COMPUTATIONAL MECHANICS 2021
36th conference with international participation
Srní
November 8 - 10, 2021

Experimental based tuning of active absorber

K. Kraus[a], Z. Šika[a]

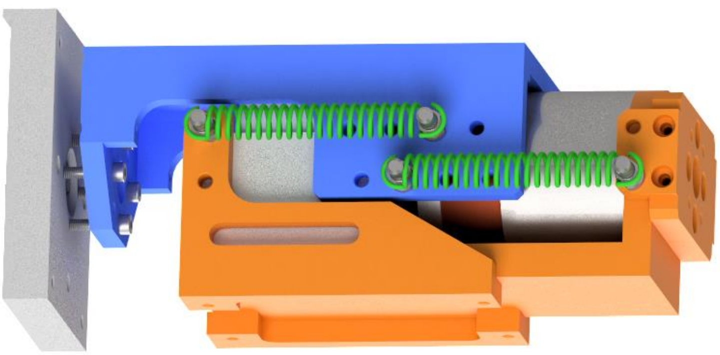
[a] *Department of Mechanics, Biomechanics and Mechatronics, Faculty of Mechanical Engineering, Czech Technical University in Prague Technická 4, Praha 6, 160 00 Prague, Czech Republic*

Vibration suppression takes place in many applications and enviroments. In various cases, for example in robotics and industrial enviroment [3], it might be convenient to use absorbers [1] to suppress vibrations of the main structure. Based on application, mass-spring absorber is attached to main structure in point of interest, tuned and actively driven if needed. In order to be able to actively tune and control absorber, some sort of sensors needs to be implemented in the main structure or in the absorber itself, such as accelerometers, encoders, geophones, etc. Depending on absorbers count and the nature of vibrations, various algorithms can be used to drive absorber's actuators, such as PID regulation, H-inf, LQR [4], Delayed resonator [2], etc. Nevertheless, besides mass and stiffness of the absorber, due to many kinds of bearings, usually some sort of damping takes place in the absorber. Lots of real cases of beraing damping are far from linear and thus burdens control algorithms. In this paper we are experimentally tuning real active absorber to be as much undamped (ideal) as possible, so it can be further controlled by superior algorithm.

An assembly MGV52 (Fig. 1a) is being used as actuated mass. It consists of AVM60-25 voice-coil actuator, linear ball bearing and built-in encoder. It has been further equipped with additional parts an external springs in order to get linear absorber with preloaded springs (Fig. 1b). dSpace computer is then used to read sensors and control voice-coil actuator through motor driver (Fig. 2a).

First of all, rough identification must take place in order to get basics characteristics, such as precise mass, stiffness and drive coefficient. Since this identification is based on measurement data from the control pc, ceratin delay of the loop between output and input of the pc (Fig. 2a) is also included among these characteristics. After that it is possible to more closely identify the damping function.

a) actuated mass with linear bearing

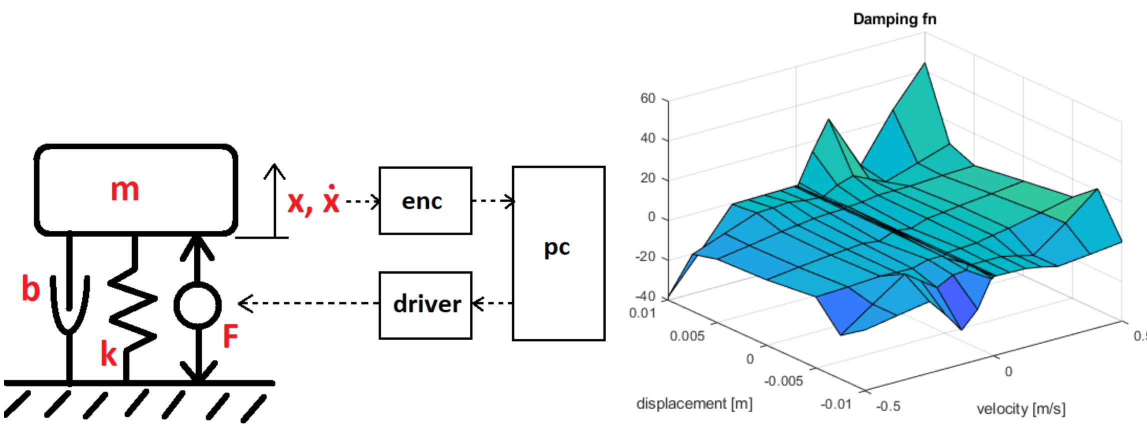


b) mass-spring configuration

Fig. 1. Absorber design based on MGV52 assembly

Ordinary linear function (viscous damping) with Coulomb damping has been set as starting point. More and more non-linear functions has been added to identify its coefficients. In the end, this assembled function has been replaced with 1-D look-up table, ie. with discrete line with tunable points. Due to Coulomb characteristics included, parameter-points are more dense when close to zero speeds. Such a configuration is far better than linear model, but generally not satisfying enough.

Since voice-coil has been chosen as an active absorber's actuator for various advantageous reasons, there are more damping sources apart from bearings. Firstly, its closed-end design with one millimeter wide gap does not allow air to flow effortlessly in and out. Secondly, and more relevantely, electrical characteristic of magnet-coil coupling greatly depends on the mutual position. Therefore, parametrical 1-D look-up table must be at least 2-dimensional. Fig. 2b shows one of more precise idendifications of damping as a function of both, displacement and velocity of the absorber. It consists of more or less conventional coulomb-viscous area in low speeds and strokes, as well as of great fluctuations (with some sense of symetry) in areas of high strokes. This parametrical plane, when put into positive feedback, is then able to reduce relative damping of the absorber and retain its stability at the same time. Such an active system is then possible to be externaly excited as well as put it stop.



a) Control scheme b) Damping function included in algorithm

Fig. 2. Absorber control algorithm

Acknowledgements

The work has been supported by the Czech Science Foundation project GA21-00871S "Active non-collocated vibration absorption for robots and mechanical structures".

References

[1] Kraus, K., Šika, Z., Beneš, P., Krivošej, J., Vyhlídal, T., Mechatronic robot arm with active vibration absorbers, Journal of Vibration and Control 26 (13-14) (2020) 1145-1156.

[2] Olgac, N., Elmali, H., Hosek, M., Renzulli, M., Active vibration control of distributed systems using delayed resonator with acceleration feedback, The Journal of Dynamic Systems, Measurement, and Control 119 (3) (1997) 380-389.

[3] Olsson, T., Haage, M., Kihlman H., "Cost-efficient drilling using industrial robots with high-bandwidth force feedback," Robotics and Computer-Integrating Manufacturing 26 (1) (2010) 24-38.

[4] Šika, Z., Kraus, K., Beneš, P., Vyhlídal, T., Valášek, M., Active multidimensional vibration absorbers for light robots, Proceedings of the 5th Joint International Conference on Multibody System Dynamics, Lisbon, Portugal, 2018, pp. 1-12.