological fluid and the control algorithm to command magnetorheological device.

The work on the design and development of magnetorheological device is non clearly explained or exposed to the readers particularly the item computations on how the magnetorheological damper been designed. The

simulations that have been carried out by research workers on the semi-active suspension system used merely one control algorithm without any efforts to compare with other control algorithm that affect the public presentation of magnetorheological damper and hence consequence the overall public presentation of vehicle ‘ s drive comfort. This thesis will undo the development of magnetorheological damper theoretical account for vehicle ‘ s suspension system through the model-based-design attack and shows how two control algorithms that are used to command the operation of magnetorheological damper can consequence the overall public presentation of vehicle ‘ s drive comfort.