DSTA 2021 dys-ta.com
16th INTERNATIONAL CONFERENCE
Dynamical Systems – Theory and Applications
December 6-9, 2021, On-line

Discussion on the influence of the inductance in the nonlinear dynamics of DC motors in coupled systems

R.H. AVANÇO[1*], D. A. ZANELLA[2] , R. DE JESUS A. CANTILLO[3], A. CUNHA JR.[4]
J. M.BALTHAZAR[5] , A. M.TUSSET [6]

[1] Universidade Federal do Maranhão , Balsas, MA, Brazil [0000-0003-2276-0230]
[2] Universidade Federal do Maranhão , Balsas, MA, Brazil [0000-0001-9613-5900]
[3] Universidade Federal do Maranhão, Balsas, MA, Brazil [0000-0001-5052-8389]
[4] UERJ – Rio de Janeiro State University, RJ, Brazil [0000-0002-8342-0363]
[5] UNESP: São Paulo State University at Bauru, Bauru, SP, Brazil [0000-0002-6082-4832]
[6] Universidade Tecnológica Federal do Paraná-Campus Ponta Grossa, Paraná, Brazil, [0000-0003-3144-0407]
* Presenting Author

Abstract: The main goal of this paper is to analyse the influence of the inductance in electromechanical systems. Specifically, a DC motor coupled to a mass horizontally moved by a yoke scotch mechanism. Recent articles claim that the inductance could not be neglected based in electric constant and mechanical constant of the motor. Although many parameters are involved, this analysis intend to demonstrate that the main reason for the relevance of the inductance is the presence of high external load varying in time. The results of torque, electric current and speed of the motor indicates the relevance of the inductance when the mass is high, and the motor has its speed diminished. In conclusion, the inductance will have a greater influence when the motor operates in lower speeds with variable loads. The reason for that is the speed has a minor relevance in the electric equation when the motor is slow, therefore the importance of inductance increases.

Keywords: DC motor, inductance, electromechanical systems, nonideal systems

1. Introduction

The system analysed is a DC motor represented in blue in Fig.1a, coupled to a mass horizontally moved through a scotch yoke. The mass is moved without friction in the wheels or in the pin linked to the DC motor. Note that in [1,2] neglecting the inductance in DC motor causes high differences in the results of the torque and speed, it was studied a problem with varying parameters like the voltage set on DC motor and the distance of the pin to the centre of the motor, while the present paper focus on the mass vibrated because we consider it is the more relevant for the results. Therefore, the present analysis is an expansion in data and in comprehension of the previous study considering the same mechanism with the same parameters. In reference [3] there was a pendulum horizontally excited by a DC motor. In this last, to neglect the inductance was not a problem for the accuracy of results. The reason for that is the size of mass is relatively smaller. All this discussion brings back the idea of the nonideal excitation well discussed in [4].

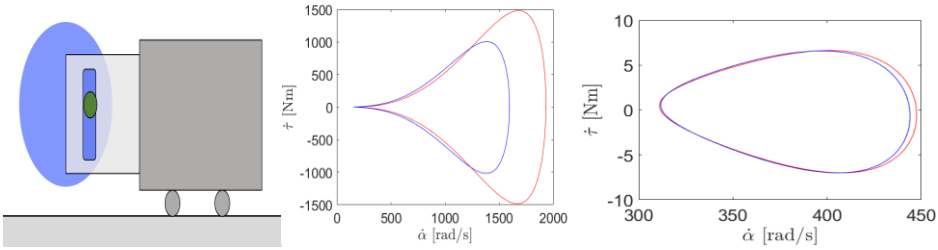
2. Numerical Results and Discussion

The governing equations of motion are:

$$l\dot{c} + rc + k_e\dot{\alpha} = v \quad (1)$$

$$j_m\ddot{\alpha} + b_m\dot{\alpha} - k_e c = -\tau \quad (2)$$

The term $\boldsymbol{l}$ stand for the inductance, **r** the resistance, **c** the electric current, $\boldsymbol{k_e}$ the electric constant, $\dot{\boldsymbol{\alpha}}$ the motor speed, **v** the voltage set, j_m the moment of inertia of the motor, b_m the damping coefficient, $\boldsymbol{\tau}$ is the torque over the motor caused by the mass. The results were found integrating with the Runge-Kutta 4th order and timestep 10^{-6} second, using total time for integration equal to 10 seconds, but only last 10% pointed were plotted. The results in Fig.1b and Fig.1c are the torque of the mass caused on the motor versus the motor speed. The graphics in red represent the model considering the electric inductance on the mechanism. The graphics in blue represent the model which neglects the electric inductance. Comparing the Fig.1(b) and Fig.1(c), it is possible to state that the different models diverge when the masses are high, and the models converge when the mass is small.



(a) (b) (c)

Fig. 1 a) The scotch yoke mechanism with the DC motor and the mass. (Elaborated by the authors) . Results of Torque versus angular speed for b) m=5kg c) m=0.05kg

3. Concluding Remarks

The current results led to conclude that the inductance may be neglected in some conditions. These conditions include mainly to observe how the angular speed in DC motor evolve during time. When the speed approaches to zero or when it has a high fluctuation, you are probably facing a situation where the inductance cannot be ignored. On the other hand, always to consider the inductance may result in more problems for compute the equations. A stiff equation may require a timestep smaller than the computer offers or just more time consume to complete the calculus. Therefore, ignore the inductance may be useful in some conditions, but in others may change considerably the results.

References

[1] Lima, R., Sampaio, R., Hagedorn, P. *et al.* Comments on the paper "On nonlinear dynamics behavior of an electro-mechanical pendulum excited by a nonideal motor and a chaos control taking into account parametric errors" published in this journal. *J Braz. Soc. Mech. Sci. Eng.* **41,** 552 (2019

[2] LIMA, R., SAMPAIO, R., HAGEDORN, P. One alone makes no coupling. In Mecanica Computacional Vol xxxvi . Pags 931-944. Noviembre 2018.

[3] Avanço, R.H., Tusset, A.M., Balthazar, J.M. , A.Nabarrete, H. A. Navarro . On nonlinear dynamics behavior of an electro-mechanical pendulum excited by a nonideal motor and a chaos control taking into account parametric errors. *J Braz. Soc. Mech. Sci. Eng.* **40,** 23 (2018).

[4] Cveticanin L., Miodrag Zukovic, Jose Manoel Balthazar. Dynamics of Mechanical Systems with Non-Ideal Excitation. ISBN: 978-3-319-54168-6**. (**2018).