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Passive vibration control of a high-speed elevator system

ANGELO M. TUSSET[1*], MARCOS GONÇALVES[2], CALEQUELA J. T. MANUEL[3], JOSE M. BALTHAZAR[4], GIANE G. LENZI[5]

1. Federal University of Technology – Paraná (UTFPR) [0000-0003-3144-0407]
2. Federal University of Technology – Paraná (UTFPR) [0000-0003-1544-9356]
3. Federal University of Technology – Paraná (UTFPR) [0000-0002-8819-0667]
4. Federal University of Technology – Paraná (UTFPR) [0000-0002-9796-3609]
5. Federal University of Technology – Paraná (UTFPR) [0000-0003-2065-9622]

Abstract: This paper, the horizontal nonlinear response of a 4 degree-of-freedom vertical transport model excited by rail-guide deformations, and with a nonlinear dynamic vibration absolver (DVA) is numerically investigated. To analyse the vibration levels and comfort of passengers, and the efficiency of using a DVA to reduce cabin vibrations, numerical simulations are performed considering lateral displacement of the cabin, an external disturbance that represents the deformations and misalignment of the rails-guide and the increase in the speed of the elevator, associating the levels of lateral accelerations of the elevator with the levels of comfort felt by passengers in accordance with ISO 2631 and BS 6841. The results of numerical simulations shown that the configuration of the appropriate parameters of the DVA is essential to ensure a better level of comfort to passengers, and that the increase in speed associated with the use of DVA can improve the level of comfort reducing accelerations in the cabin.

Keywords: vertical transport, nonlinear dynamics, dynamic vibration absolver.

1. Introduction

Figure 1 shows an equivalent physical model to represent the horizontal motions of an elevator system, including a nonlinear dynamic vibration absolver (DVA) in cabin.

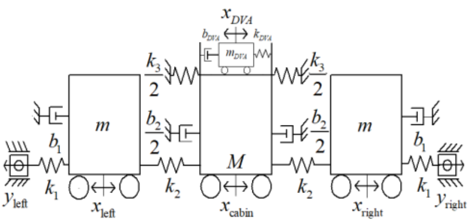

Fig. 1. Motion equivalent model for the horizontal of the elevator

The equations of motion can be obtained considering formula Lagrange and described with differential equations system as follows:

$$
\begin{cases}
m\ddot{x}_{left} + b_1\dot{x}_{left} + (k_1 + k_2)x_{left} - k_2 x_{cabin} = k_1 y_{left} \\
\left(M + m_{DVA}\right)\ddot{x}_{cabin} + b_2\dot{x}_{cabin} + 2k_2 c x_{cabin} + k_3 x_{cabin}^3 - k_2 x_{left} - k_2 x_{right} + \\
+ b_{DVA}(\dot{x}_{cabin} - \dot{x}_{DVA}) + k_{DVA}(x_{cabin} - x_{DVA})^3 = 0 \\
m_{DVA}x_{DVA} - b_{DVA}(\dot{x}_{cabin} - \dot{x}_{DVA}) - k_{DVA}(x_{cabin} - x_{DVA})^3 = 0 \\
m\ddot{x}_{right} + b_1\dot{x}_{right} + (k_1 + k_2)x_{right} - k_2 x_{cabin} = k_1 y_{right}
\end{cases}
\tag{1}
$$

2. Results and Discussion

Figure 1 shows the compensated acceleration (a_w), and estimated vibration dose value (eVDV), considering the parameters: M=1120(kg), m=17.5(kg); m_{DVA}=20 (kg), k_1=250000(N/m); k_2=19027(N/m); k_3=6.(10[15]) (N/m), b_1=668.21(N.s/m); b_2=2058.2(N.s/m); k_{DVA}=10000 (N/m), $b_{DVA}=k_{DVA}/2$(N.s/m), ω=31.419 (rad/s) and $y_{right} = y_{left} = 0.1\sin(\omega t)$ [1-2].

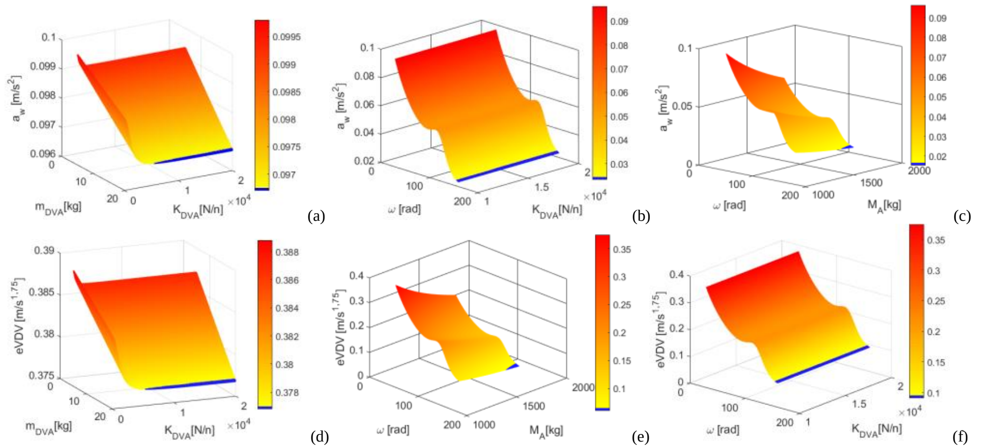

Fig. 1. (a, c) a_w and eVDV for (m_{DVA}=[5:20] and k_{DVA}=[50:20000]). (b, d) a_w and eVDV for (ω=[30:160] and k_{DVA}=[50:20000])). (b, d) a_w and eVDV for (ω=[30:160] and M=M_A=[1120:1720]) .

3. Final Considerations

The results shown that the absorber mass (m_{DVA}) is the most relevant variable in the control, and with its use passenger comfort can be improved in design of the elevator vibration control.

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