DETERMINATIONS OF SHOCK ABSORBER DUMPING CHARACTERISTICS TAKING STROKE VALUE INTO CONSIDERATION ACCOUNT

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Summary
The paper presents the results of the hydraulic vehicle shock absorbers' researches on indicator test stand. The front twin tube hydraulic shock absorber for Fiat Punto was researched. The aim of this investigation was to determine the dumping characteristics (points of force for maximum linear velocity) taking stroke value into account. The stroke and rotary velocities were selected so that to different combinations the same maximum linear velocity was taken. For that extortion parameters the influence of stroke value on force versus displacement and force versus velocity diagrams was determined. The dumping surface in stoke and linear velocity function was determined too.

Keywords: shock-absorbers, dumping characteristics.

WYZNACZENIE CHARAKTERYSTYK TŁUMIENIA AMORTYZATORA SAMOCHODOWEGO PRZY UWZGLĘDNIENIU WARTOŚCI SKOKU

Streszczenie
W ramach pracy przeprowadzono badania hydraulicznego amortyzatora samochodowego na stanowisku indykatorowym. Obiektem badań był bezciśnieniowy dwururowy amortyzator hydrauliczny stosowany w zawieszeniu przednim samochodu marki Fiat Punto. Celem przeprowadzonych badań było wyznaczenie punktowych charakterystyk tłumienia (wartości sił tłumienia dla maksymalnych wartości prędkości liniowej) przy dodatkowym uwzględnieniu wartości skoku roboczego. Wartości skoku i prędkości kątowej zostały tak dobrane, aby przy różnych kombinacjach otrzymać zbliżone wartości maksymalnej prędkości liniowej. Dla tak dobranych parametrów wymuszenia określono wpływ skoku na kształt przebiegów wykresów prędkościowych i charakterystyk punktowych. Wyznaczono także powierzchnię sił tłumienia w funkcji prędkości liniowej i skoku.

Słowa kluczowe: amortyzatory samochodowe, charakterystyki tłumienia.

1. INTRODUCTION

In simulation research of suspension dynamic the vehicle shock absorber is described as the element of viscosity dumping and the dumping force depends only on linear velocity function. For low frequency extortion apparent stiffness effect and the influence of stroke value on dumping characteristic are not taken for consideration.

In real conditions of shock absorber work the axel resonance frequency is higher than the body resonance frequency and the amplitude of these vibrations is small. In these conditions the direction of piston move is often changed and small quantity of oil is flowed by valve. This is cause the differences in dumping force in case of higher amplitude and lower frequency to lower amplitude and higher frequency. On indicator test stand with the sinusoidal extortion the change of maximum linear velocity can be got in two ways: constant stroke and changeable rotary velocity (frequency) or constant rotary velocity and changeable stroke. In scientific literature the authors often insist on thesis that these two ways lead to this same results. This thesis is true for low frequency of extortions. In real conditions, frequency of extortions has got wide range so for different amplitudes the linear velocity can be over few m/s. The forms of loop determined on indicator test stand differ considerable from theoretical elliptic loop describing viscosity dumpers. These differences are connected with many factors: cavitations, valve inertia, oil properties, friction between moving parts and many other. These factors show that the dumping characteristics are dependent from stroke too. The example of investigations where results (dumping force) are presented as surface in stoke and linear velocity function [9] shows fig 1.

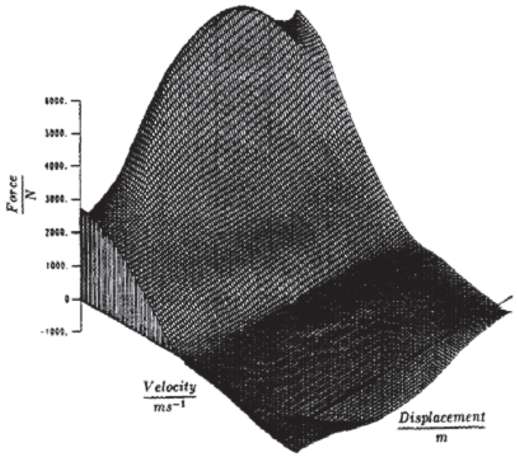

Fig. 1. Dumping surface in stoke and linear velocity function [9]

2. INDICATOR TEST STAND AND RESEARCH OBJECT

The researches were made on indicator test stand. On this stand can be determined force versus displacement and force versus velocity diagrams for selecting strokes and velocities[1, 3, 6, 7, 8]. The Faculty of Transport at the Silesian University of Technology is in the possession of mechanical indicator test stand [2, 4, 5]. The view of indicator test stand and kinematic scheme of this stand presents fig 2.

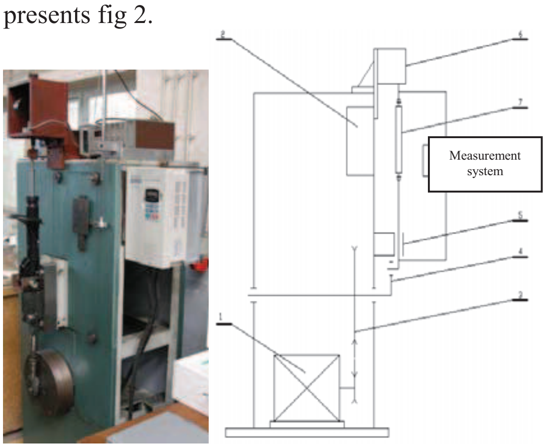

Fig. 2. The indicator test stand view and kinematic scheme: 1- electric motor, 2- frequency converter, 3- belt transmission, 4- eccentric system, 5- slider ways, 6- force sensor, 7- shock absorber.

This test stand is electric engine driven. The rotary velocity of engine is controlled by frequency converter. The belt transmission with cog belt connects the engine and the eccentric system with arm. Length of this arm determines the stroke in research and can by changeable by steps about 4 [mm]. The rotary move of eccentric system is changed into linear move of slider.

The lower end of shock absorber is mounted in slider. The piston rod is mounted in force sensor where the dumping force is measured.

To measure of forces the bi-directional extensometer sensor was used (range of sensor was 5 kN). The linear displacement of shock absorbers lower end is measured too. To measure linear displacement inductive displacement sensor PTx 200 was used. The analog signal from these sensors are recorded using SigLab 20-22A with high frequency sampling (2048 [Hz]).The minimum 15-th stress cycle (bound and rebound) was recorded every time. The analog signals were filtering with FIR (finite impulse response) filter and the force-displacement diagrams are the average of all recorded cycles.

The twin tube hydraulic shock absorber for front suspension of Fiat Punto was researched (fig.3). Before the measurement procedure the shock absorber was initially heated up to temperature stabilization.

Fig. 3. The twin tube hydraulic shock absorber for front suspension of Fiat Punto

3. ANALYSE OF RESEARCH RESULTS

For determining set of shock absorber dumping characteristics, series of researches for different combinations of stroke value and rotary velocity was made. For every stoke, the frequency of extortion was chosen so as to set the same maximum linear velocity every time.

The results of researches show the cumulative force versus displacement (fig.4) and force versus velocity diagrams (fig.5)

The shape of loop on force versus velocity diagrams is changed in stroke function. For higher strokes and higher frequency they are visibility curvature. These curvatures are made adequately to time moment of open bump and rebound values. For low stroke this curvatures aren't visible and the shape of loop is similar to elliptic curve.

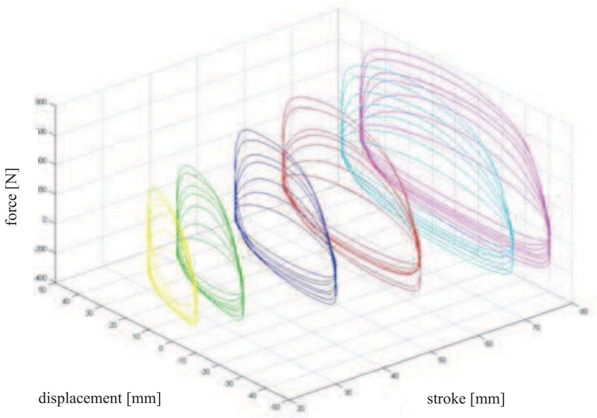

Fig. 4. Force versus displacement diagrams (each color for different stroke)

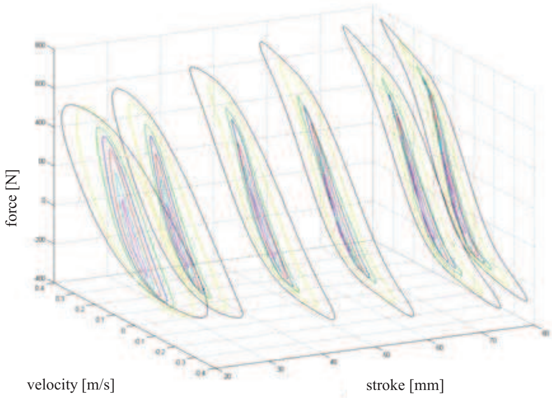

Fig. 5. Force versus velocity diagrams (each color for different maximum linear velocity)

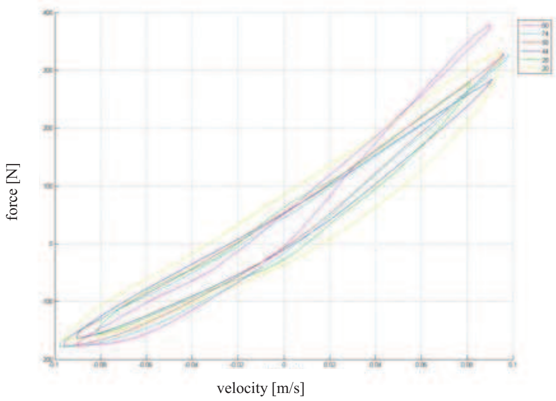

Fig. 6. Force versus velocity diagrams for chosen maximum linear velocity 0.1 [m/s] (each color for different stroke)

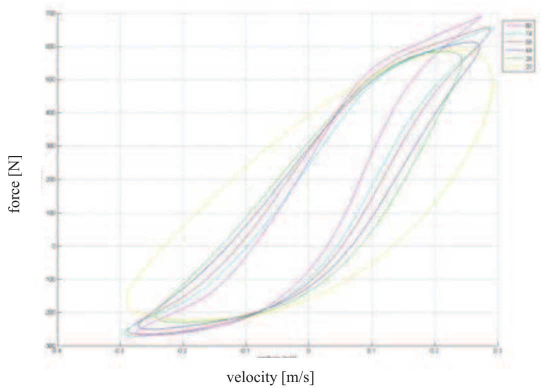

Fig. 7. Force versus velocity diagrams for chosen maximum linear velocity 0.3 [m/s] (each color for different stroke)

On fig 6 and 7 there are shown diagrams for different strokes. For maximum linear velocity above 0.1 m/s there are not any visible differences. For maximum linear velocity above 0.3 m/s there are visible differences related to time moment of open bump and rebound values. The next fig. 8 and 9 show set of shock absorber dumping characteristics series (force points for maximum linear velocity for different strokes).

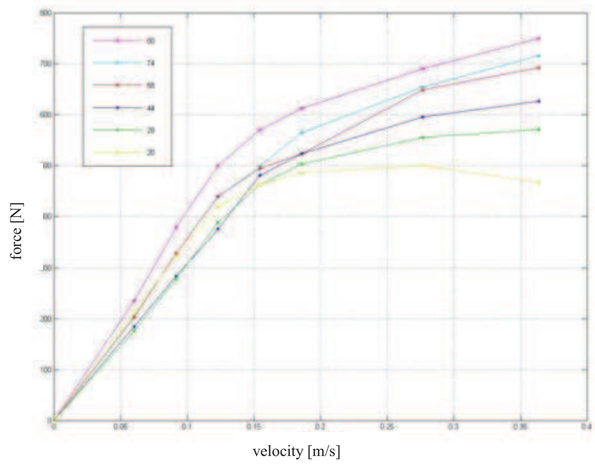

Fig. 8. Dumping force characteristic for bump (each color for different stroke)

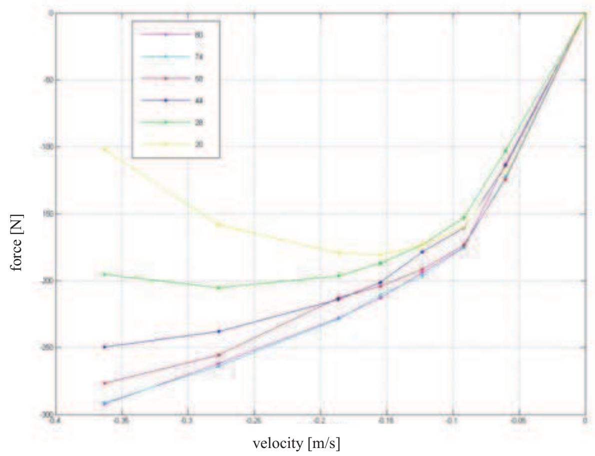

Fig. 9. Dumping force characteristic for rebound (each color for different stroke)

Analyse of obtaining points dumping characteristics for bound and rebound let state that for low strokes and higher maximum linear velocities the force of dumping is lower for bump and for rebound.

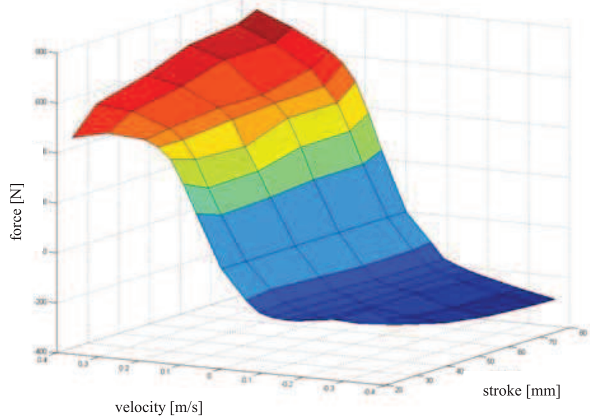

Fig.10. Dumping force surface in stroke and linear velocity function

The dumping characteristics for bump and rebound presented on fig 8 and 9 were expanded in second parameter (stroke) so this way the dumping surface in stroke and linear velocity function was made (fig10).

4. CONCLUSION

The results presented in paper show some disadvantages and simplification resulting from taking dumping characteristics of shock absorber only as a function of maximum linear velocity. Particularly that form of describing of shock absorber dumping characteristics is used in simulation research of vehicle dynamic. The analyse of presented results put emphasis on the influence of some factors like cavitations or valve inertia on shape of loop on force versus velocity diagrams and dumping forces on dumping characteristics. For higher maximum linear velocity and short stroke on dumping characteristics the dumping forces are lower than forces for long short for bump and rebound. These results will be used in simulation researches while taking into account dumping force as surface.

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