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IMPROVED RIDE AND HANDLING CHARACTERISTICS OF AN ATV USING INPUT BASED CONTROL WITH MR DAMPER

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ABSTRACT

The objective of this paper to improve ride and handling characteristics of an ATV (All Terrain Vehicle) using Input based control. Using a virtual model the mathematical model is developed. For reduction in tradeoff between both ride and handling characteristics a Fuzzy control system is developed and incorporated in the simulation. In ATV front wheels (both left and right) are provided with photo electric sensor, which gives the input to the rear suspensions through the developed Fuzzy control system. Rear suspensions are fitted with OEM MR Dampers (MRD). Steering wheel sensor fitted in a steering column gives the direction of the steering position and this input is given Fuzzy. The results of simulation also show that the proposed methodology furnishes better results of both characteristics.

Keywords—ATV; Input Based Control;FuzzyControl; MR Damper; Ride and Handling Characteristics.

1-INTRODUCTION

The ride and handling characteristics are a most important tradeoff of the vehicle manufacturers. For the design of suspension, it is always being a challengeable task to maintain comfort for ride, handling for drivers, and continuous traction with terrain and body altitude control under all driving conditions. In a wide range of operating conditions of varying road conditions, speed of the vehicle and load suspension plays imperative role. In common during cornering, braking and bumping a high stiffness and damping are required to provide good handling characteristics. But, when a vehicle runs on a low, medium rough road and turning low stiffness and damping is required.

The constant spring and damper rating of the conventional suspension is not giving any appreciable solution and active suspension adding the disadvantage of cost, weight and power consumption. A semi active suspension system gives a feasible solution for the problem. Even spring stiffness is not getting changed; the damping ratio is getting varied in larger range. This feature is an important criterion for using MR Damper in a vehicle.

There are various Controlling strategies are used to [1-3] activating the MRD and its accessories. Dyke [4] used Clipped-Optimal Control Strategy based on feedback from acceleration. Lyapunov's direct approach [5] reduces the response by minimizing the cost function. Semi active hybrid control [6] technology dissipates energy from MRD. The other paper details about Fuzzy Moving Sliding Mode Controller (FMSMC) [7] explain the coefficients and intercepts of sliding surface changes. Quarter car model [8, 9] is used with FLC for MRD.

For controlling the MR damper various control strategies are used. This paper describes the Input based control of the current input to the MRD at exact time period. Various combinations of the conditions and rules have been feed forwarded to fuzzy controller. According to the bump input to the front wheels and/or steering input fuzzy controller triggers current the power cord. From power cord current is sent to a required MRD.

2-PROPOSED INPUT BASED CONTROL SYSTEM AND MR DAMPER

In preview system sensors are collecting the road profile and giving the signals to the controller, and it gives path to the SAS. But, it needs a complicated sensory arrangement and intricate algorithm system to regulate and receive the road profile from the sensory information. In this technique, the source of road profile from sensory information is the main challenge of the system, and it is frequently carry out with miscalculation, of the road profile. In other type of preview [10] control systems by calculating the vibrant variables at the front axle, the road profile under the rear wheel is forecasted. The instant at which roughness achieved to the front wheel can be calculated based on the vehicle speed and wheel base. For that reason, this method is called wheelbase preview control. As an advantage of this system, they do not need to complex sensory system in front of the vehicle. With this information, controller has enough time to response properly to the road inputs. This guides to lift up the performance of the suspension system.

The sensors are placed at front wheels of the ATV to identify variation in between road surfaces and tyres. When the front wheel hits the bump, the height of the bump is measured and also it checks whether both wheels (right and left) hits the bump (or) left/right wheel hits individually. If both wheel hits the bump, the signal is sent to the ECU. The ECU triggers power supply of predetermined values fed into the control system. Then the controller gives the power input to the damper which in activates the magneto rheological fluid and became stiffer. Similarly it works for left/right wheel individually. In this work the above scheme is proposed and tested in rolling dynamometer, and implemented the results as an input for the simulation of a [11, 12] Full Car Model of ATV.

*Damping Coefficient 530Ns/m @ i=0A, (Tested Values) 2505Ns/m @ i=2A

Figure 1: All Terrain Vehicle (ATV)

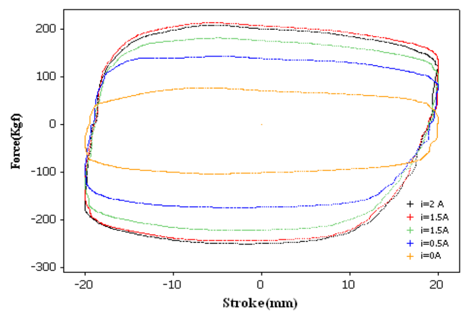

Figure 2: Stroke vs. Force

For the above ATV model 7 DOF (Four in vertical –Heave, Three in rotational-Rolling, Pitching & Yawing) mathematical modeling is created and it is used for the simulation.

A magneto rheological fluid (MR fluid) is a type of smart fluid in a carrier fluid, usually a type of oil. When subjected to a magnetic field, the fluid greatly increases its apparent viscosity, to the point of becoming a visco elastic solid. Importantly, yield stress of the fluid when in its active ("on") state can be controlled very accurately by varying the magnetic field intensity. When subjected to a magnetic field, magnetic particles inside increase the fluid's viscosity, rendering it visco elastic solid. For the testing purpose OEM [13] of Lord Corporation’s 8041-D Long stroke damper is used. It has been tested in a DTM and Half Car Dynamometer. The test results and data are used to simulate full car model.

3- CONTROL ALGORITHM

Table 3 describes various driving condition/ rules for the ATV running on terrain. Rules have been framed according to bump(s) hitting on the front tyre, reference to steering turn conditions. For the sake of simplicity right turn is considered negative, left turn is considered positive and no turn (straight run) is considered as zero. But for steering there is three conditions to be satisfied. Right side steering value is considered minimum, left side steering is considered maximum and no steering input is considered median value between these two. Defuzzification becomes the control signal; results fuzzy set getting converted to a number. The resulting fuzzy set is thus defuzzified into a crisp control. WTAVER (Weighted Average) method is used shape of the fuzzy set, due to its relatively good in computational complexity.

After designing the controller, it was evaluated for its performance. The rules shown in table 3 as considered as input to the MRD fixed on the both the rear wheels. For MRD during the activation maximum input of current given is 2A and for the deactivating period it is Zero A. Supposed these type of approach is called ON/OFF control with Skyhook control strategy. The interested part of simulation is only vertical displacement of the body and its roll angle reference to lateral direction. Before testing with controller performance, it is necessary to understand suspension system dynamics when ATV negotiates bump / turn or both considered as input. If damper is not provided with suspension setup, causes less/no damping, results increase continuous vibration on the system. Practically it means reduction in stabilizing of the system.

To testing the performance of the controllers, the reaction of the MRD simulated subject to input from the road profile of irregularities and banking of the vehicle (sprung mass) displacement, velocity, acceleration, suspension deflection and roll angle were simulated with preview based and input based control. In this paper displacement and body roll angle graphs only tabulated.

Table 1.Controller Values for the Simulation

Sl No.	BUMP LEFT	BUMP RIGHT	STEERING TURN(θ)			OUTPUT FROM CONTROLLER	
			RIGHT (-θ)	CENTRE	LEFT (θ)	i (I/P)-LEFT	i(I/P)- RIGHT
1	0	0	-	Median	-	0	0
2	1	0	-	Median	-	1	0
3	0	1	-	Median	-	0	1
4	1	1	-	Median	-	1	1
5	1	0	-θ	-	-	1	0
6	1	0	-	-	θ	0	1
7	0	1	-θ	-	-	1	0
8	0	1	-	-	θ	0	1
9	1	1	-θ	-	-	1	0
10	1	1	-	-	θ	0	1

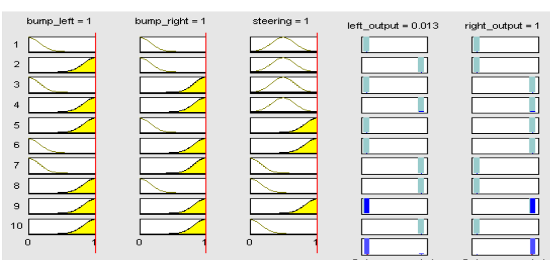

Figure 3: Rule Viewer-Input to MRD

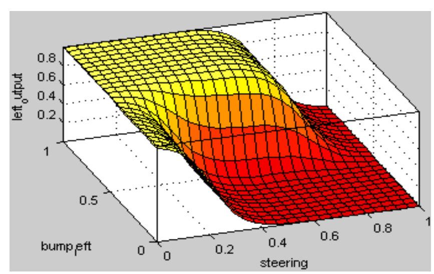

Figure 4: Bump Vs Steering

4-DISCUSSIONS

The graph (Figure 5, 6) shows reduction in displacement, roll angle of the ATV comparing conventional damper, preview based with Input based control system. Considering sixth example (Table 1,Figure 3) bump hits on left, supposed to give power input to the left wheel only, for the ride comfort. But the weight age/ predilection has been considered for the handling of the vehicle. Even though it is the left bump, the ATV turns in the left side affecting handling characteristics of it. That is inner wheel of ATV is lifted compare to outer wheel. Due to this the rolling effect will be increased. To avoid/reduce this rolling the current input has been given in to the required wheel damper and that damper become stiffer, avoiding further downward movement towards the ground. Front wheel input, Wheel radius, Wheel base and speed of the vehicle, appropriate calculation for the time delay period to experience of rear wheel are very important things to be considered to increase efficiency of the controller. It directly helps to increases vehicle performance.

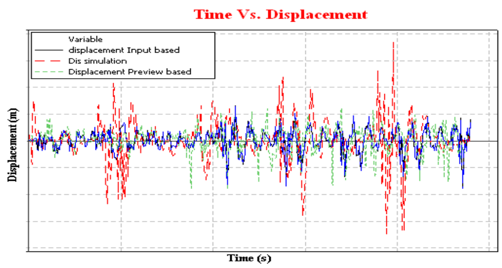

Figure 5: Time vs. Displacement

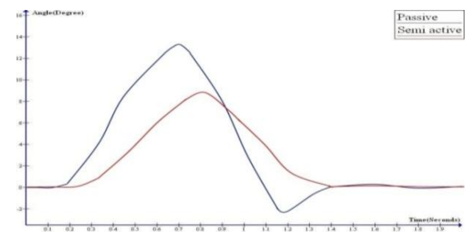

Figure 6: Vehicle Roll motion (Roll angle)

5 -CONCLUSION

In this paper an Input Based Control system approach system has been studied. MRD fitted in rear wheels are controlled by the Fuzzy based control algorithm. The proposed methodology established similar results with the passive damper and preview based but an enhanced performance of the ride quality and handling characteristics.

6- FUTURE WORK

The MRD will be fitted in Prototype ATV and to be tested by using proposed methodology. This can be done by tweaking the control system and adjusting the way dampers react. This type of damper will be extremely useful for off-roading purposes due to its adaptability. All this can be expected in near future, when the system can be optimized easily for use in a diversity of vehicles.

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