INSTITUTE OF FUNDAMENTAL TECHNOLOGICAL RESEARCH
AND COMMITTEE ON MECHANICS
POLISH ACADEMY OF SCIENCES

7th European Conference on Structural Control

Book of Abstracts and Selected Papers

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WARSAW 2022

EXPERIMENTAL VERIFICATION OF THE KINEMATIC CONTROL FOR PNEUMATIC IMPACT ABSORBER

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1. Scope of investigations

The subject of this contribution is a pneumatic absorber developed for protection of mechanical systems under impact excitation. The absence of oil evaporation as well as the reduction of environmental pollution makes dry pneumatic systems attractive in selected industrial applications [1] [2]. Therefore their development may occur to be advantageous.

The presented results concern the method of braking objects that are initially in motion. Investigated technique of bringing to stop the body of mass M involves the use of pneumatic cylinder equipped with piezoelectric valve (fig. 1). The purpose of the valve application is to enable control of the flow from the space being contracted with the piston movement inside the sleeve to the expanded space. This flow is regulated to minimize top value of the reaction force.

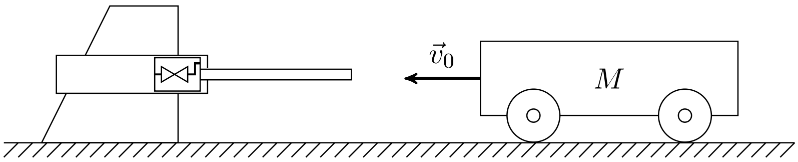

Figure 1: Mode of operation of the pneumatic cylinder applied as a bumper

Presented results cover both the theoretical investigations and the laboratory verification of the impact energy dissipation with adaptation to different values of the impact parameters.

2. Dynamic-based and kinematic-based adaptation to the impact

Control of the absorber may by performed in two ways [4] [3]:

- estimation of the initial kinetic energy of moving body and maintaining the adequate force vs distance travelled dependency,
- estimation of the velocity of moving body and maintaining the adequate deceleration.

Both these methods are based on the demand of utilization the whole admissible piston stroke. In order to make them resistant to unexpected perturbations during the braking process, real-time measurements of the system kinematics and relevant force control are required.

The presented work is focused on the latter method – fully kinematic problem.

3. Control method

The data including the object velocity v and the remaining distance x_{rem} of the piston inside the sleeve is sufficient to compute the required object deceleration: $|\ddot{x}_{req}| = \frac{v^2}{2x_{rem}}$. This value is compared with the measured deceleration and the controller opens or closes the valve – dependently on the result of this comparison. Here no assumptions about the friction or contact element rheological properties are required because the controller does not use the model of the system. The main assumption taken, both in the numerical simulation and in the controller-implemented algorithm, is the absence of mechanical shock effects at the very first period of collision. During system modelling any vibrations are neglected while in the real system the data supplied to the controller was filtered.

4. Configuration of the set-up and the main results

The method of adaptive impact energy dissipation with the use of the controllable pneumatic absorber was investigated on drop test stand (fig. 2). In each experiment the carriage supported on vertical linear guide system was dropped and braked by the absorber attached to it. Tests were executed by various drop heights and carriage masses. Also remaining distance x_{rem} in the controller-implemented algorithm was modified. The

Figure 2: Experimental set-up

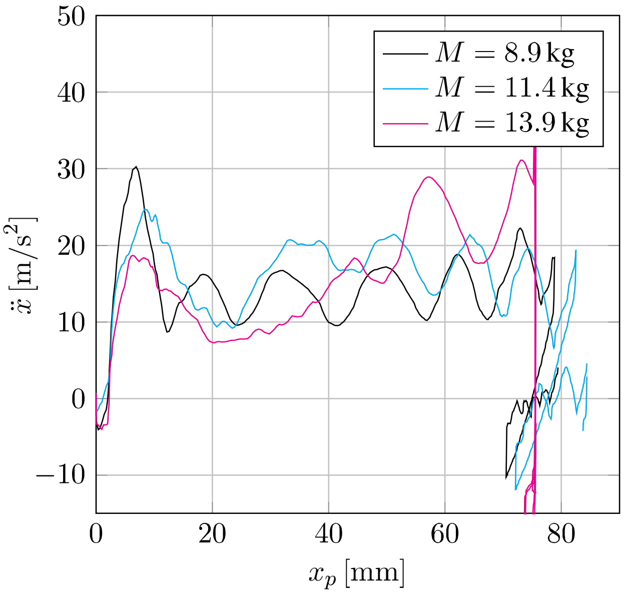

Figure 3: Exemplary dependencies of carriage deceleration vs piston displacement

exemplary results of deceleration control are depicted in fig. 3. In these cases the carriage was equipped with various weights; drop height was equal to 150 mm. The oscillations around the desired deceleration value visible on each plot are the result of compliance of the contact element and delays in the valve response to the digital control: each rising slope responds to the force increase caused by gas compression with piston movement inside the sleeve. During experimental series was stated the absorber robustness to variability of rubber or foam separator placed between coliding elements.

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Acknowledgments This work was financially supported by the National Centre for Research and Development (NCBiR) under the grant agreement LIDER/13/0063/L-10/18/NCBR/2019. The authors gratefully acknowledge the support of the National Science Centre, Poland, granted under agreements 2017/25/B/ST8/01800 and 2018/31/D/ST8/03178.