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THE BEHAVIOR OF MECHANICAL MODEL WHEEL’ S LOADER

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ABSTRACT

In this work is described a dynamical model for the tire-suspension system of wheel loader. This model is based on the subdivision of the global dynamical system into its physical components: the tire, the wheel, and suspension. The numerical simulation results concerning a truck tire will be presented.

1.Introduction

This paper discusses the development of simplified dynamical model for the tire-suspension system of wheel loader. The dynamic behavior of tires is decisive to satisfy comfort, handling and stability requisites of machine ride.

The mechanical model is composed by the global dynamic parameters (inertia, stiffness and damping) of the system components (tire, wheel and suspension).

2. The mechanical model of tire

The mechanical model is two-dimensional (2-D) and considers only the global dynamics characteristics of the tire-suspension system, as shown in Figure 1.

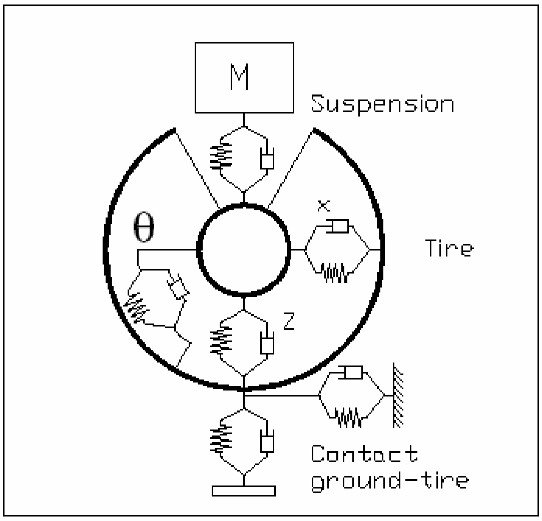

Figure 1. The tire-suspension model

This is a model with 3 degrees of freedom (the angular displacement “θ”, the horizontal displacement “x” and vertical displacement “z”). The wheel inertia plus half part of the tire inertia compose the external ring, and the other half of tire inertia composes the external ring inertia.

The tire stiffness and damping for the directions x, z and θ are globally represented.

The suspension, with 1/4 of vehicle mass, is connected to the internal ring (spring and damper).

Considering action dominated by the vertical behavior of the system, a simplified model from the previous model shown on Figure 2.

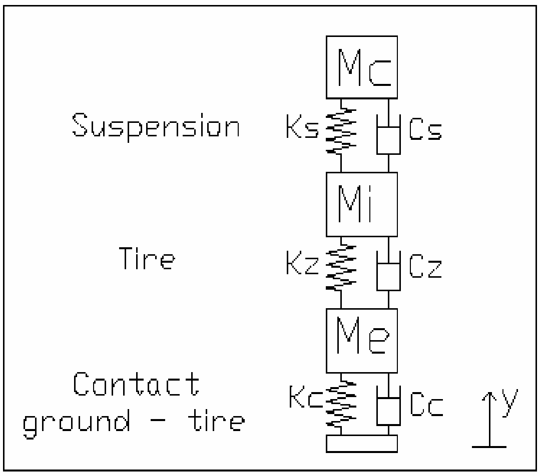

Figure 2. Simplification tire-suspension model

In this model M_c corresponds to L’ of loader mass, M_i is the mass of wheel added to half of the tire mass while M_e corresponds to half of tire mass.

The stiffness and damping coefficients K_s, C_s belong to suspension, K_z and C_z to tire and K_z and C_z to the tire-ground contact.
The parameter x_r represents the excitation of the system modeled through the road profile.
The system dynamic equations are:

$$[M]\cdot\{\ddot{x}\}+[C]\cdot\{\dot{x}\}+[K]\cdot\{x\}=\{F\} \qquad (1)$$

where:

$$[M]=\begin{bmatrix} M_c & 0 & 0 \\ 0 & M_i & 0 \\ 0 & 0 & M_e \end{bmatrix};$$

$$[C]=\begin{bmatrix} C_s & -C_s & 0 \\ -C_s & C_s+C_z & -C_z \\ 0 & -C_z & C_c+C_z \end{bmatrix};$$

$$[K]=\begin{bmatrix} K_s & -K_s & 0 \\ -K_s & K_s+K_z & -K_z \\ 0 & -K_z & K_c+K_z \end{bmatrix};$$

$$\{x\}=\begin{Bmatrix} x_v \\ x_w \\ x_t \end{Bmatrix}; \quad \{F\}=\begin{Bmatrix} 0 \\ 0 \\ K_c x_r + C_c \dot{x}_r \end{Bmatrix}.$$

where
x_v is the displacement of the mass M_c;
x_w is the displacement of the mass M_i;
x_t is the displacement of the mass M_e.

Table 1: Data for the mechanical model

Element	Parameters	Values
Ľ Vehicle	M_c	2 500 kg
Suspension	K_s	184 400 N/m
	C_s	464 N.s/m
Tire-wheel	M_e	73 kg
	M_i	33 kg
	K_z	90 540 N/m
	C_z	414 N.s/m
Contact	K_c	220 000 N/m
	C_c	200 N.s/m

The numerical data used in this work has been obtained either experimentally or through component catalogs (tabel 1). The values of tire stiffness and damping have been obtained by experimental tests on a truck tire of measure 295/80 R22.5”.

The same external excitation conditions have been used as input conditions representing the same road profile.
The excitations used are one step on the road, simulated by the impulse function, according to Figure 3. These excitation were modeled trying to simulate the real conditions of use.
The acceleration of the suspended mass (M_c) has been presented as the dynamical response.

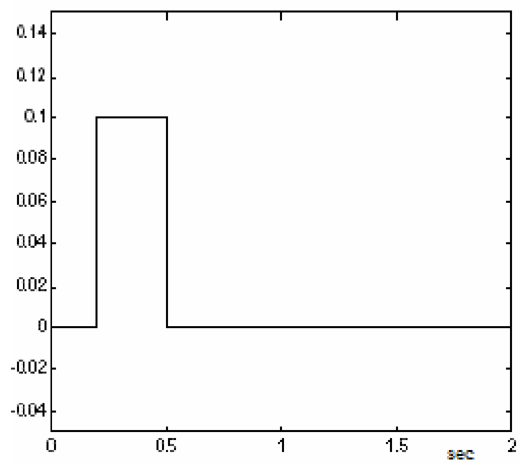

Figure 3. Excitation [m] is a step on the road

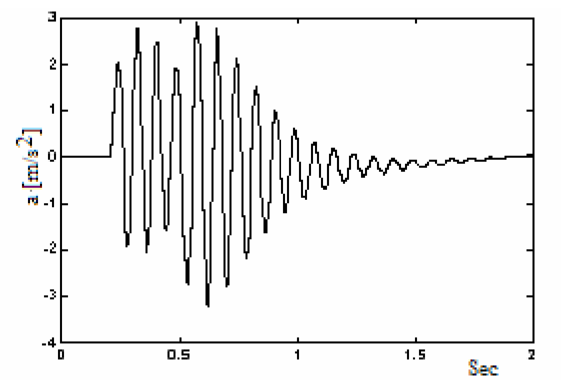

Figure 4. Acceleration of suspended mass for mechanical model of wheel loader

3. Conclusions

With this model it is possible also to accomplish an analysis of the components of the system (tire, suspension, and vehicle mass).
The results from the numerical simulations have shown that the results are compatible with the responses expected for real situations.

References

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