THE STATISTICAL ANALYSIS OF DAMPING PARAMETERS OF HYDRAULIC SHOCK ABSORBERS

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Summary
The paper presents comparison of damping characteristics determined for new hydraulic shock absorbers. The damping characteristics were determined on indicator test stand for six new front shock absorbers of the same type. On the basis of these results was made the statistical analysis as well as the comparison of the received characteristics .

Keywords: shock absorber, damping characteristics, statistical analysis

ANALIZA STATYSTYCZNA PARAMETRÓW TŁUMIENIA
AMORTYZATORÓW HYDRAULICZNYCH

Streszczenie
W ramach referatu przedstawiono porównanie charakterystyk tłumienia wyznaczonych dla nowych amortyzatorów hydraulicznych. Charakterystyki tłumienia wyznaczono na stanowisku indykatorowym dla sześciu przednich nowych amortyzatorów tego samego typu. Na podstawie otrzymanych wyników przeprowadzono analizę statystyczną oraz przeprowadzono porównanie jakościowe otrzymanych charakterystyk.

Słowa kluczowe: amortyzator hydrauliczny, charakterystyka tłumienia, analiza statystyczna

1. INTRODUCTION

The technical condition of the shock can be examined on indicator shock absorber test stand. Such an examination can plot the work graph of the shock absorber (force versus displacement) as well as the velocity graph (force versus linear velocity) and determine damping characteristics [1, 2, 3, 8, 9, 10, 11, 12].

Determination of the damping characteristics can be achieved in two ways. In the first one, it is described on the basis of designated force-displacement diagram at a constant stroke and variable angular velocity.

In the second approach, the angular velocity is constant and the value of the stroke is changed. The damping characteristic is determined assuming a value for the maximum damping piston velocity (separately compression and decompression).

It is worth saying that the designation implementation of the characteristics of this two methods may lead to some discrepancies in the designated characteristics (The author confirms that in the publication [7], the designated maximum linear velocity is combination of the value of the stroke and the angular velocity) [13].

The indicator test stand used in researches is on the Department of Transport, Silesian University of Technology – fig. 1 [4, 5, 6].

Fig.1. Indicator test stand

The measurement system used in test is shown on fig. 2. 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 the basic error of 0.5% of the measuring range. The analyzer SigLab 20-22 overall accuracy: ± 0.0025% of full scale. Uncertainty due to the components used in measurement system is therefore about 1%.

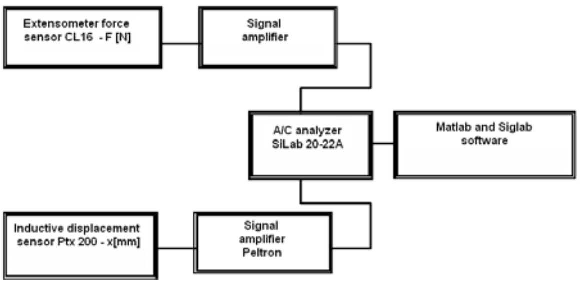

Fig. 2. Measurement system

2. DETERMINING OF DAMPING CHARACTERISTIC FOR ONE SHOCK ABSORBER

After installing each of the shock absorbers to the test stand and checking the correctness of the assembly process, has followed the warm -up of the cold oil in shock absorber (work for about 60 [s]). After an initial warm-up data acquisition has followed upon. There were recorded signals of displacement and force with sampling frequency 2048 [Hz]. Each measurement lasted 15 to 60 [s] depending on the speed force which allowed each register at least 25 full cycles consisting of compression and decompression.

The time realization of this signal is presented on fig.3

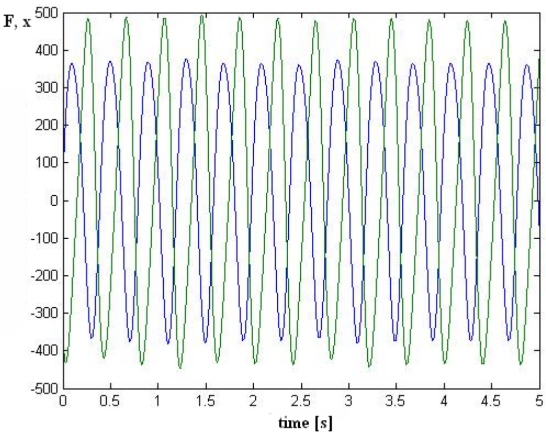

Fig. 3. Time realization of recorded force and displacement signals.

Time realizations imposed for subsequent complete cycles to gave the closed loop (force versus displacement diagrams). Close loop is presented on fig. 4.

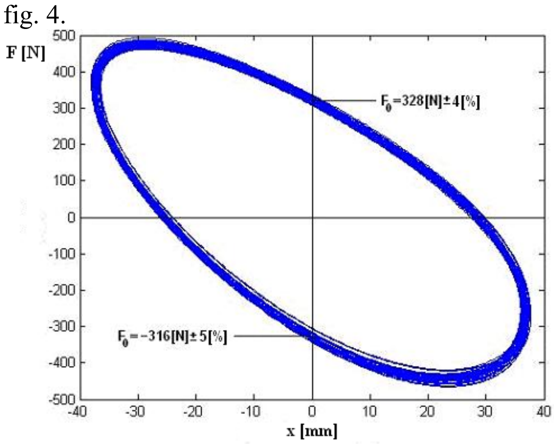

Fig. 4. Close loop realization of recorded force and displacement signals

The next step was determining the average loop and value of the forces for damping characteristics (the value of force for displacement zero - maximum linear velocity, separately for compression and decompression). 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% [7].

Last step of determining damping characteristic was joining the points determining for different linear velocity (average line for close loop). Damping characteristic is presented of fig 5.

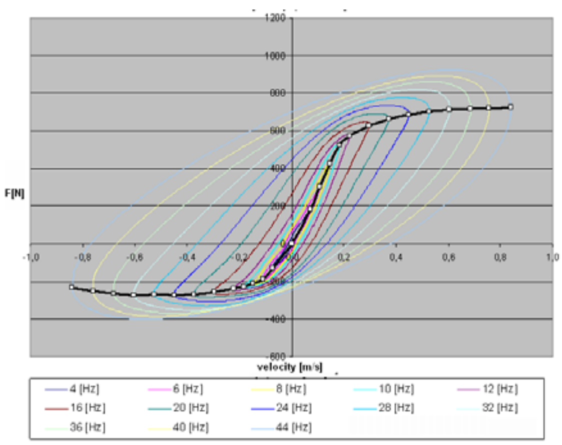

Fig. 5. Force vs. velocity diagram (frequency set on inverter in [Hz]) and damping characteristic (black line)

3. STATISTICAL ANALYSIS FOR SIX SHOCK ABSORBERS

There were researched six twin-tube hydraulic front shock absorbers used in the McPherson strut. The examined shock absorbers are presented on fig.6

Fig. 6. Six examined front hydraulic shock absorbers

For each shock absorbers damping characteristics were determined in accordance with the procedure set out in section 2. Example diagrams for six shock absorbers for the same frequency are presented on fig. 7 and 8.

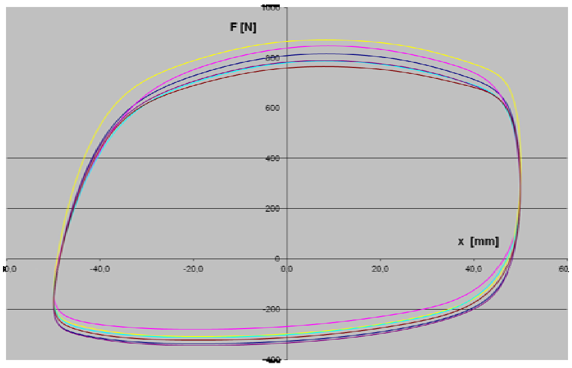

Fig. 7. Force vs. displacement diagram for six shock absorbers (for one chosen frequency)

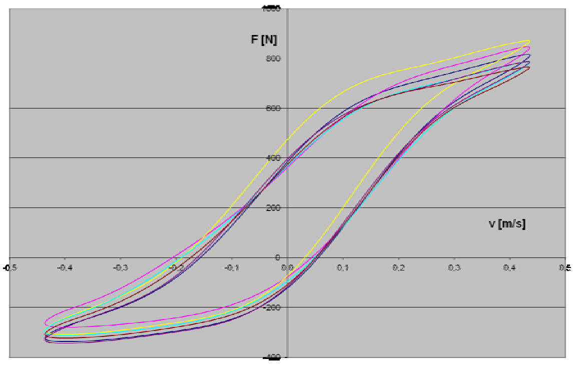

Fig. 8. Force vs. velocity diagram for six shock absorbers (for one chosen frequency)

Comparing the graphs for each shock absorber, there was no quality difference (very similar loops of changes forces).

The next step was determining damping characteristics for each shock absorber (fig. 9). There are noticeable differences in the force value of the damping characteristics of each shock absorber.

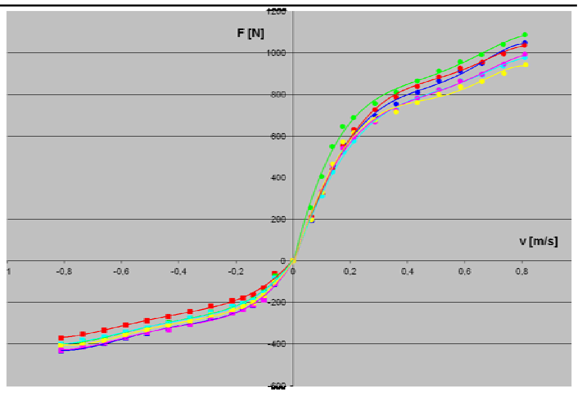

Fig. 9. Damping characteristics for six shock absorbers

For values of force on damping characteristics were made statistical analysis (tab. 1). For the same six shock absorbers were calculated mean and standard deviations of points of damping characteristic.

Tab.1 Statistical analysis calculate for six shock absorbers

	v [m/s]	F [N] mean	σ [N]	2 σ [N]	2 σ [%]
compression	-0,06	-90	22	43	-48
	-0,10	-163	21	43	-26
	-0,14	-195	19	38	-20
	-0,17	-213	20	41	-19
	-0,21	-227	22	43	-19
	-0,29	-255	23	45	-18
	-0,36	-283	23	46	-16
	-0,44	-307	23	47	-15
	-0,51	-328	22	44	-13
	-0,59	-348	23	46	-13
	-0,66	-374	24	47	-13
	-0,74	-391	23	46	-12
	-0,81	-407	23	47	-12
decompression	0,06	210	23	47	22
	0,10	338	34	69	20
	0,14	468	43	86	18
	0,17	567	43	85	15
	0,21	622	38	77	12
	0,29	699	36	71	10
	0,36	754	38	76	10
	0,43	806	40	80	10
	0,51	852	43	86	10
	0,59	895	45	91	10
	0,66	925	48	96	10
	0,74	970	51	102	11
	0,81	1015	52	105	10

The mean characteristic with standard deviation for six shock absorbers is presented on fig 10. Typically, in laboratory practice, the use of normal distribution is assumed to 2σ estimate (although little sample- only six shock absorbers consciously assumed normal distribution).

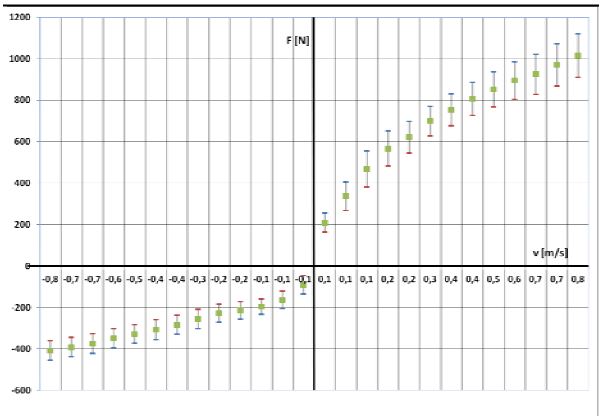

Fig. 10. Mean damping characteristic with 2σ range calculate for six shock absorbers

4. SUMMARY

Determination of the damping characteristics for one shock absorber 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. Comparison of the characteristics for the same six shock absorbers has shown that differences can be range over a dozen percent.

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