

## THE UNCERTAINTY OF DETERMINING SHOCK ABSORBER DAMPING CHARACTERISTIC ON INDICATOR TEST STAND

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### Summary

The paper presents the research results of twin-tube hydraulic front shock absorber used in the column McPherson. It was conducted on indicator test stand. The force vs displacement and force vs. velocity diaphragms were determined. Loop diagrams are set of average for several full cycles shock absorber (compression and decompression). For this average the uncertainty of shock absorber damping characteristics was determined.

Keywords: shock absorber, damping characteristic

### NIEPEWNOŚĆ WYZNACZANIA CHARAKTERYSTYKI TŁUMIENIA AMORTYZATORA NA STANOWISKU INDYKATOROWYM

#### Streszczenie

W ramach referatu przedstawiono wyniki badań amortyzatora hydraulicznego dwururowego przedniego stosowanego w kolumnie McPhersona przeprowadzonych na stanowisku indykatorowym. W ramach badań wyznaczono wykresy pracy oraz wykresy prędkościowe. Wykresy pętlicowe stanowią realizacje średnie wyznaczone dla kilkudziesięciu pełnych cykli pracy amortyzatora (sprężanie i rozprężanie). Dla tak wyznaczonych realizacji średnich określono niepewność wyznaczenia charakterystyki tłumienia amortyzatora.

Słowa kluczowe: amortyzator hydrauliczny, charakterystyka tłumienia

## 1. INTRODUCTION

The objective assessment of the technical condition of the shock can be examined on indicator shock absorber test stand. Such examination can generate the work graph of the shock absorber (force-displacement) and a velocity graph (force-linear velocity) and determine damping characteristics. Example of testing of MTS shock absorber test stand has been depicted in Fig. 1.



Fig. 1. MTS shock absorber test stand

Determination of the damping characteristics can be achieved by two ways. The first based on designated force-displacement diagram at a constant stroke and variable angular velocity. Forced damping value assuming the maximum speed of the piston at compression and decompression can receive points for the shock absorber damping characteristics as shown in Fig. 2.

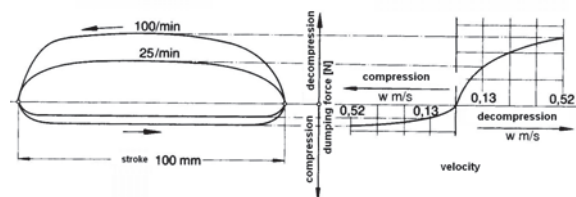


Fig. 2. Determined shock absorber characteristics with variable angular velocity and constant stroke [3]

In the second approach, the angular velocity is constant and the value of the stroke is changing (Fig. 3) The damping characteristic is determined the same way as in the first case, assuming a value for the maximum damping piston velocity (separately compression and decompression).

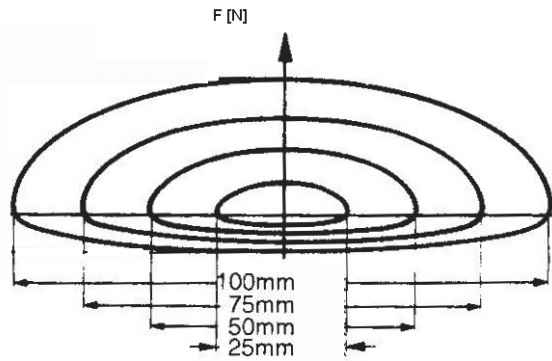


Fig. 3. Determined shock absorber characteristics with variable stroke and constant angular velocity [3]

The implementation of the calculation of the characteristics of the first and second approach may lead to some discrepancies in the designed characteristics (authors confirmed that in the publication [5]).

These differences result from differences in the components designated maximum velocity, i.e. the value of the stroke and the angular velocity. For the assumed constant linear speed for large values of stroke at low frequencies is much larger pumped fluid than is the case with short strokes and high-frequency excitation. Therefore, it was proposed to develop the characteristics of the graph  $F(v)$  to the plane of  $F(s, v)$  – force vs stroke and linear velocity (Fig. 4).

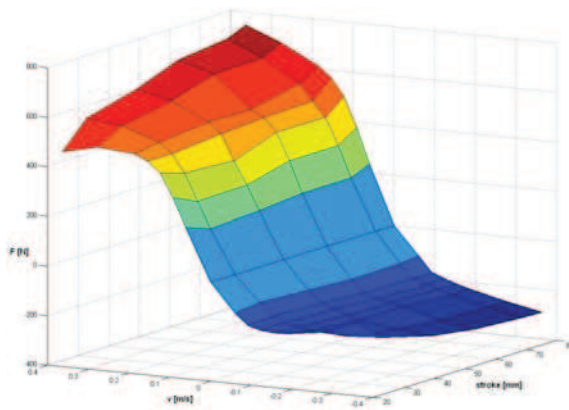


Fig. 4. Shock absorber damping force as a function of velocity and stroke

## 2. RESEARCH ON INDICATOR TEST STAND

The research on twin-tube hydraulic front shock absorber used in the MsPherson strut were carried out on indicator test stand. The Figure 5 shows view of the indicator test stand with mounted shock absorber.



Fig. 5. Indicator test stand

The measuring system diagram is shown in Figure 6.

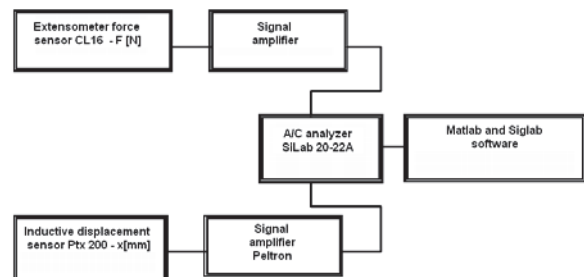


Fig. 6. Measurement system

The force sensor CL 16 accuracy class of 0.5% is relative to the result of a measurement in the range of 10% to 100% range of the sensor. Displacement transducer is characterized by a basic error of 0.5% of the measuring range. The analyzer SigLab 20-22 overall accuracy:  $\pm 0.0025\%$  of full scale.

After mounting the shock absorber to the test stand, and checking the correctness of the assembly process followed warm up of the cold oil in shock absorber (work for about 60 [s]). After an initial warm-up followed data acquisition process.

Measurements were made for 13-teen different angular velocities (frequency set on inverter) of excitation and constant stroke 50 [mm]. The plots of force vs. displacement (Figure 7) and force vs. linear velocity (Figure 8) are averaged loop.

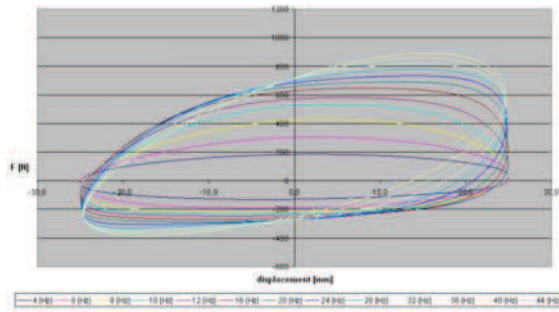


Fig. 7. Force vs. displacement (frequency set on inverter in [Hz])

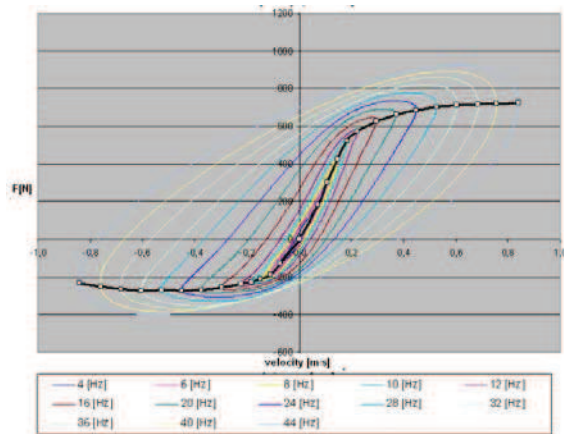


Fig. 8. Force vs. velocity (frequency set on inverter in [Hz]) and damping characteristic (black line)

The figure 8 contains marked damping characteristics designated for the maximum velocity limit (black line).

The averaged loop diagram were determining by the procedure as follow. The minimum number of 25 full cycles consisting of compression and decompression were recorded. The figures 9 and 10 shows imposed the single loop recorded at the time of forces and displacements.

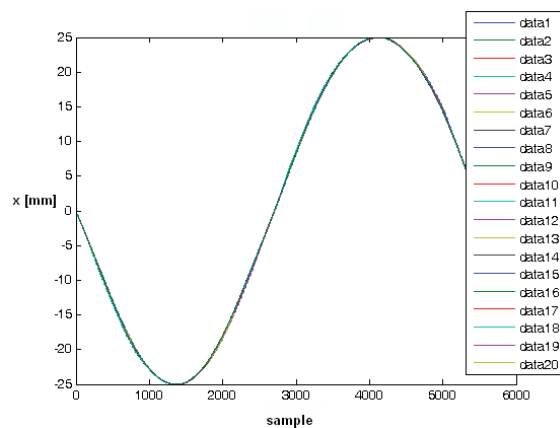


Fig. 9. Imposed displacements single loop recorded at time.

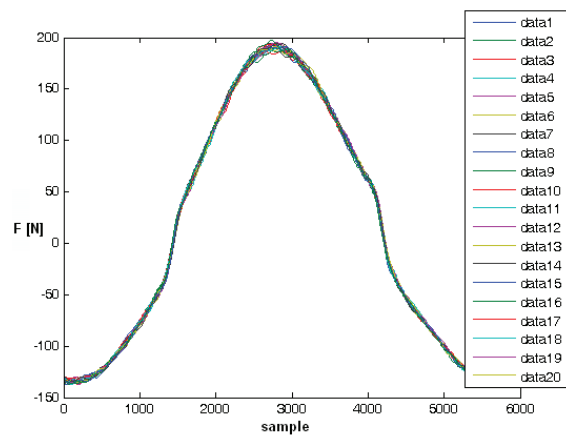


Fig. 10. Imposed forces single loop recorded at time

The value of force when displacement is zero (the position in the middle of the stroke -maximum linear velocity) is taken to the damping characteristics (separately compression and decompression). Sample values of forces for maximum velocity (for frequency 0.48 Hz) recorded in subsequent cycles shows figure 11.

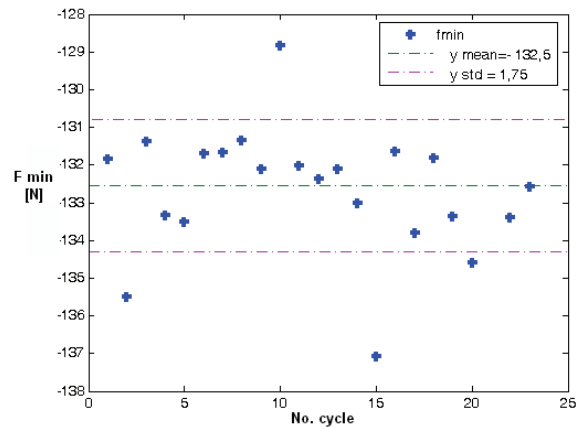


Fig. 11. Sample values of forces for maximum velocity in subsequent cycles

In the laboratory practice the normal distribution is assumed to  $2\sigma$  estimate (ie with a probability  $p \approx 0.95$ ) for the statistics of the measurements. Figure 12 and 13 show the damping characteristics for compression and decompression with the area of uncertainty.

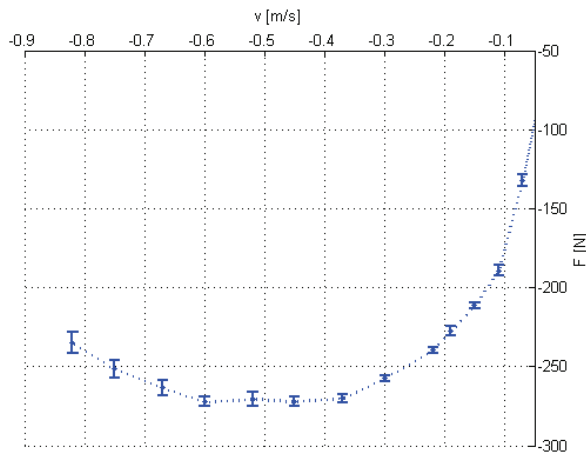


Fig. 12. Damping characteristics with the area of uncertainty for compression

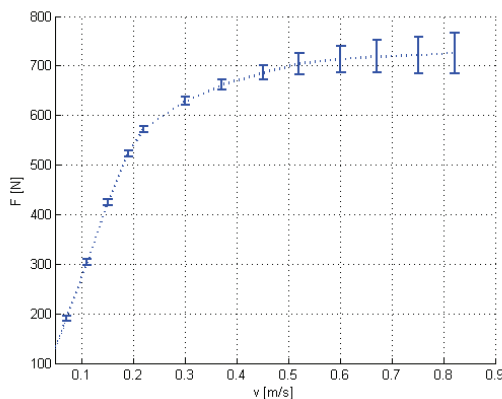


Fig. 13. Damping characteristics with the area of uncertainty for decompression

### 3. SUMMARY

Determination of the damping characteristics based on the average value of force for point of maximum velocity is affected of a small uncertainty of 5%. This value is also related to the accuracy of determining the representative loop. Small uncertainty of loop changes for a constant excitation provides quality of the shock absorber.

### LITERATURA

- [1]. Dixon J. C. *The shock absorber handbook*. Society of Automotive Engineers, USA 1999
- [2]. Gardulski J., Warczek J.: *Investigation on force in frictional kinematic pairs to assess their influence on shock absorber characteristic*. Transport Problems, volume 3, Issue 1, Gliwice 2008 s.19-24.
- [3]. Konieczny Ł.: *Badania amortyzatorów hydraulicznych na zmodyfikowanym stanowisku indykatorowym*. Zeszyty Naukowe Politechniki Śląskiej, s. Transport, z.61 Wydawnictwo Politechnik Śląskiej, Gliwice 2007 s.151-156.
- [4]. Konieczny Ł., Śleziak B.: *Wpływ wybranych parametrów na charakterystyki tłumienia*

*amortyzatorów hydraulicznych*. Zeszyty Naukowe Politechniki Śląskiej, s. Transport, z.64 Wydawnictwo Politechnik Śląskiej, Gliwice 2008 s.145-150.

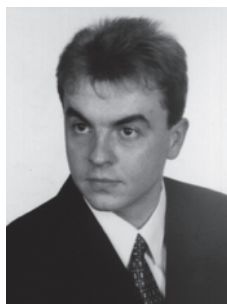
- [5]. Konieczny Ł., Burdzik R., Warczek J.: *Determinations of shock absorber damping characteristics taking stroke value into consideration account*. Diagnostyka 2010 nr 3, s. 51-54.
- [6]. Lanzendoerfer J.: *Badania pojazdów samochodowych*. WKiŁ, Warszawa 1977.
- [7]. Michalski R, Wierzbicki S.: *An analysis of degradation of vehicles in operation*. Eksploatacja i Niezawodność – Maintenance and Reliability 2008; 1(37): 30-32.
- [8]. Reipell J., Betzler J.: *Podwozia samochodów – podstawy konstrukcji*. WKiŁ Warszawa, 2001, Sikorski J.: *Amortyzatory – budowa – badania – naprawa*. WKiŁ, Warszawa 1984.



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