

## IMPACT PROCESS IDENTIFICATION FOR IMPACT CYLINDER PISTON

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**Abstract:** The phenomenon of the tool rebound from the object processed, that can be noticed particularly in the case of impact marking, has a negative influence on the quality of the processing of moving objects, which is a result of the blur effect caused by the shift of the object processed at the time of its retraction. The objective of the study was to determine the influence of both the capacity of the chamber of the accumulator and the working pressure on the characteristics of the phenomenon of the piston rebound from the obstacle that can be noticed after it hits a hard fender for the very first time. The article presents the results of research consisting in the analysis of the rebound phenomenon for impact cylinder pistons. The tests were carried out for cylinders whose structure allowed for the change in the capacity of the accumulator chamber. Cylinders with the pistons of 40 and 100 mm in diameter and supplied by 4 and 6 bar pressure were subject to tests that were undertaken at the test stand equipped with Phantom V310 high speed digital camera

**Key words:** Impact Cylinder, High Speed Camera, Marking, Bounce, Kinetic Energy

### 1. INTRODUCTION

Impact cylinders are a kind of pneumatic actuators characterised by the speed of the movement of the piston several times higher than the one of typical actuators, which depending on the structure, can even reach the speed greater than 10 m/s. Sudden acceleration is caused by the differential surface system, as a result of which the entire surface of the piston is subject to the influence of the pressure of the air stored in the container, known as an accumulator, located at the back of the cylinder.

High working velocities of the piston allow for the application of impact cylinders as a drive system ensuring high level of kinetic energy. A relation between the energy and the mass as well as the dimensions of the drive constitutes a significant advantage of the device. The application of the pneumatic drive system greatly increases the resistance of the kinematic system to overload taking place at the time of the impact. These features allow for the application of high speed actuators in situations when the piston's force is of percussive character. The main areas of technological application include marking, perforation and the production of light pressed products (Lenczewski and Łunarski, 1999; 2000, 2011; Mikulczyński and Kiczowski, 1999).

Because of the application of the gaseous working medium, the collision of the piston with the obstacle is characterized by a high restitution coefficient. As a result of the collision, uncontrolled rebound of the piston from the object and its pneumatically enforced return to the object's surface take place. These are caused by the influence of the pressure of the air stored in the chamber of the cylinder (Liu and Jiang, 2007). The second time the piston hits the object ends with a dynamic finisher.

This phenomenon badly influences the quality of edges created at the time of marking or pressing. The intensity of disturbances increases in the case of operations performed on a fast moving object. As a result of a constant movement of the object, the area of the second impact of the piston does not agree with

the first one and thus the edges of the initially created cavity are damaged and blurred. In order to estimate the parameters of the technological process of quick marking, it is necessary to determine the real time of the impact of the head with the processed surface.

Current studies concerning the determination of energy parameters of cylinders allowed the characteristics of the piston stroke to be recorded with the use of laser triangulation method (Czajka and Giesko, 2008). The resolution of the method, however, did not allow for the recording of the brief collision of the tool with the obstacle. Simulation tests for high speed cylinders were predominantly directed at the development of a mathematical model enabling the optimization of process parameters and the selection of a proper tool (Kiczowski and Grymek, 2000). The application of high speed digital cameras enabled the movement of the piston to be recorded with high resolution which allowed for exact identification and analysis of the collision process (Zbrowski and Jóźwik, 2012a, b). The application of high speed vision techniques resulted in the increase in sampling frequency up to 6 kHz.

### 2. PRESENTATION OF THE PROBLEM

Tests carried out with view of determining the movement characteristics for impact cylinders indicated that after the collision of the piston with the obstacle a rebound of the piston connected with a dynamic finisher and a stop could be noticed.

In the case of some applications, the rebound of the piston is pretty disadvantageous as repeated uncontrolled strikes of the piston may worsen the quality of the geometry or the structure of the processed surface. A blur effect caused by the shift of the processed object can be observed for the processing of fast moving objects (Fig. 1).

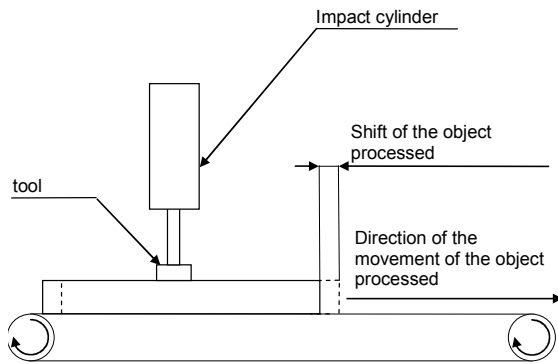


Fig. 1. Blur effect caused by the rebound

The characteristics of the movement of the piston (Fig. 2) depict the rebound effect in which after the collision of the piston with the fender, an oscillatory change in the direction of the movement can be noticed.

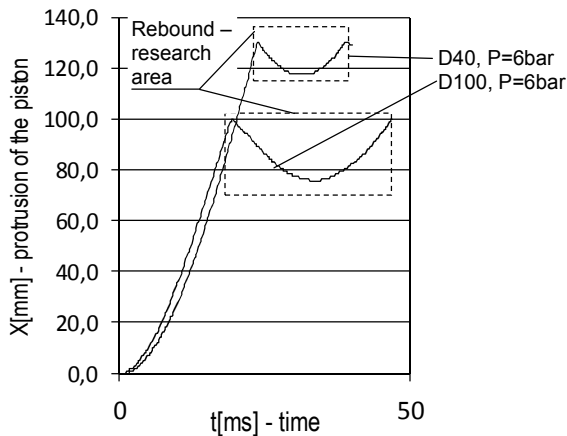


Fig. 2. Characteristics of the moment of the piston in the time function

The objective of the tests conducted was to determine the influence of the capacity of the chamber of the accumulator and the working pressure on the characteristics of the rebound of the piston from the processed surface after the first strike.

### 3. RESEARCH METHOD AND TEST STAND

The measurements were carried out on the test stand intended particularly for impact cylinder tests (Giesko et al., 2007; Czajka et al., 2008; Giesko and Zbrowski, 2008) that was modified in a way enabling the observation of the phenomenon (Fig. 3). The movement of the cylinder was impeded by a 25 mm thick steel plate that was used as a hard fender, which was located 130 mm away from the head of the piston of the D40 cylinder and 100 mm from the head of the piston of the D100 cylinder.

A high speed Phantom V 310 camera by Vision Research and halogen lighting were used (Fig. 3). The tests were carried out for actuators equipped with a regulation screw enabling the regulation of the volume of the chamber of the accumulator. The cylinders that were under investigation had piston of 40 and 100 mm in diameter and they were supplied by the air of 4 and 6 bars.

The measurement system was calibrated with the use of the pattern length located behind the piston, parallel to the direction

of its movement. The parameters of the camera and the lighting system used allowed the phenomenon to be recorded at the speed of 6000 fps, resolution of 800x600 pixels and the exposure time of 0.1 ms.

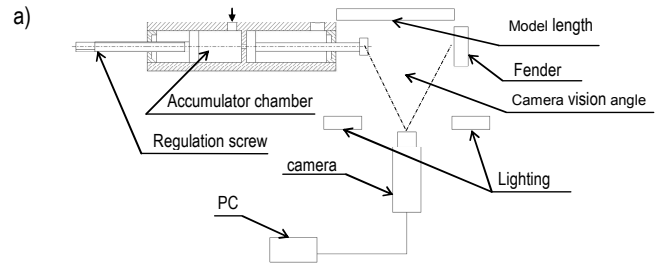


Fig. 3. Measurement stand: a) draft, b) view

### 4. TESTS RESULTS

Characteristics of the movement of the piston were determined with the use of TEMA MOTION commercial software intended for image analysis. High resolution of the method revealed that after its collision with the fender, the piston rebounds of its surface and then hits the obstacle again and stops. The speed of the first impact is presented in Fig. 4.

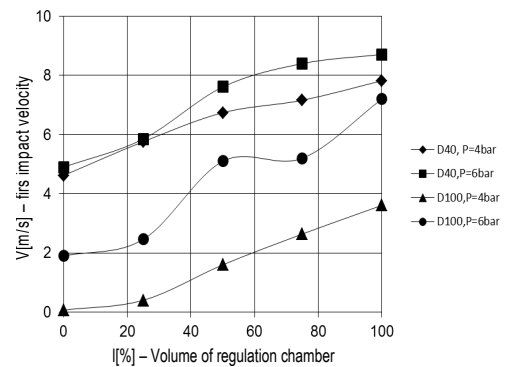
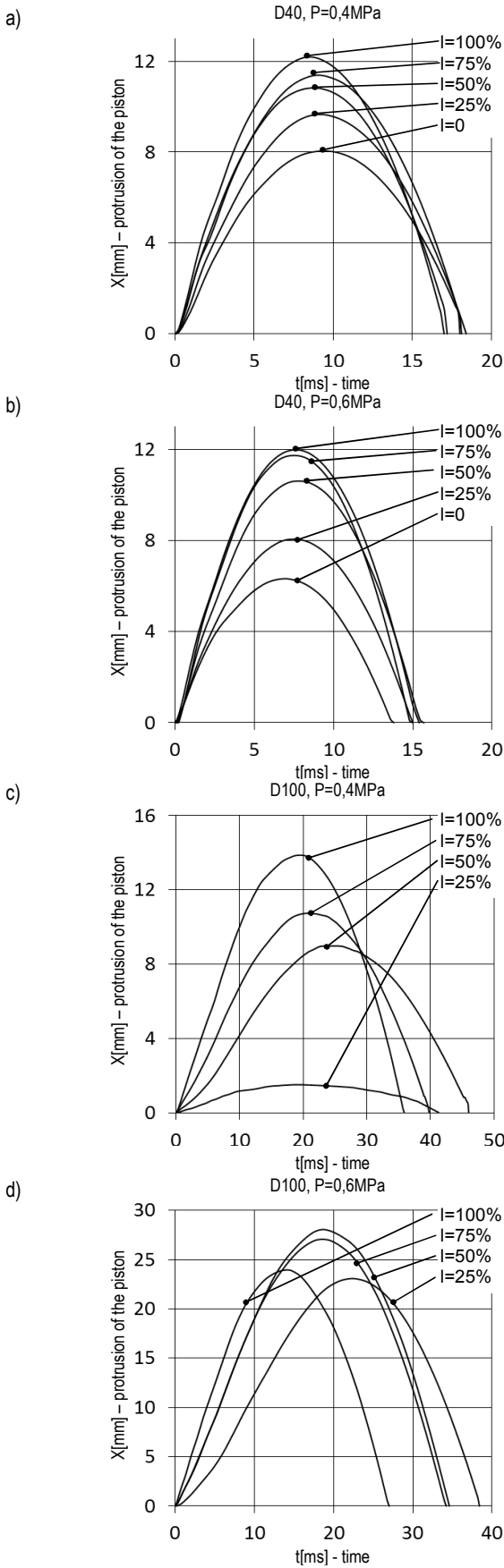


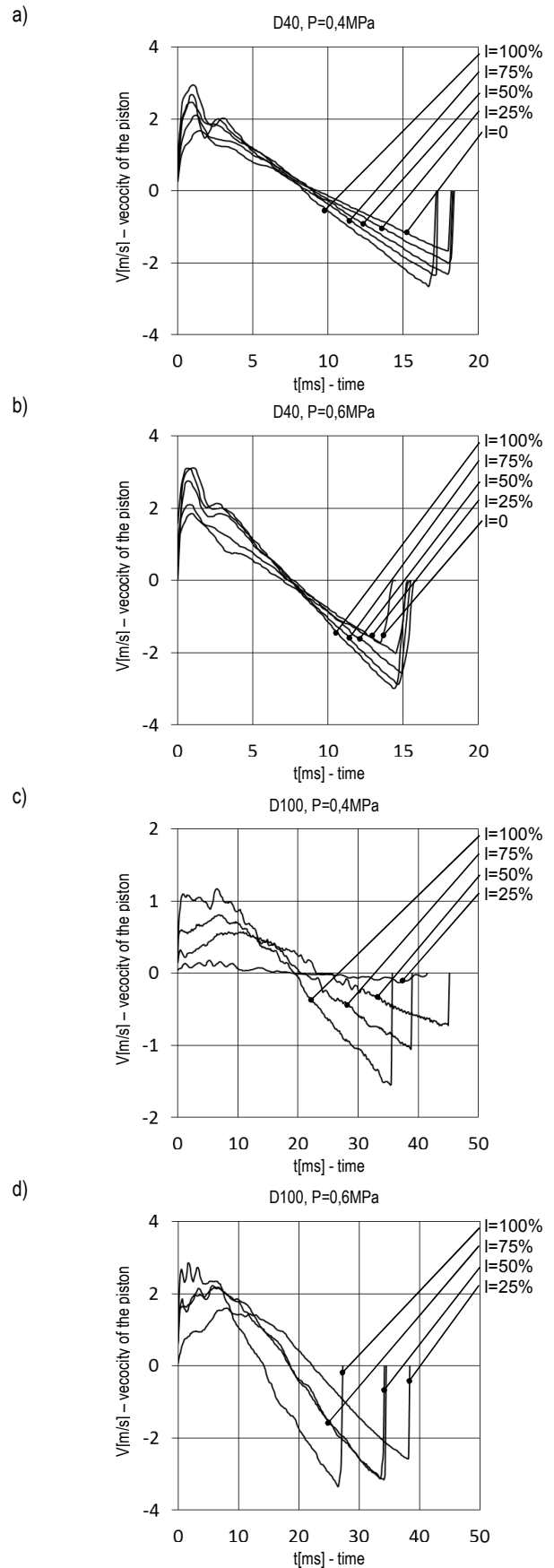
Fig. 4. Impact speed

The rebound phenomenon was not observed for the D100 actuator with the minimum capacity of the chamber of the accumulator.

From the characteristics of the movement path of the piston recorded in the function of time (Fig. 5) it appears that for D40 and D100 cylinders supplied by the pressure of 0.4 MPa, the distance of the rebound increases together with the volume of the regulatory chamber, whereas for the D100 actuator fed by the pressure of 0.6 MPa, the rebound time is visibly shorter, with no significant differences in the distance.



**Fig. 5.** Characteristics of the movement path of the piston in the function of time: a) D40 actuator with pressure of 0.4 MPa, b) D40 actuator with pressure of 0.6 MPa, c) D100 actuator with pressure of 0.4 MPa, d) D100 actuator with pressure of 0.6 MPa. (The „l” values stand for the volume of the regulation chamber)



**Fig. 6.** Characteristics of the speed of the piston in the function of time: a) D40 actuator with pressure of 0.4 MPa, b) D40 actuator with pressure of 0.6 MPa, c) D100 actuator with pressure of 0.4 MPa, d) D100 actuator with pressure of 0.6 MPa. (The „l” values stand for the volume of the regulation chamber)

The characteristics of the speed of the piston movement in the function of time (Fig. 6) indicate that the speed of the rebound is proportional to the volume of the chamber of the accumulator and the supply pressure.

The increase in the volume of the chamber of the accumulator leads to the growth in the distance the piston moves at after the rebound (Fig. 7) and accelerates the speed of the rebound (Fig. 8).

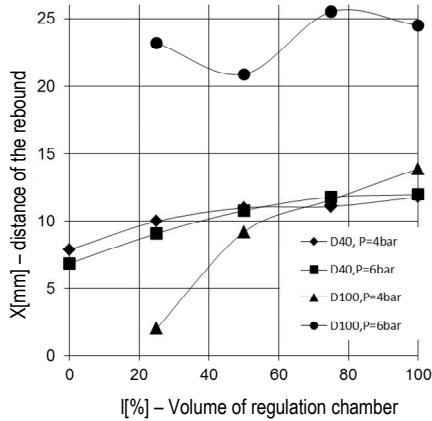


Fig. 7. Characteristics of the distance of the rebound in relation to the volume of the chamber of the accumulator

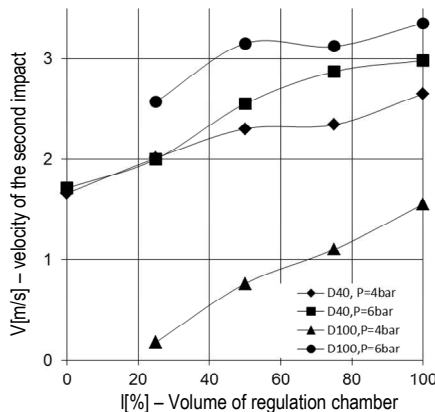


Fig. 8. Characteristics of the speed of the finisher in relation to the volume of the chamber of the accumulator

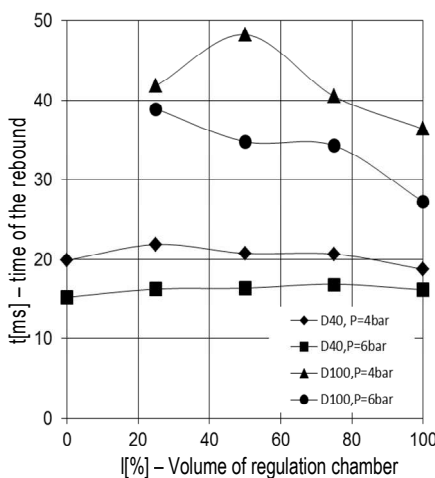


Fig. 9. Characteristics of the rebound time in relation to the volume of the chamber of the accumulator

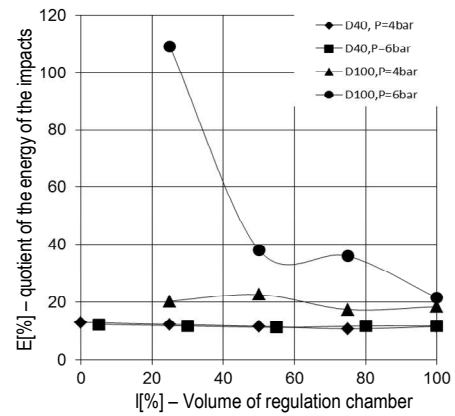


Fig. 10. Energy characteristics for the finisher in relation to the volume of the chamber of the accumulator

At the time of the first collision, there was vacuum in the chamber of the D100x200 actuator (speed of the piston decreased) (Lenczewski and Łunarski, 2001). The increase in the speed of the backward movement of the piston could be noticed for ca. 8 ms after the rebound (Fig. 7). High value of the rebound for the feed pressure of 6 bars is a result of the increased speed of the first impact in comparison to the feed pressure of 4 bars.

The rebound time for the D40 cylinder does not change much, while for the D100 actuator it decreases together with the level to which the regulatory chamber is filled up (Fig. 9). For the D40 actuator the energy of the finisher amounted to ca. 12% of the energy of the first impact. For the D100 actuator the energy quotient for the first and the second impact is dependent on the feed pressure and the volume of the chamber of the accumulator (Fig. 10).

## 5. CONCLUSIONS

Application of high speed vision techniques enables precise recording of the collision of the piston of the impact cylinder with the obstacle.

The characteristics of the movement of the piston obtained can be used for the designing of technological stands in which the object processed moves at a great speed in relation to the tool mounted on the piston of the impact cylinder. The determination of the rebound time allows the permissible speed of the shift of the object processed to be established.

On the basis of the tests conducted a following remark can be made: D100 actuators supplied by the standard pressure of 6 bars are characterized by a longer rebound time than D40 ones. This is connected with the piston stroke; the speed of the repeated rebound is, however, greater than in the case of the D40 actuator.

The reduction of the feed pressure for both the actuators tested results in a prolonged time of rebound and badly influences the efficiency of the technological process.

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