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DIAGNOSING WEAR AND TEAR OF PISTON PACKING IN CAR HYDRAULIC SHOCK ABSORBERS

Summary. The paper presents method of diagnosing hydraulic shock absorber with wear and tear of piston packing. There are diagrams of shock absorbers for different cases of tightness reduction. Damping characteristics for different cases of reduction in tightness are shown at the end of article.

DIAGNOZOWANIE ZUŻYCIA EKSPLOATACYJNEGO USZCZELNIENIA TŁOCZKA SAMOCHODOWEGO AMORTYZATORA HYDRAULICZNEGO

Streszczenie. W artykule przedstawiono diagnozowanie zużycia eksploatacyjnego uszczelnienia tłoczka samochodowego amortyzatora hydraulicznego. Zaprezentowano wykresy amortyzatorów dla różnych przypadków ubytku uszczelnienia. Na końcu artykuły umieszczono charakterystyki tłumienia dla amortyzatorów z różnym ubytkiem uszczelnienia.

1. INTRODUCTION

Technical condition of shock absorbers has an important effect on operation of the car, especially on its operational safety. The longer operation, the more changes, often hardly identifiable, occur in the absorber parameters. Typical signs of wear and tear observed in car hydraulic telescopic shock absorbers include:

- worn piston packing,
- leakages of absorber fluid,
- changes in valve characteristics,
- disorders in physical and chemical properties of the absorber fluid,
- mechanical damages.

Piston packing becomes worn in result of rubbing against inner surface of the absorber pipe. Such situation makes radial clearance between the piston and the pipe wider and wider, thus leading to much reduced pressure in the absorber. Loss of the fluid causes aeration and decrease in effective pitch of the absorber run. The valves can be damaged in result of reduced elasticity of the springs. Such reduction causes loss of the valve tightness with leakage of the fluid. Ageing of the absorber fluid results in changes in its properties (viscosity, density etc.). Mechanical damages can be caused by e.g. excessive dynamic forces due to rough road (holes), seizing, collisions etc.

As shown above, different types of damages can lead to similar reduction in damping effectiveness of the absorbers. Therefore it seems useful to develop suitable measurement methods enabling clear identification of the type of the damage.

Control tests performed so far for the absorbers mounted in the car are tentative only, whereas undismantable design of the absorbers makes diagnosing by organoleptic methods practically impossible. Therefore there is a need to develop a diagnostic method of identifying the accepted type of the damage without dismantling the absorber into separate components. The problem involves answering a question like „Can damping characteristics, determined by the tests, be used to diagnose wear and tear of the piston packing?”. The paper attempts to answer the question.

2. OBJECT AND METHODS OF TESTING

We used the car shock absorbers from FIAT-Punto II. They are of double-pipe non-pressure type as shown in fig. 1.

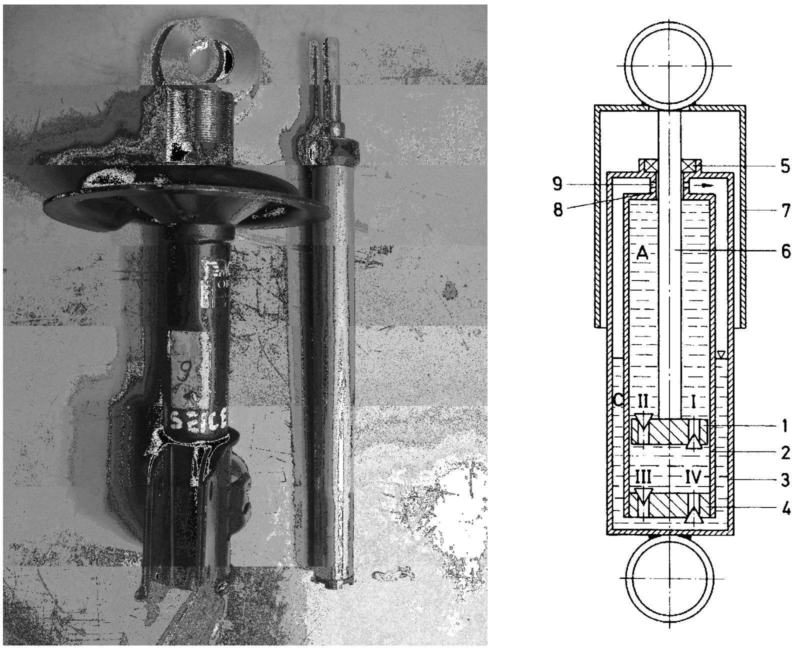

Fig. 1. Two-pipe shock absorber: 1 - piston, 2 - cylinder, 3 - outer pipe, 4 - lower valve, 5 - piston rod packing, 6 - piston rod, 7 - dust hood, 8 - piston rod guide, 9 - notch, A - working chamber, C - compensatory hamber

Rys. 1. Schemat amortyzatora dwururowego: 1 - tłoczek, 2 - cylinder, 3 - rura zewnętrzna, 4 - zaworek dolny, 5 - uszczelnienie tłoczyska, 6 - tłoczysko, 7 - osłona przeciwpyłowa, 8 - prowadnica tłoczyska, 9 - otwór przelewowy, A - komora robocza, C - komora kompensacyjna

Shock absorbers used in the test car have undismantable design. For the purposes of our tests it was necessary to redesign them into dismantable type. The following procedure was used: Overlapped ends of the outer pipe were replaced by suitable threaded sleeves (fig. 2a,b). Other components (packings,vents etc.) were kept intact. The absorbers were filled with the same fluid after careful measure. Therefore the introduced changes had no effect on damping characteristics.

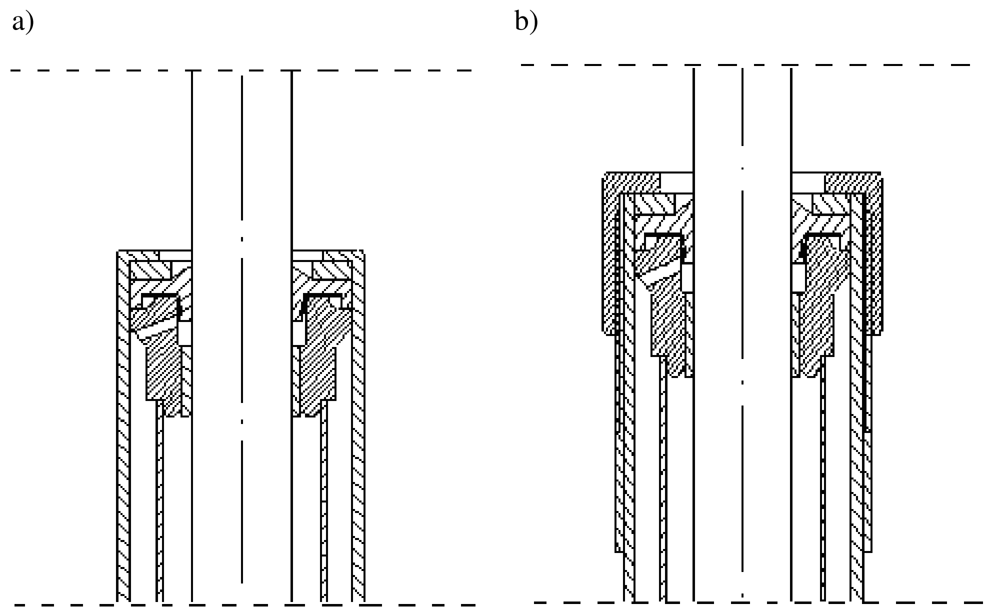

Fig. 2. Redesign of the shock absorbers into dismantable type
Rys. 2. Przeróbka amortyzatorów na rozbieralne

3. TESTING PROCEDURE

Wear and tear of the piston packing causes reduction in packing ring diameter accompanied by wider radial clearance between the piston and inner surface of the pipe (sleeve). Wear and tear of the packing ring was simulated through reboring. The simulation was only possible after the absorbers were changed into „dismantable" type.

It was decided that the measurements should refer to the following three cases:

1) new shock absorbers, with nominal diameter of the ring,
2) shock absorbers with diameter smaller by 0.05 mm than nominal,
3) shock absorbers with diameter smaller by 0.20 mm.

Such shock absorbers were tested on an indicator test rig designed for shock absorbers (fig. 3) where a frequency converter enabled continuous change of the driving motor rotational speed together with the piston speed against the pipe.

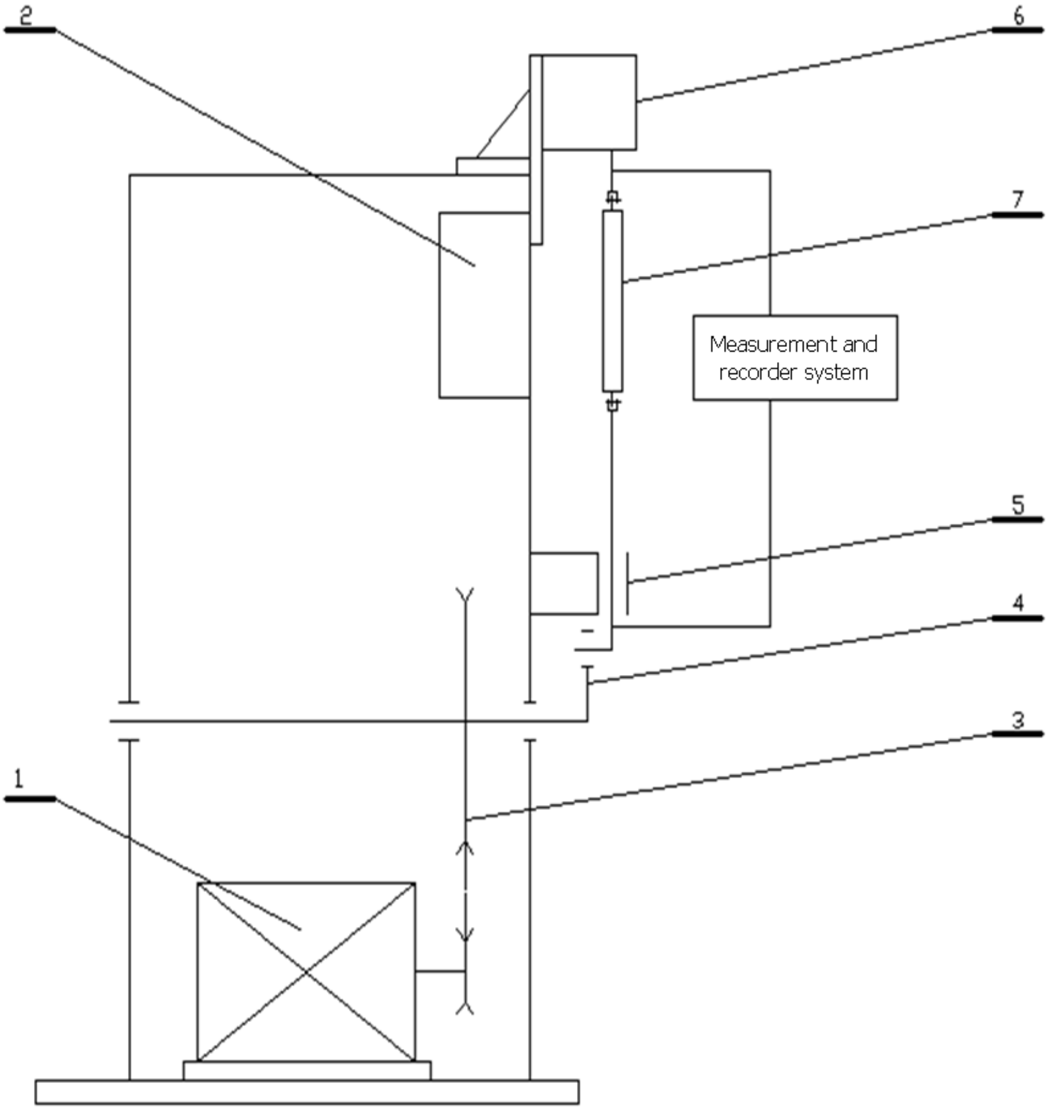

Fig. 3. Indicator test rig for shock absorbers: 1 - electric motor, 2 - frequency converter, 3 - belt transmission, 4 - crank-shaft,piston and connecting rod system, 5 - slide guides, 6 - force sensor, 7 - shock absorber under testing

Rys. 3. Schemat stanowiska indykatorowego do badań amortyzatorów: 1 - silnik elektryczny, 2 - przemiennik częstotliwości, 3 - przekładnia pasowa, 4 - układ korbowy, 5 - prowadnice suwakowe, 6 - czujnik siły, 7 - badany amortyzator

4. RESULTS OF MEASUREMENTS

The measurements were performed with stable stroke for the following frequencies of the rig crank-shaft, pistons and connecting-rod system:

- 4[Hz],
- 8[Hz],
- 12[Hz],
- 16[Hz],
- 20[Hz].

The parameters to measure were: damping force Ft and relative travel S of the piston rod against the pipe (piston stroke). Results of the measurements: sets of indicator diagrams in damping force - piston stroke coordinate system for three clearance values with five angular velocities of the rig crank-shaft, pistons and connecting-rod system. Respective examples are shown in fig. 4-8.

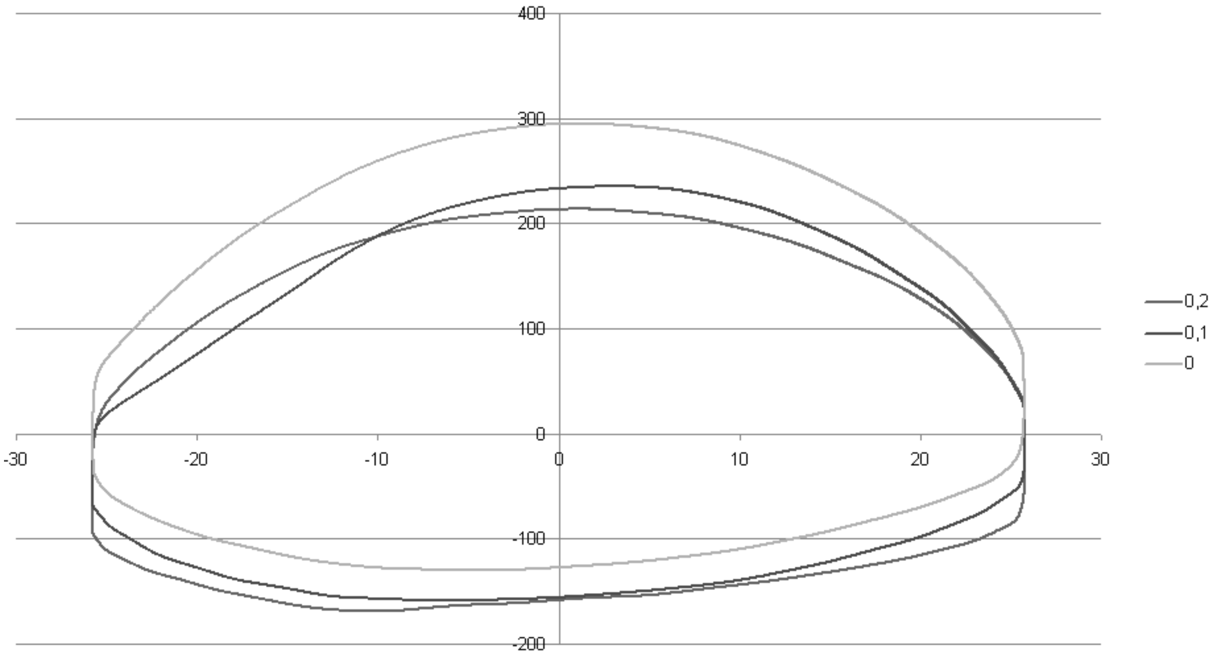

Fig. 4. Force-displacement diagram for different cases of reduction in tightness, with excitation rate f=4[Hz]
Rys. 4. Wykres pracy dla różnych przypadków ubytku uszczelnienia przy częstości wymuszenia f=4 [Hz]

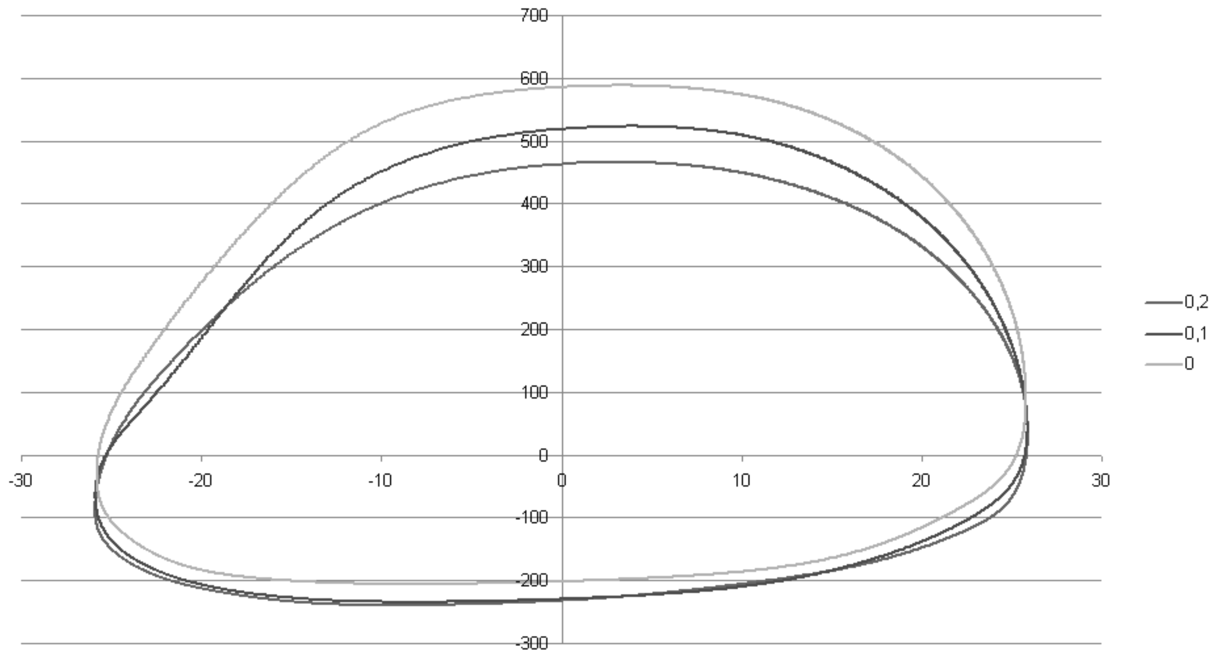

Fig. 5. Force-displacement diagram for different cases of reduction in tightness, with excitation rate f=8[Hz]
Rys. 5. Wykres pracy dla różnych przypadków ubytku uszczelnienia przy częstości wymuszenia f=8 [Hz]

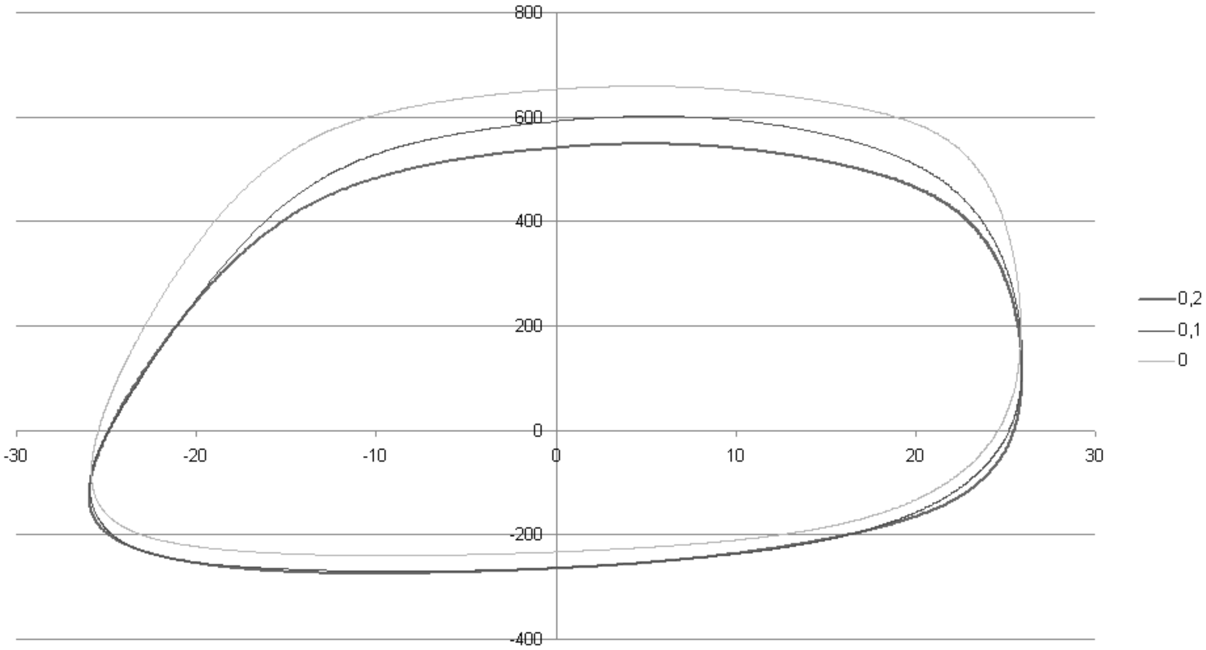

Fig. 6. Force-displacement diagram for different cases of reduction in tightness, with excitation rate f=12[Hz]
Rys. 6. Wykres pracy dla różnych przypadków ubytku uszczelnienia przy częstości wymuszenia f=12 [Hz]

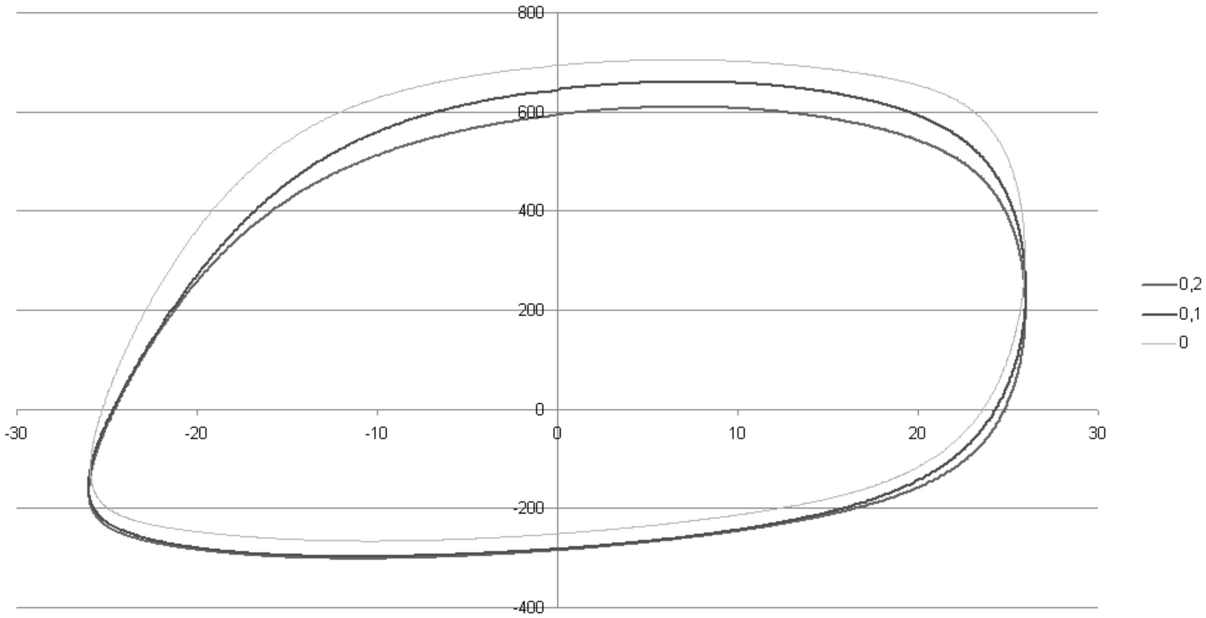

Fig. 7. Force-displacement diagram for different cases of reduction in tightness, with excitation rate f=16[Hz]
Rys. 7. Wykres pracy dla różnych przypadków ubytku uszczelnienia przy częstości wymuszenia f=16 [Hz]

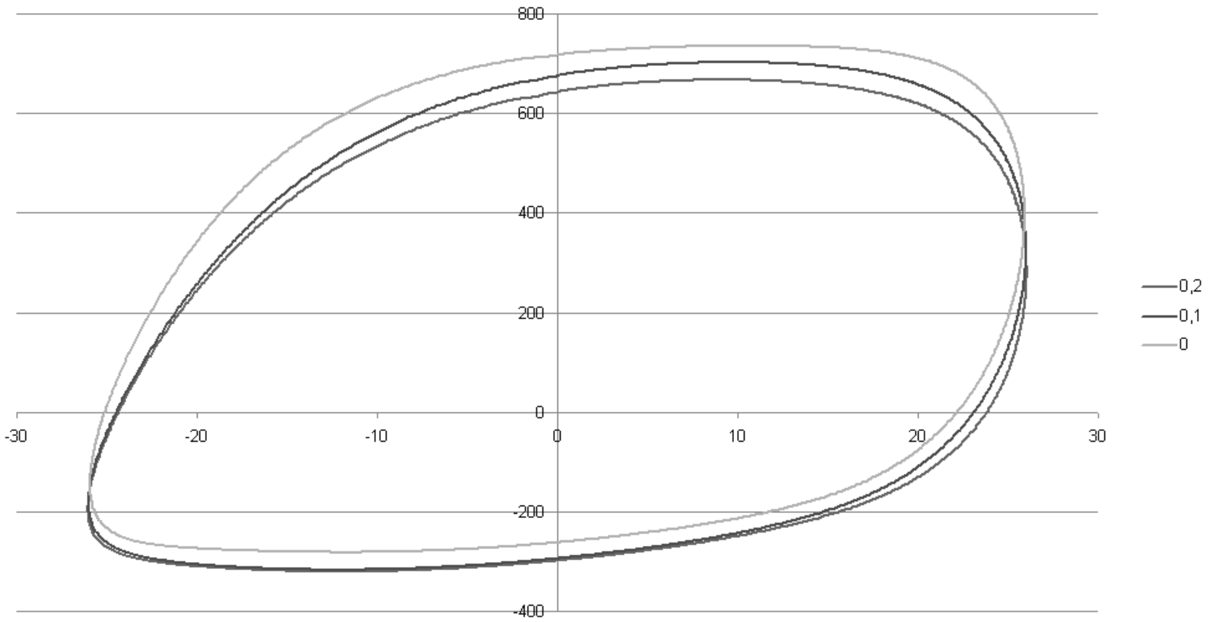

Fig. 8. Force-displacement diagram for different cases of reduction in tightness, with excitation rate f=20[Hz]
Rys. 8. Wykres pracy dla różnych przypadków ubytku uszczelnienia przy częstości wymuszenia f=20 [Hz]

5. ANALYSIS OF RESULTS

Results of the measurements (damping force in function of piston stroke) were differentiated using MATLAB environment. In effect thereof, so-called velocity diagrams were obtained for damping force in function of piston velocity (fig. 9-13). These present, upon expansion, the shock absorber damping characteristics (fig. 14).

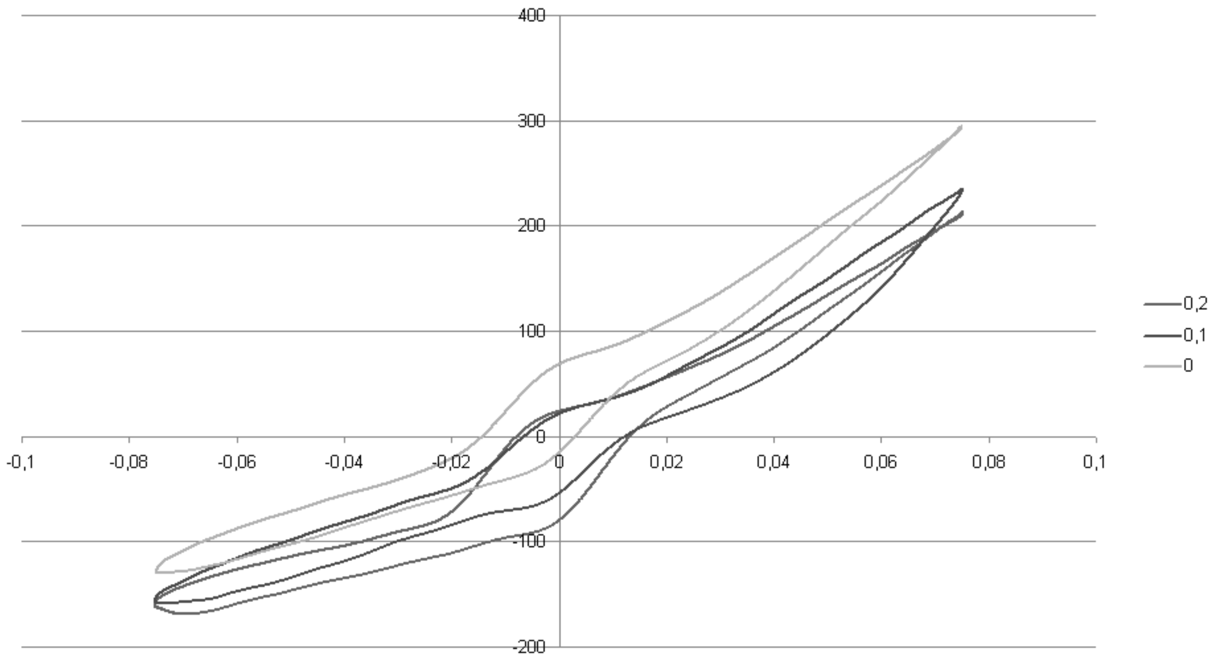

Fig. 9. Velocity diagram for different cases of reduction in tightness, with excitation rate f=4 [Hz]
Rys. 9. Wykres prędkościowy dla różnych przypadków ubytku uszczelnienia przy częstości wymuszenia f=4 [Hz]

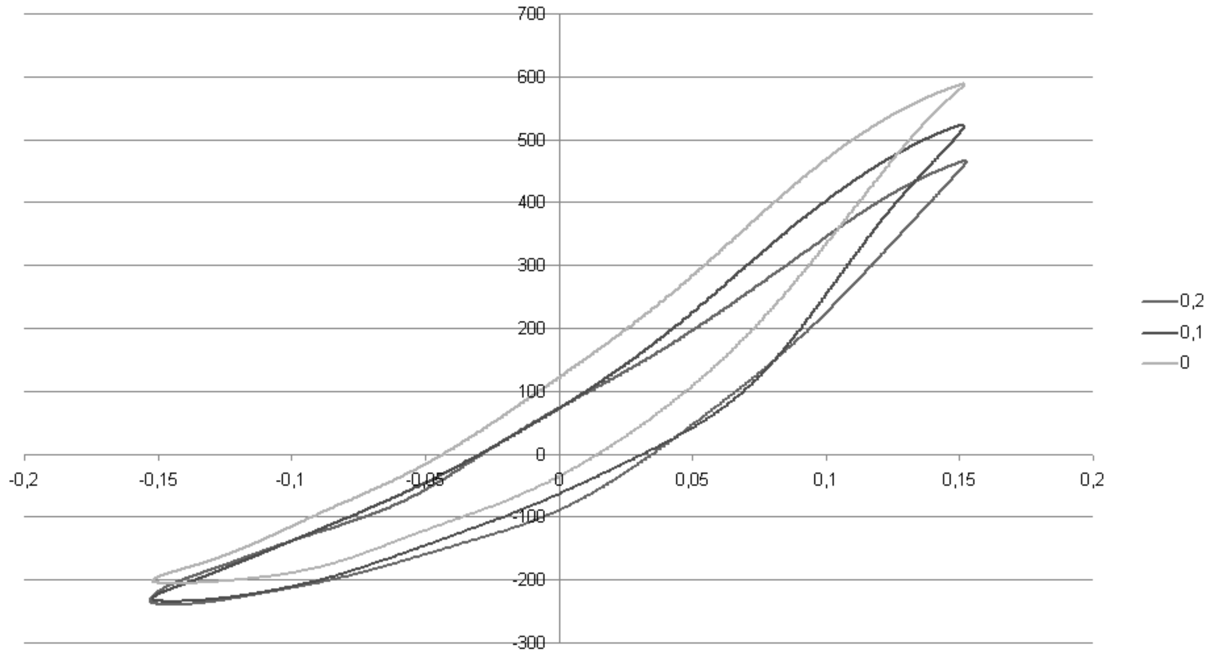

Fig. 10. Velocity diagram for different cases of reduction in tightness, with excitation rate f=8 [Hz].
Rys. 10. Wykres prędkościowy dla różnych przypadków ubytku uszczelnienia przy częstości wymuszenia f=8 [Hz]

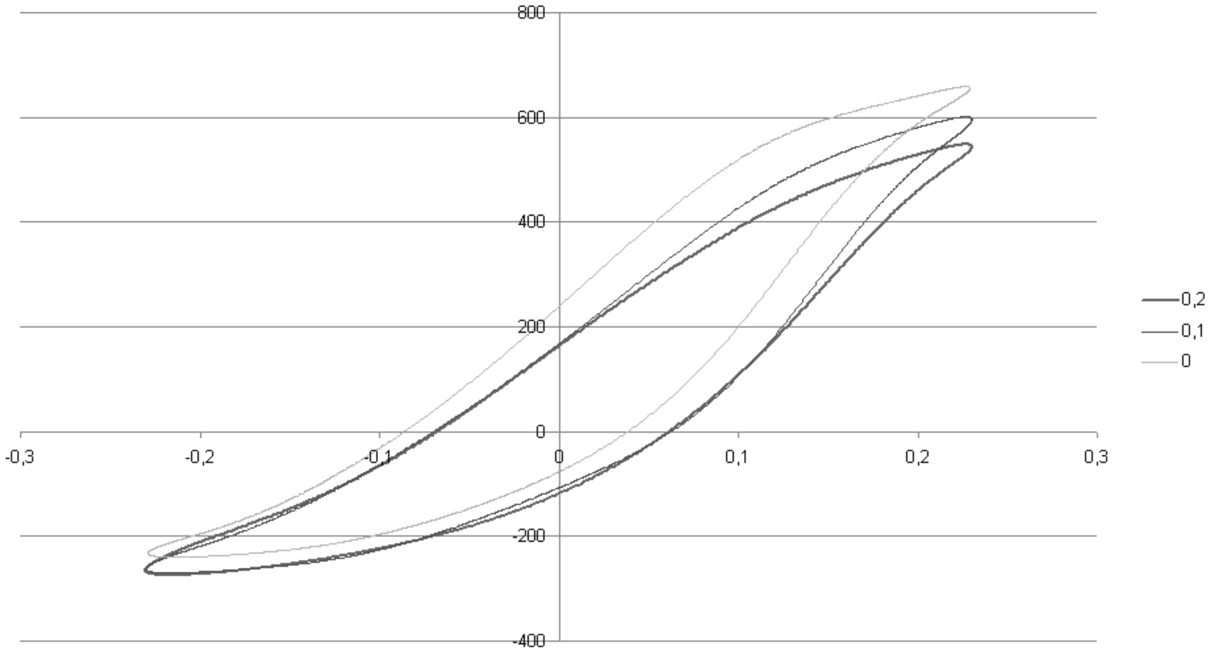

Fig. 11. Velocity diagram for different cases of reduction in tightness, with excitation rate f=12 [Hz]
Rys. 11. Wykres prędkościowy dla różnych przypadków ubytku uszczelnienia przy częstości wymuszenia f=12 [Hz]

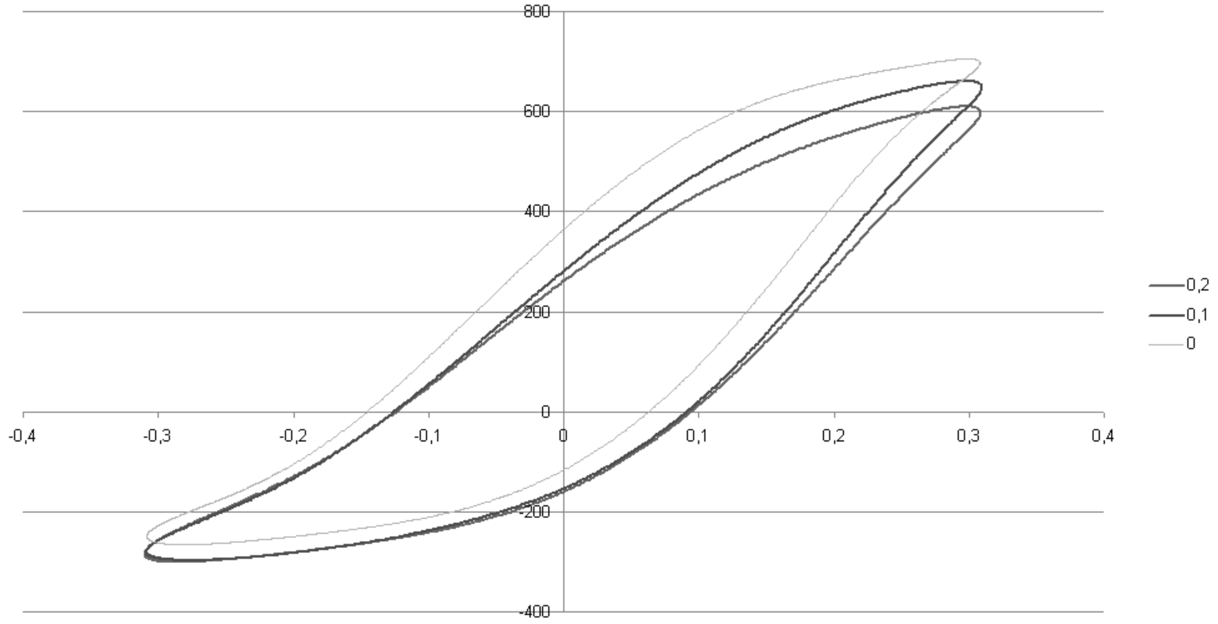

Fig. 12. Velocity diagram for different cases of reduction in tightness, with excitation rate f=16 [Hz]
Rys. 12. Wykres prędkościowy dla różnych przypadków ubytku uszczelnienia przy częstości wymuszenia f=16 [Hz]

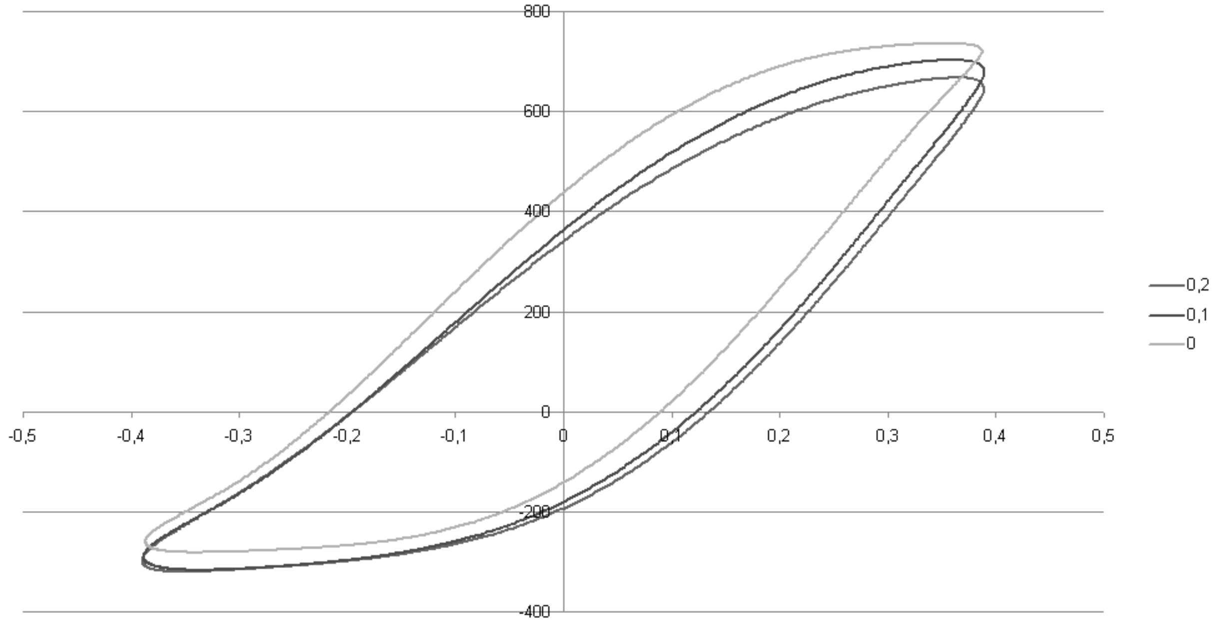

Fig. 13. Velocity diagram for different cases of reduction in tightness, with excitation rate f=20 [Hz]
Rys. 13. Wykres prędkościowy dla różnych przypadków ubytku uszczelnienia przy częstości wymuszenia f=20 [Hz]

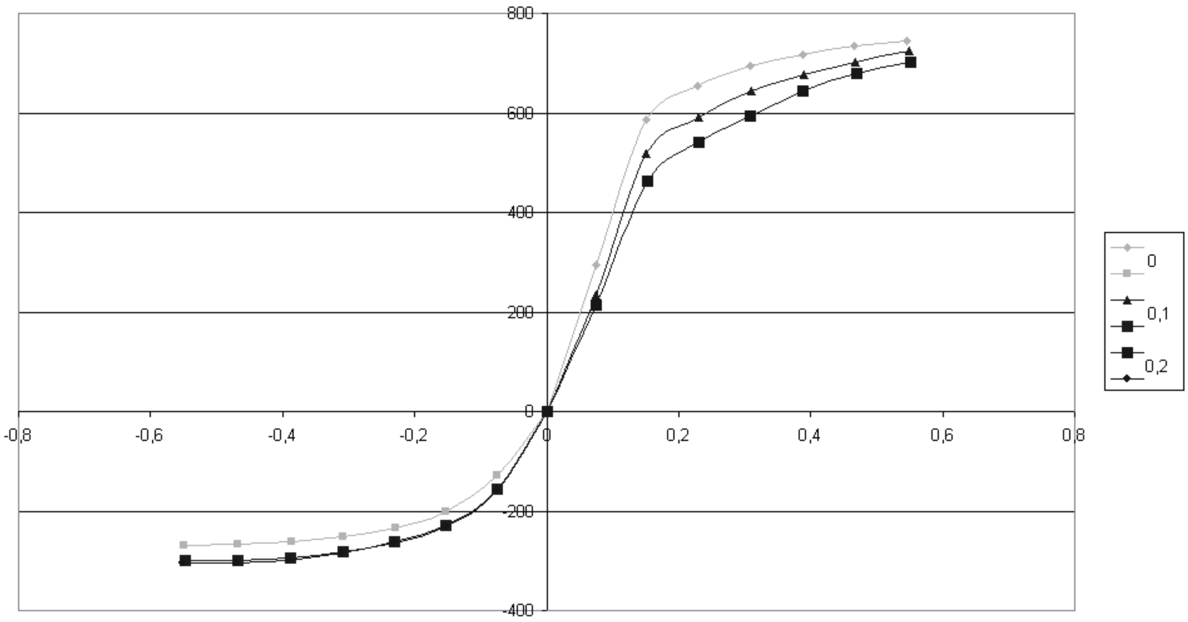

Fig. 14. Shock absorber damping characteristics for different cases of reduction in tightness
Rys. 14. Charakterystyki tłumienia amortyzatorów dla różnych przypadków ubytku uszczelnienia

The following conclusions are made from the analysis performed as above:
- Wear and tear within the range of 2L=0.05 mm do not cause changes in damping force. This means that value of the clearance is well within acceptable wear and tear limits.
- With wear and tear 2L=0.2 mm there are not only changes in damping characteristics but also significant reduction in damping force (5.5%). The differences can be a diagnostic parameter.

6. CONCLUSION

Shock absorber damping characteristics, obtained in result of testing on an indicator test rig, can be a suitable estimator to be used for diagnosing wear and tear of shock absorber piston packing, an important advantage being its fairly high resolving power.

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Received 09.01.2009; accepted in revised form 17.08.2009