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CONSIDERATION ABOUT SUSPENSION SYSTEMS

Mircea FENCHEA
“Politehnica” University of Timisoara, mfenchea@yahoo.com

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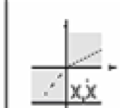
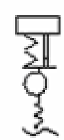
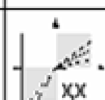
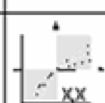
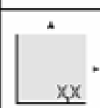
Abstract. A typical vehicle suspension is made up of two components: a spring and a damper. The spring is chosen based solely on the weight of the vehicle, while the damper is the component that defines the suspension’s placement on the compromise curve. Depending on the type of vehicle, a damper is chosen to make the vehicle perform best in its application.

1. INTRODUCTION

In general, four different suspension systems can be used (table 1). In case of conventional systems, springs and dampers have a constant characteristic curves. Adaptive systems can set elements to realize an adaptation of the chassis performance to different circumstances. In contrast to this system, semiactive suspension systems work with faster adjustable setting elements. These suspension systems can produce forces in the 1st and 3rd quadrant of the force-displacement or force-velocity diagram.

The full active suspensions can produce forces in all four quadrants of the diagrams. In comparison to the semiactive suspension which just needs energy for the drive of the setting elements and the electronics, full active suspensions also need very high energy for the force actuators. The main qualities of the different suspension systems are summarized in table1.

Table 1. Classification of suspension systems

	Forces	Switching Frequency	Energy Consumption	Model
passive				
adaptive		smaller than the body natural frequency	little	
semi-active		larger than the body natural frequency	medium	
active		larger than the body natural frequency	high	

2. ADAPTIVE DAMPING

The adaptive system is realized with three different damper curves: soft, standard and hard. The driving manoeuvre with the vehicle model is performed with all three different dampers and the results were compared.
As for the soft and the hard damper the characteristic curves can be calculated by using the factor 2/3 concerning the soft level and the factor 1,5 concerning the hard level in comparison to the standard damper.

3. ACTIVE SKYHOOK-DAMPER

The active damping offers the possibility for a direct continuos setting of the damper. As Fig. 1 shows, an additional damper is used between the vehicle and the reference system "surrounding". In contrast to a semiactive system, this active damper with the value d_a can be used to build up an additional force for every arbitrary body movement. This force depends on the relative velocity between the body and the reference system. In order to replace this system by a force element between body and wheel it is not enough to change the damping coefficient of the passive damper d_p. What is more, active forces have to be produced. Compared with passive and adaptive systems, the higher energy consumption of active systems is due to this condition. The damping force F_d between body and wheel can be calculated by the following equation:

$$F_d = d_p \cdot v_{rel} + d_a \cdot v_a \qquad (1)$$

with

$$v_{rel} = v_a - v_r$$

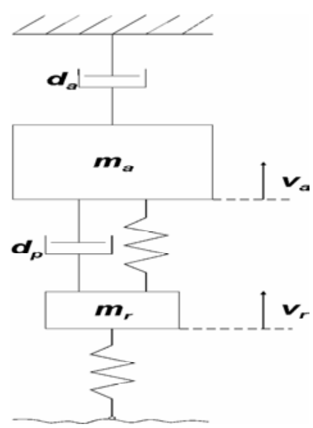


Fig. 1: Model of an active Skyhook-damper

4. SEMIACTIVE SKYHOOK-DAMPER

The model of the semiactive Skyhook-damper is shown in Fig. 2. The variable damping force is modeled by a variable damping constant. Contrary to the active system, the system can only be altered in certain areas. No forces were added by using additional energy. All forces were created by the relative displacement and the velocity between the body and the wheel with damper and spring elements. As for the use of this system for driving comfort, limits exist. The resulting damper forces can be calculated with equation (2) and (3).

$$F_d = d_p \cdot v_{rel} + d_a \cdot v_a \quad for \quad v_{rel} \cdot v_a > 0 \qquad (2)$$

$$F_d = d_p \cdot v_{rel} \quad for \quad v_{rel} \cdot v_a < 0 \qquad (3)$$

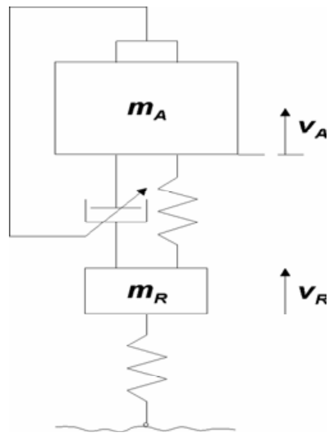


Fig.2: Model of an semiactive Skyhook-damper

5. CONCLUSIONS

Passive damping refers to energy dissipation within the structure by add-on damping devices such as isolator, by structural joints and supports, or by structural member's internal damping.

Active damping refers to energy dissipation from the system by external means, such as controlled actuator, etc.

Vehicles with semiactive and active Skyhook systems show better results in the area of the body natural frequency. In this area, the outcome for the semiactive model is 15% better and the result for the active model is even 30% improved in comparison with the outcome of the standard vehicle. By combining the different constant damping coefficients in a way to choose always the coefficient which corresponds best to the frequency, also with an adaptive system a distinctive improvement can be realized.

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