LODZ UNIVERSITY OF TECHNOLOGY

EDUCATION, RESEARCH, INNOVATION

NOVEL TMD WITH INERTER

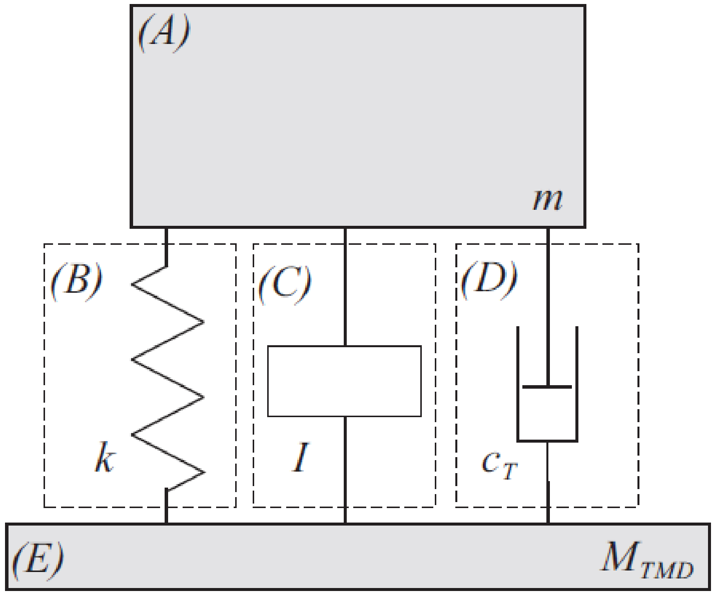
The tuned mass dampers (TMDs) are widely used to absorb energy from mechanical and structural systems. In the case of structural systems, TMDs usually have large masses. To minimize the mass of TMD, we can add an inerter that acts as an artificial inertance in the system and helps to improve the mitigation of vibrations. Ineter also allows to vary the frequency of the TMD, so that the working regime would be much wider. We achieved such a property by adding an inerter with stepless variable inertance to the tuned mass damper.

Ability to vary the natural frequency

Natural frequency of the TMD is given by the following formula:

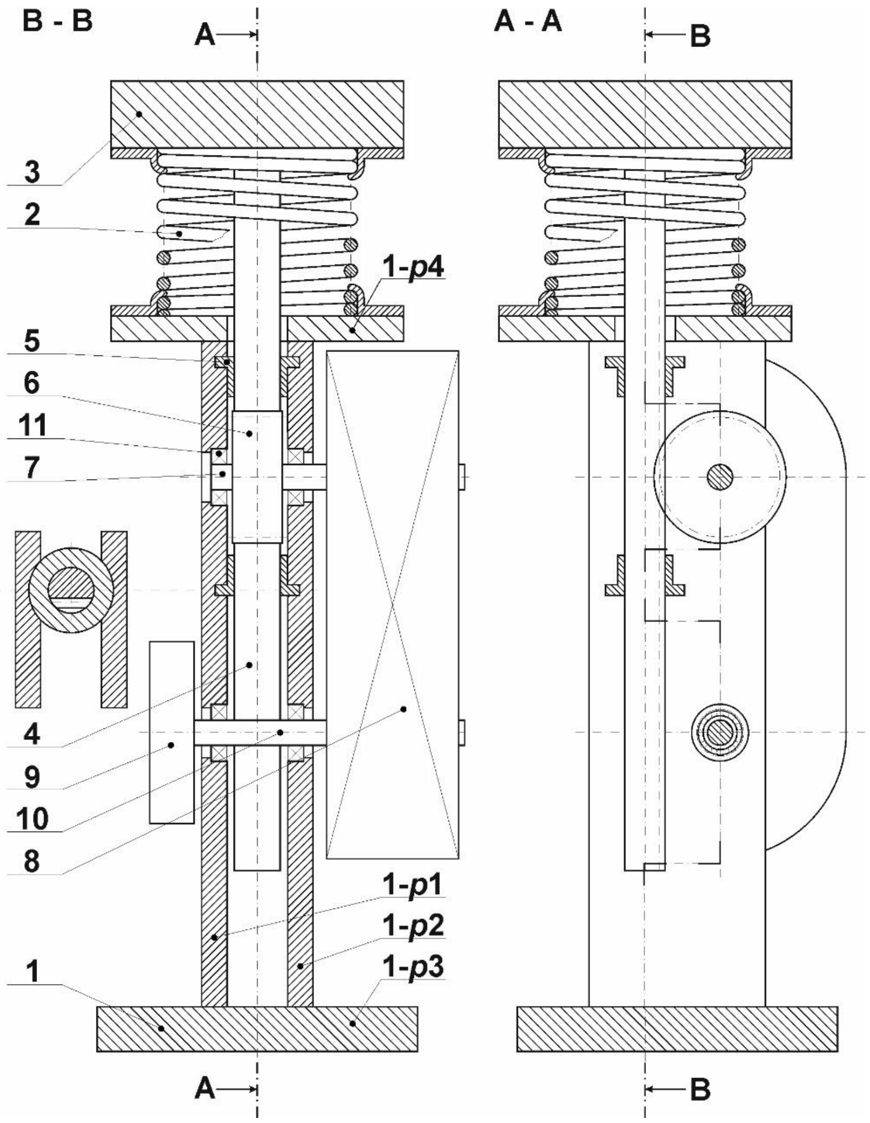
$$\omega(m, k, I) = \sqrt{\frac{k}{m + I}}$$

The change of inertance I allows us to tune the natural frequency of the TMD to the frequency of the excitation.

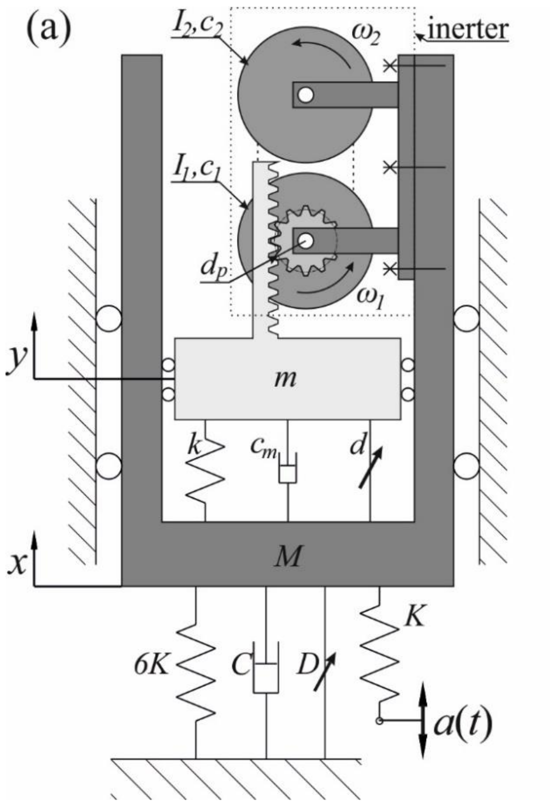


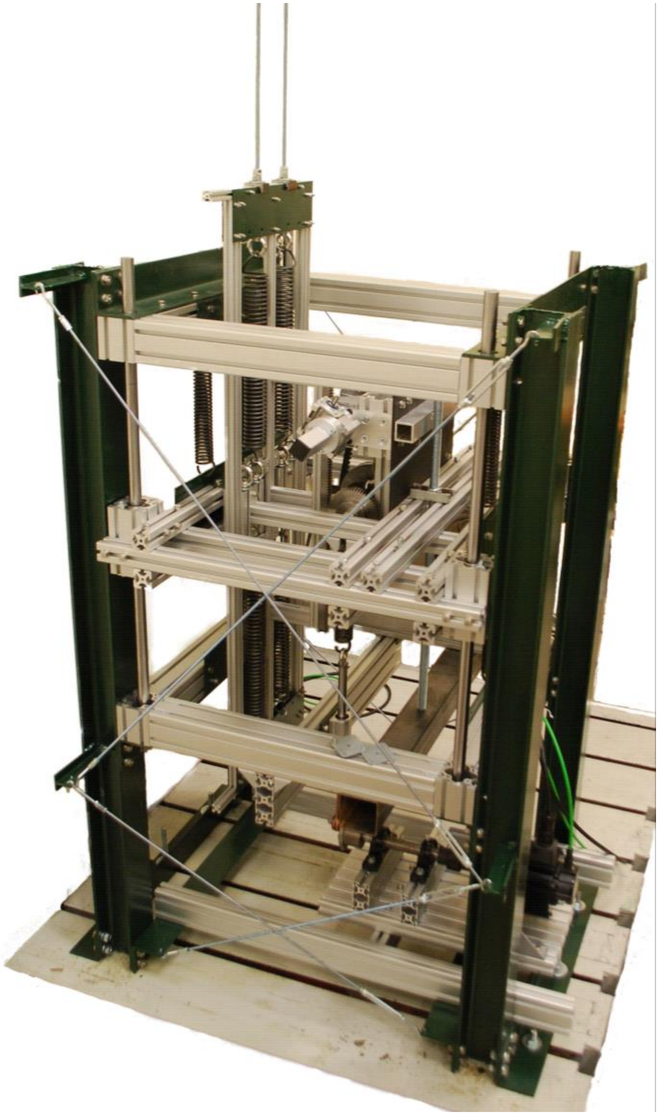
The model of the device consist of: inertial component (A) that is coupled via elastic link (B), inerter (C), and dash-pot (D) to support (E) that allows fixing the device to the damped structure.

The body of the device (1) is constructed as a combination of the two paralel, vertical plates - namely plate (1-p1) and (1-p2) and integrated with two smaller paralel, horizontal plates: (1-p3) and (1-p4). Lower horizontal plate (1-p3) is used to mount the device on a structure that vibrations we want to mitigate. The upper horizontal plate (1-p4) has a handle that is used to mount spring (2). The other end of the spring (2) is anchored to plate (3). This plate (3) is connected to gear rack (4) guided in two sliding supports (5) that are mounted in vertical body plates. Thanks to that, massive plate (3) together with gear rack (4) can move in direction of the axis of the device and function as a moving element of TMD. Gear rack (4) cooperates with toothed gear (6) that is affixed on the drive shaft (7) of CVT (8). Flywheel (9) that accumulates energy is mounted on the driven shaft (10) of the CVT. Bearings (11) of both transmission shafts are mounted in vertical body plates.

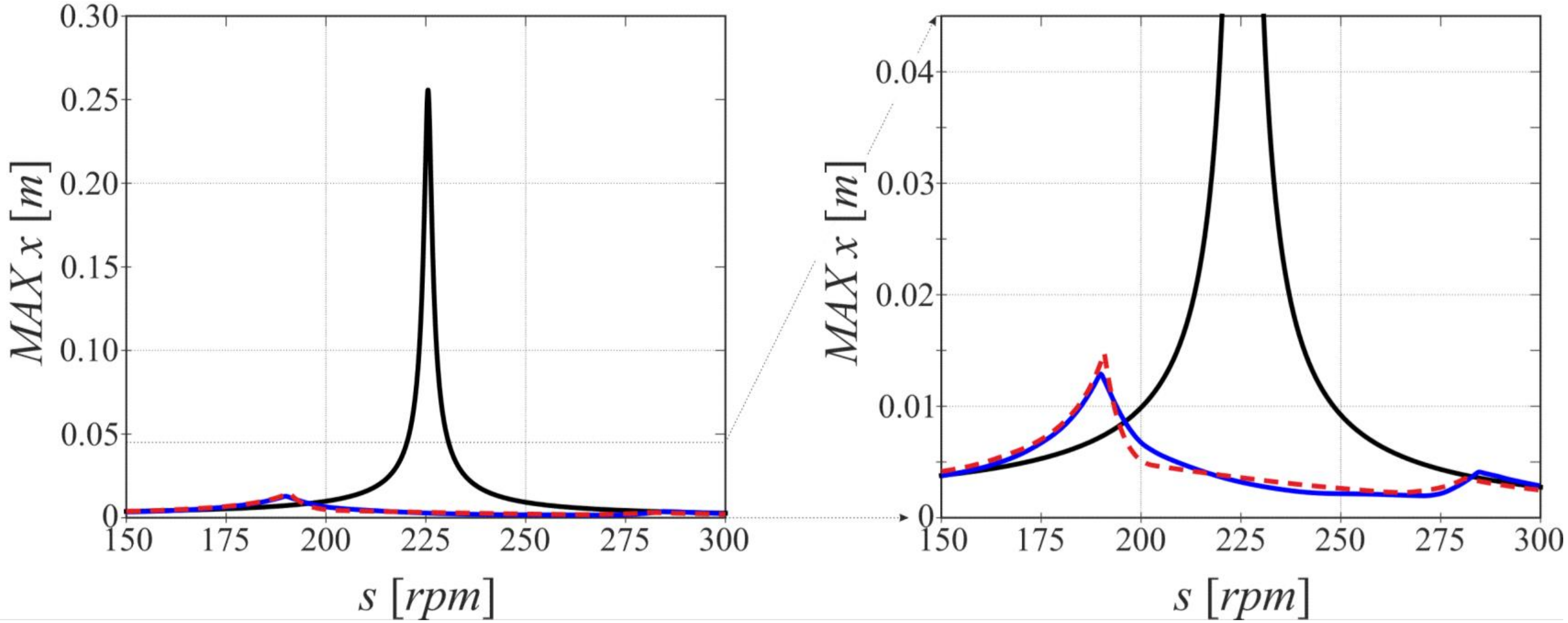


Experimental rig and its model





Main result



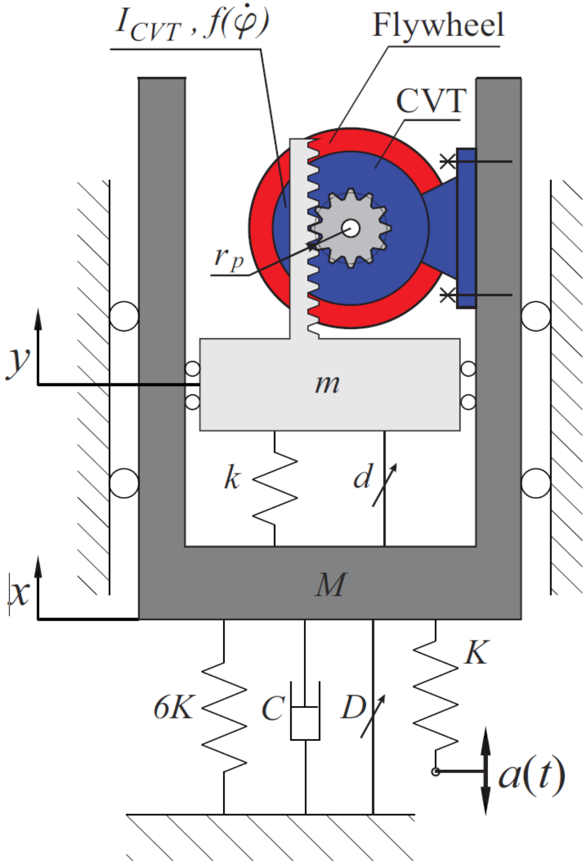
Frequency response curves (maximum amplitude (*MAX x*) of the main system versus frequency of the excitation (*s*)) present the overall damping efficiency of the TMD. The black line presents a numerical simulation of the response of the system without TMD; the red dashed line shows the experimental, and the blue line presents the numerical simulation of the response of the system with TMD. The TMD reduces the amplitude in a wide range of excitation frequencies.

Other analyzed models

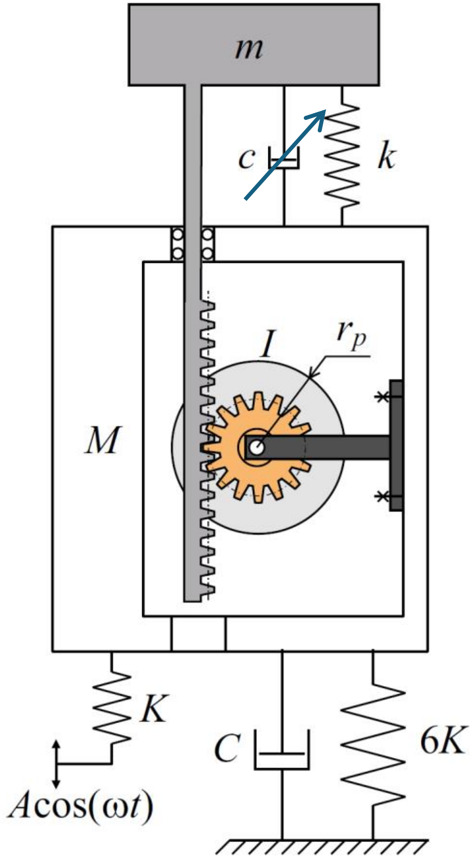
(a) Tuned mass damper with variator

(b) Tuned mass damper with adaptive dashpot

(a)



(b)



Projects

[1] Project Iuventus Plus Ministry of Science and Higher Education of Poland, IP2014 035273, Tuned mass damper with inerter which enables changes of inertance (2015 – 2017). PI: Przemysław Perlikowski

[2] Project OPUS, National Science Centre, 2015/17/B/ST8/03325, Mitigation of vibrations by tuned mass damper with inerter and non-linear damper (2016 – 2021). PI: Przemysław Perlikowski

Main papers

[1] P. Brzeski, T. Kapitaniak, P. Perlikowski, Journal of Sound and Vibration 349, 56-66 (2015).

[2] P. Brzeski, M. Lazarek, P. Perlikowski, Journal of Sound and Vibration 404, 47-57 (2017).

[3] M. Lazarek, P. Brzeski, P. Perlikowski, Mechanism and Machine Theory 119, 161-173 (2018)

[4] M. Lazarek, P. Brzeski, P. Perlikowski, International Journal of Mechanical Sciences 231, 107487 (2022)

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