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Modeling and Simulation of a Simple Linear Suspension with Simcenter Amesim Software

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Abstract. The present paper aims at presenting an approach to the modelling and simulation of a car suspension system considered as a ground - spring - shock absorber system. The suspension system uniformly transmits the forces acting on the vehicle to the running surface and at the same time isolates it from the forces acting from the running track, improving its comfort and maneuverability. Simcenter Amesim is a simulation program for modelling and analyzing multi-domain systems. The software package is a suite of tools used to model, analyze and predict the performance of mechatronic systems. The car suspension simulation scheme was developed using the Amesim program and consisted of the suspended mass (body), the spring-damper subsystem (wheel damper), the unsuspended mass (chassis) and the auxiliary damping elements (wheel joints, tires and friction between the elements their assembly). We found that the damping speed of the suspended part is achieved faster than that of the unsuspended part after analyzing the two graphs of the damping speed of the body and chassis by about 0.3 [s] less. Tires also have an influence on the general damping system, which in our case was not considered.

Keywords: car; Amesim; spring; damping speed

JEL Classification: E17

1. Introduction

Driving comfort is described as the general comfort of people in the car while traveling with it. The main factors of discomfort are the vibrations and oscillations that reach the car and which produce noise. To remove the disruptive factor (road irregularities), specially designed components are used to achieve movement without negatively affecting the safety and comfort of passengers and the conditions of storage of the transported goods. The suspension system is a mechanism that connects the wheels and the car body. The suspension system uniformly transmits the forces acting on the vehicle to the running surface and at the same time isolates it from the forces acting from the running track, improving its comfort and maneuverability.

Simcenter Amesim is a commercial simulation program for modeling and analyzing multi-domain systems. He is part of the field of systems engineering and falls into the field of mechatronic engineering. The software package is a suite of tools used to model, analyze and predict the performance of mechatronic systems. The models are described by the use of time-dependent nonlinear analytical

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equations that represent the hydraulic, pneumatic, thermal, electrical or mechanical behavior of the system. Simcenter Amesim is part of the Siemens PLM Software Simcenter portfolio. It combines 1D simulation, 3D CAE and physical testing with intelligent reporting and data analysis. This portfolio is intended for the development of complex products that include intelligent systems, by implementing a predictive engineering approach.

2. Materials and Methods

To create a simulation model for a system, a multitude of libraries are used, which contain predefined components for different physical domains. The icons in this system must be connected to each other through their input and output ports. We developed a simulation scheme using the Amesim program consisting of suspended mass (body), spring-damper subsystem (wheel damper), unsuspended mass (chassis) and auxiliary damping elements (wheel joints, tires and friction between their assembly elements), figure 1.

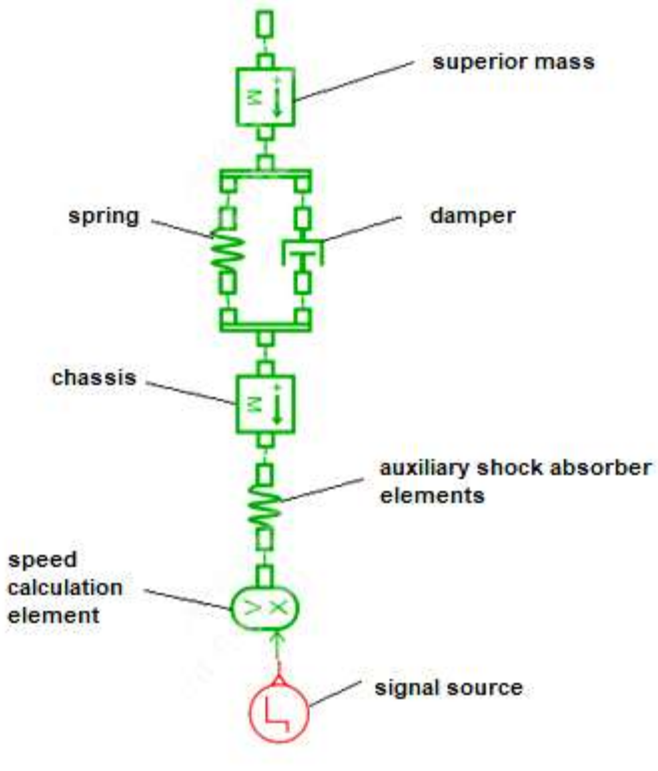

Figure 1. Simple Linear Mechanical Suspension Diagram

The upper mass is reported on only one of the four wheels of the vehicle because the actuating force of the shock absorber is uneven on each wheel of the car, due to road irregularities. The total mass is related to four, so the upper mass is equal to 400 [kg], and the mass of the chassis 60 [kg], figure 2.

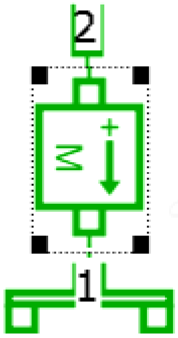

Figura 2. Superior mass

Figure 3 shows graphically the damping speed of the suspension at the lower joint. The damping speed of the body mass varies over time from 32 [m/s] and stops at about 0 [m/s] in 1.5 [s]. Figure 4 shows the graph of the displacement of the body mass that oscillates from the maximum value of 1.42 [m] depreciating in time of 1.6 [s] to the value of 0.95 [m]. Figure 5 shows the graph of the acceleration of the mass suspended in time, which from the maximum value of $1.6 \cdot 10^3$ [m/s^2] is depreciated to the value of about 0 in 1.7 [s].

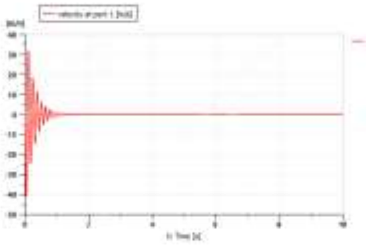

Figure 3. Body Mass Damping Speed

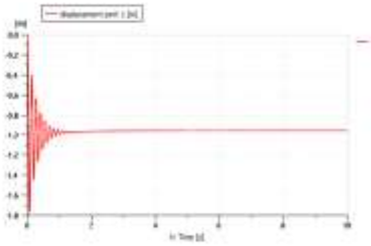

Figure 4. Movement of the Spring Mass Over Time

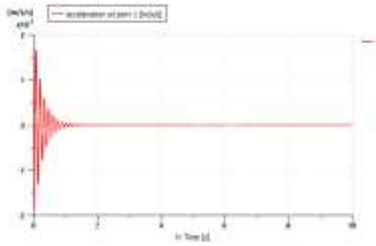

Figure 5 Acceleration of the Suspended Mass Over Time

In the case of the shock absorber, the forces acting on it intervene through the two ports 1 and 2, figure 6.

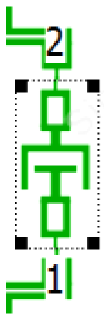

Figure 6. Damper

The actuating speed in port 1 of the shock absorber from the maximum value of 42 [m/s] is damped to the approximate value 0 in 1.6 [s], shown in figure 7. The actuating speed of the shock absorber in port 2 from the maximum value of 32 [m/s] reaches the depreciation value at about 0 in 1.7 [s], shown in Figure 8.

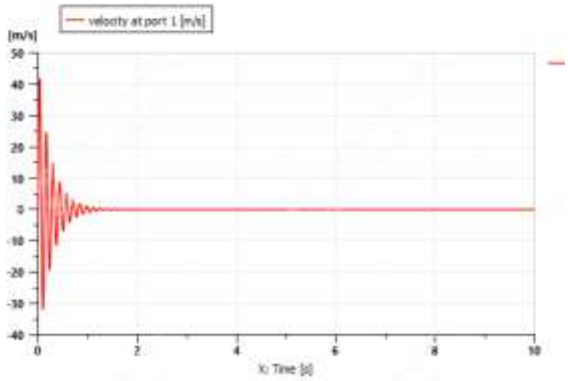

Figure 7. Damping Speed in Port 1

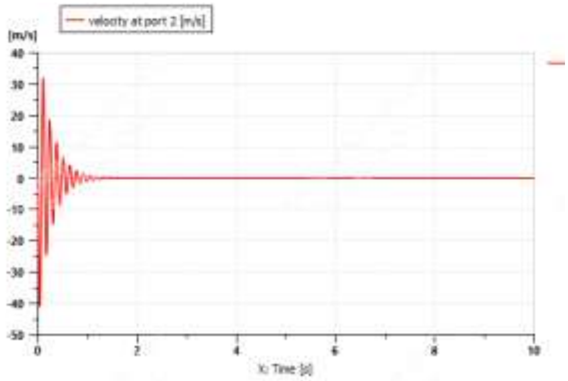

Figure 8. Damping Speed in Port 2

In the case of the spring it takes over both the forces acting from the top and those from the bottom, required by a force of 10^5 [N/m], figure 9.

Figure 9. Spring

The damping speed in port 1 of the spring from the values oscillating between +42 … -31 [m/s] decreases to the value 0 in 1.8 [s], figure 10. The displacement of the arc in port 1 from the maximum value of 1.42 [m] is stabilized in time of 1.8 [s], at the value of approximately 1 [m] figure 11.

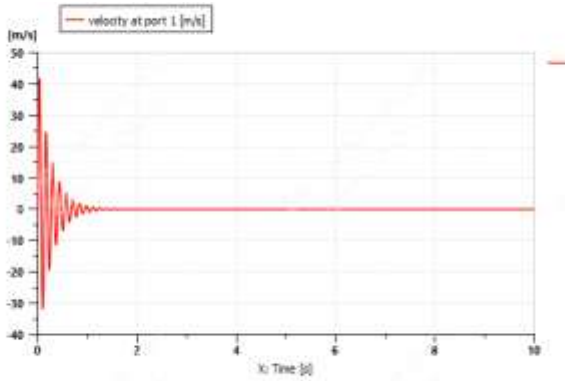

Figure 10. Damping Speed in Port 1

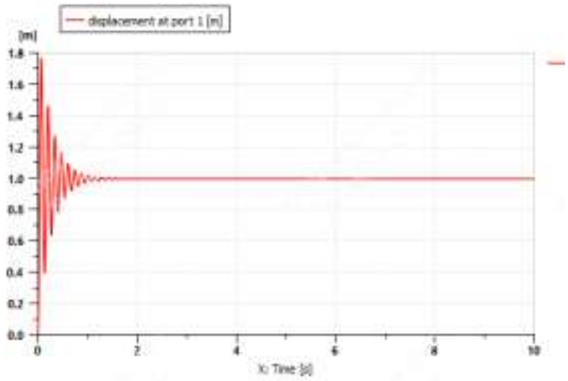

Figure 11. Moving the Spring in Port 1

The damping speed in port 2 of the spring from the values oscillating between +32 … -40 [m/s] decreases to the value approximately 0 in 1.8 [s], figure 12. The displacement of the arc in port 2 from the value of -1.43 [m] is stabilized in time of 2.5 [s] to the value of -0.95 [m], figure 13.

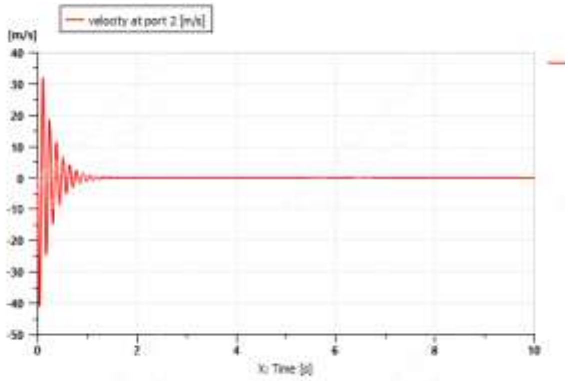

Figure 12. Damping Speed in Port 2

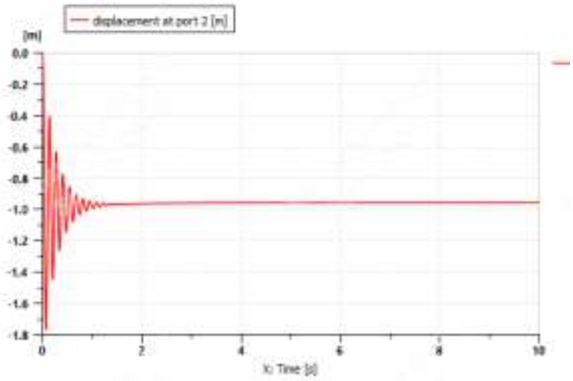

Figure 13. Moving the Spring in Port 2

The mass of the chassis acts on the damping system, an example given only for one of the four points of support of the vehicle. A mass of 60 [kg] per wheel is applied to it, figure 14.

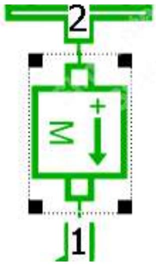

Figure 14. Mass Chassis

The drive speed in port 1 of the chassis mass is between the values + 32 … -41 [m/s] and stabilizes at the value of approximately 0 over 1.8 [s], figure 15. Figure 16 shows the graph of chassis mass displacement where, at start-up, we obtain the value of 1.43 [m/s] and stabilize at the value of approximately 1 [m/s] for 2 [s].

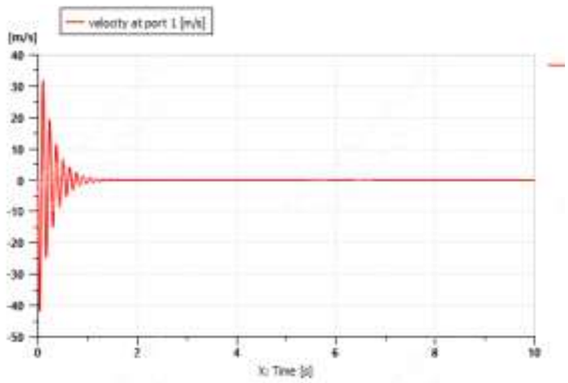

Figure 15. Damping Speed in Port 1

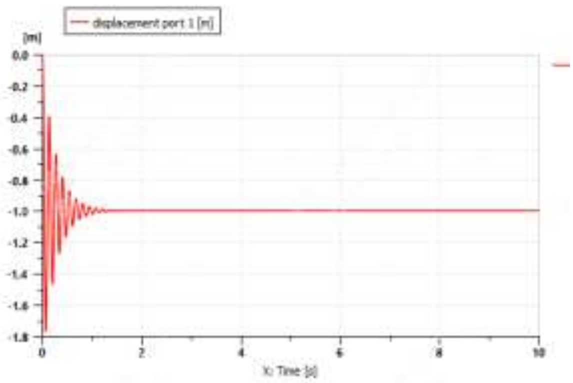

Figure 16. Displacement of the Chassis Mass in Port 1

The auxiliary damping elements of the vehicle are the wheel joints and the friction between their assembly elements, figure 17.

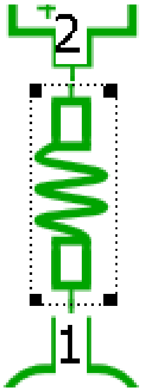

Figure 17. Auxiliary Damping Elements

Figure 18 shows the graph of the operating speed in port 2 which starts from the value 32 [m/s] and stabilizes at the value of approximately 0 over 1.8 [s]. Figure 19 shows the graph of the displacement of the damping auxiliaries in port 2 which starts from the maximum value of 1.43 [m] and stabilizes at the value 1 in 1.8 [s].

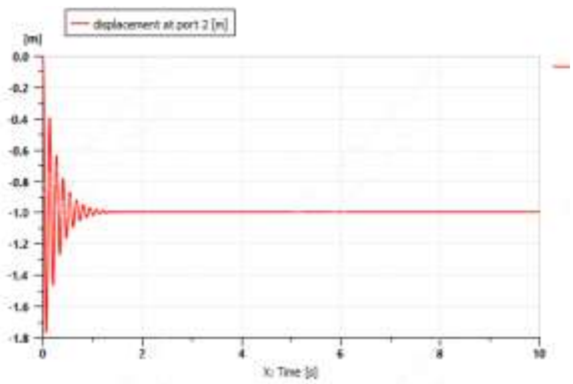

Figure 18. Damping Speed in Port 2

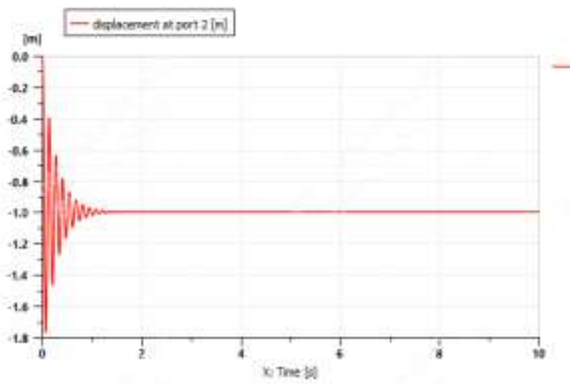

Figure 19. Movement of Auxiliary Elements in Port 2

3. Conclusions

This paper presents a way to simulate the operation of the car shock absorber by analyzing each component of the shock absorber from a kinematic and the suspension system of the vehicles, together with the other systems that are part of the vehicle, has always had a constant evolution both from a constructive and functional point of view. This research aims to analyze the linear mechanical suspension system made using the Simcenter Amesim Student simulation application. The tires also have an influence on the general damping system, which in this case was not taken into account.

As we have shown during the work, the car suspension system is responsible both for ensuring comfort in traffic, and especially in meeting the requirements for ensuring the maneuverability, stability and maneuverability of vehicles. We can say that if the car suspension system is completely decommissioned it leads to immobilization of the entire vehicle in the vast majority of cases.

We found that the damping speed of the suspended part is achieved faster than that of the unsuspended part after analyzing the two graphs of the damping speed of the body and chassis by about 0.3 [s] less.

4. Acknowledgement

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