BASIC DYNAMIC PARAMETERS OF COMPOSITE LEAF SPRINGS

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Abstract

In this paper research results of ability vibration's suppression steel and composite leaf springs were presented. Polymeric composite leaf springs and steel were studied. Composite leaf springs were made from epoxy-glass composite reinforcement by glass fibre. Composite springs became designed to can replace steel spring of van. Executed investigations base on dynamic loadings of leaf springs and registering of vibrations amplitude and reaction of props. Load was realized through lowering from definite height of mass which hit into spring wresting it from balance. Mass stayed on spring to total atrophy of vibrations. Measured and registered parameters permitted to count logarithmic decrement suppressions of tremblings and coefficient of suppression of tremblings. This coefficient was counted for composite and steel leaf springs. Basic exploational parameters of leaf springs were compared as well as basic advantages of applying to vehicles building of composite materials were analysed. Analyses lead to conclusion that composite leaf springs in comparison to steel springs: about three times better suppress of tremblings, they are about five times lighter and give smaller dynamic burdens of vehicles body. Wide applying of composites materials on carrying structures of vehicles will contribute to lower of vehicles mass and to decrease of emission greenhouses' gases.

Keywords*: motor vehicle, glass-epoxy composite, light cars, leaf springs*

1. Introduction

The growing oil prices as well as pollution forces the engineers worldwide to search for alternative energy sources for mobile transportation and use new materials for car body build. It seems that we are at crucial point now. “It's not evolution, it's revolution.

The emissions from the transport sector have to be reduced. The EU has set goals for the reduction of greenhouse gas emissions 20 % until 2020. Increased use of composite materials for car body build is one solution to reach these goals. Others are more energy efficient cars and changeover to cleaner transport models.

Use of polymers composite materials to building of elements vehicle suspensions this is not only straight replacement steel by different material. Composite material makes possible, any formation of transverse section produced element, and similarly its stiffness. Possible is constructing of suspensions with assumption characteristics as well as construct of integrated elements of suspensions fulfilling simultaneously part of springy and leading elements. Thanks it was been possible to simplication of construction vehicle's suspension and to lower considerably its weight and costs of production. Moreover larger ability accumulating of springy energy by composite material can permit onto applying smaller and straighter dampers. Numerous researchers prove that springy elements constructed from composites materials in comparison to steel possess higher fatigue durability, they are resistant onto corrosion and they are repeatedly lighter. Serious advantage of composite materials is way of its damaging under of fatigue loading. Elements made from this materials, opposed to steel, do not rapidly damage. What considerable to increase safety of vehicle exploitation. Listed properties of composite materials will decide about wider applying of them to building of cars' vehicles in this also to building springy elements of suspensions.

2. General idea

Research ability of suppress vibrations composite spring leaf, was aim of this work. Composite left spring was exchangeable with steel spring applied in delivery van. Comparison of property of steel and composite spring was made.

Realization of work demanded realizations of composite spring with identical like steel properties as well as solution of many technical problems to obtainment repeatability of properties. This problem was described in work [6]. Composite leaf springs were researched. Way of installations and dimensions was like in steel springs. Diagram construction's of composite springs which used to investigations is presented on Fig. 2. These springs have solid width and changing thickness. The springs leaf was made in parabole shape, has three layers. Central layer (3 Fig. 2) thickness is changed along length. External layer (2 Fig. 2) called covers have solid thickness. Every layer was made from epoxy composite which was strengthened by glass continuous fibre. Such structure of spring leaf was result necessity of assurance sufficient on cutting and bending durability and required flexibility. On the two ends spring leaf has special profile nests which co-operated with steel – rubber funnels. Detailed description building of spring became introduced in [6].

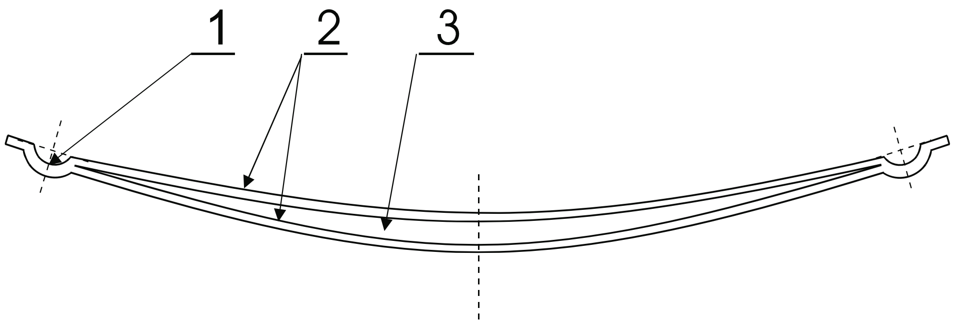

Fig. 1. Diagram of composite leaf spring: 1 - nests to fixing of funnel, 2 - covers, 3 - core

Fig. 2. Composite leaf spring

Tab. 1. Basic dimensions of leaf spring

Parameter	leaf spring	
	composite	steel
Width of spring [mm]	80	80
Length of spring [mm]	1305	1305
Mass of spring [kg]	12	50

3. Experimental researches

Research device was introduced on Fig. 3. It was constructed from two of principle components: loading component and measurement- registering component. Loading device is built from striking part – 6 (Fig. 3) and steering component – 8 (Fig. 3). Measurement –registering device is erected from sensor of force- 2, sensor of perpendicular dislocations of spring resource – 3, sensor of horizontal dislocations ends of spring – 3. The device has given possible static and dynamic loading of leaf spring. Loading has been realized by free lowering of striking part which was hanged on tench and was placed in runners. Strength of props was measured by sensor of strengths. Perpendicular and horizontal dislocations of spring as well as it are movable end by sensors of dislocations. Signals from sensors were transmitted to the computer of PC where they were recorded on textual files. Steel and composite leaf springs have been investigated. Springs leaf have been loaded by striking part. After hitting striking part was stayed on spring down to atrophy of vibrations.

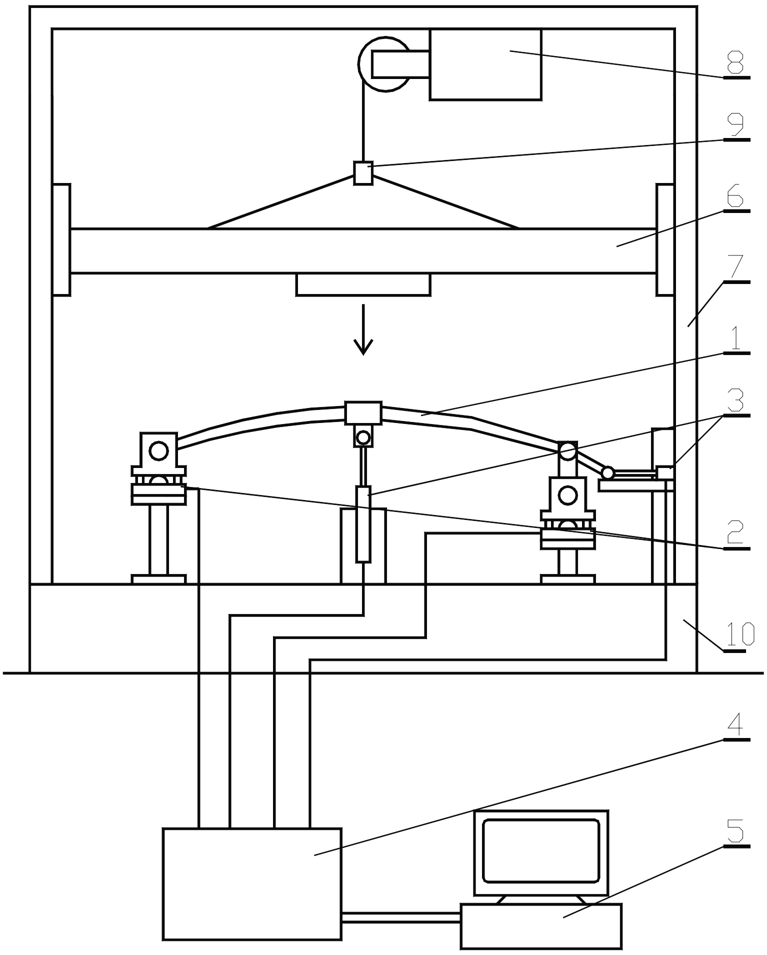

Fig. 3. Diagram of research device. 1- leaf spring, 2- sensor of force, 3- sensor of dislocations, 4- amplifier, 5- PC computer, 6- striking part, 7- runners, 8, 9 - steering component

Data from sensors were recorded on textual files in computer of PC. Using this data for each test was made graphs which showed radial diffraction and sum of perpendicular reaction of props in function of time. Also for every test coefficient of suppression of vibrations was calculated. In the Table no 2 and drawing no 4 measurements data for composite leaf spring have showed, in drawing no 5 and Table no 3 for steel spring leaf.

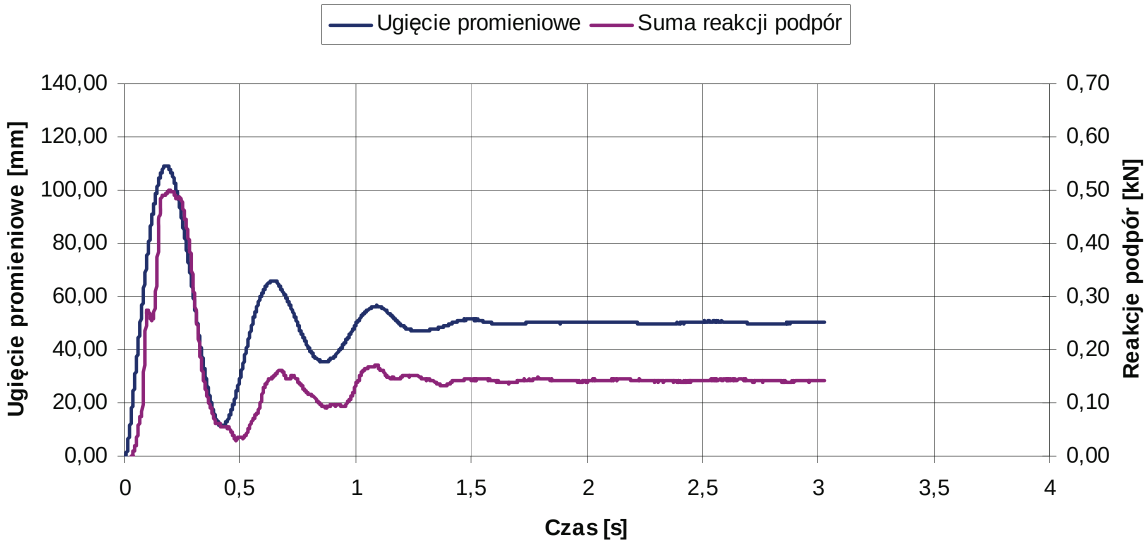

Fig. 4. Diffraction and total of perpendicular reaction of props in function of time composite leaf spring

Tab. 2. Coefficients of suppression of vibrations for composite leaf spring

No. of test	Deflexion I a_n [mm]	Deflexion II a_{n+1} [mm]	Tim I t_n [s]	Tim II t_{n+1} [s]	Period of vibrations [s]	Logarithmic decrement of suppression D	Coefficients of suppression q
0-1	27.6	0.74	0.420	0.890	0.470	1.3	2.77
0-2	25.4	0.54	0.225	0.692	0.467	1.54	3.30
0-3	15.9	0.34	0.223	0.725	0.502	1.54	3.07
20-1	47.1	15.3	0.160	0.603	0.443	1.12	2.53
20-2	36.7	7.5	0.202	0.652	0.450	1.59	3.53
20-3	49.7	11.3	0.187	0.627	0.440	1.48	3.63
30-1	59.0	15.8	0.180	0.634	0.454	1.32	2.91
30-2	61.8	27.4	0.176	0.663	0.502	0.81	1.95
30-3	60.6	23.8	0.186	0.665	0.490	0.93	1.84

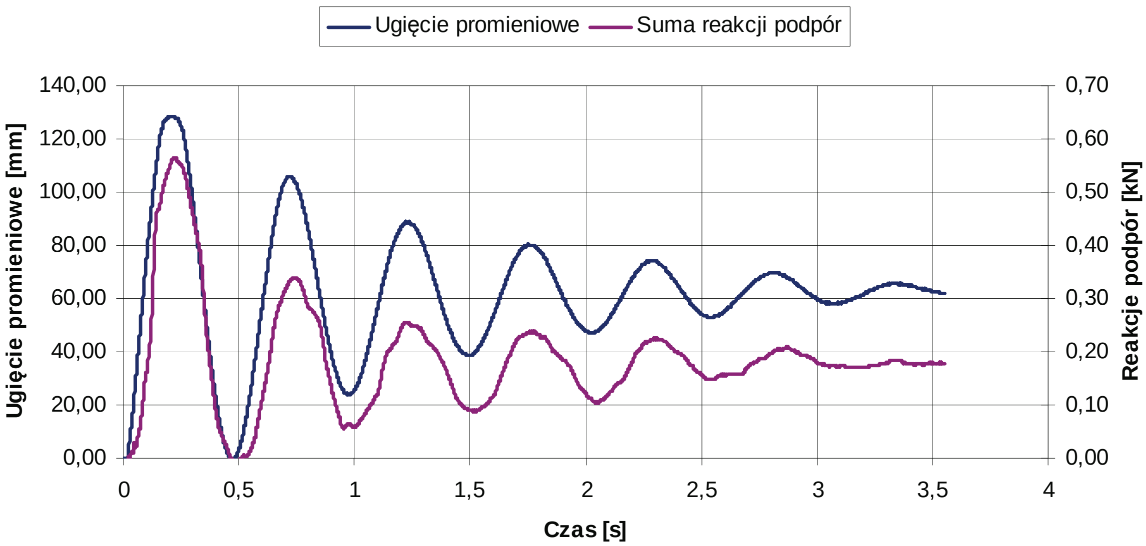

Fig. 5. Diffraction and total of perpendicular reaction of props in function of time steel leaf spring

Tab. 3. Coefficients of suppression of vibrations for steel leaf spring

No. of test	Deflexion I a_n [mm]	Deflexion II a_{n+1} [mm]	Tim I t_n [s]	Time II t_{n+1} [s]	Period of vibrations [s]	Logarithmic decrement of suppression	Coefficients of suppression
0-1	43.9	24.4	0.262	0.785	0.523	0.59	1.12
0-2	45.3	24.3	0.259	0.788	0.529	0.62	1.18
0-3	45.2	24.5	0.258	0.776	0.518	0.61	1.18
10-1	49.4	28.2	0.223	0.745	0.522	0.56	1.08
10-2	50.8	33.1	0.222	0.757	0.535	0.43	0.80
10-3	51.0	30.2	0.218	0.728	0.51	0.53	1.03
20-1	62.7	36.6	0.212	0.723	0.511	0.54	1.05
20-2	65.4	38.0	0.20	0.714	0.512	0.54	1.06
20-3	65.8	38.6	0.199	0.732	0.533	0.53	1.00
30-1	66.2	43.5	0.2	0.706	0.506	0.42	0.83
30-2	66.0	46.4	0.194	0.711	0.517	0.35	0.68
30-3	66.4	43.8	0.21	0.723	0.513	0.41	0.81

4. Summary

After precipitation from position of equilibrium composites springs within 1.5 s brought to full muffling of vibrations. In the same time steel springs reduced amplitude of vibrations about 40 %. After this time steel spring in further draught trembled with diminishing amplitude. To full muffling of vibrations of steel spring reached after about 5 s. On drawings 4 and 5 courses of vibrations were shown one from steel leaf springs and one from composite leaf springs. Time of muffling the vibrations of steel spring was over four times longer than composite springs.

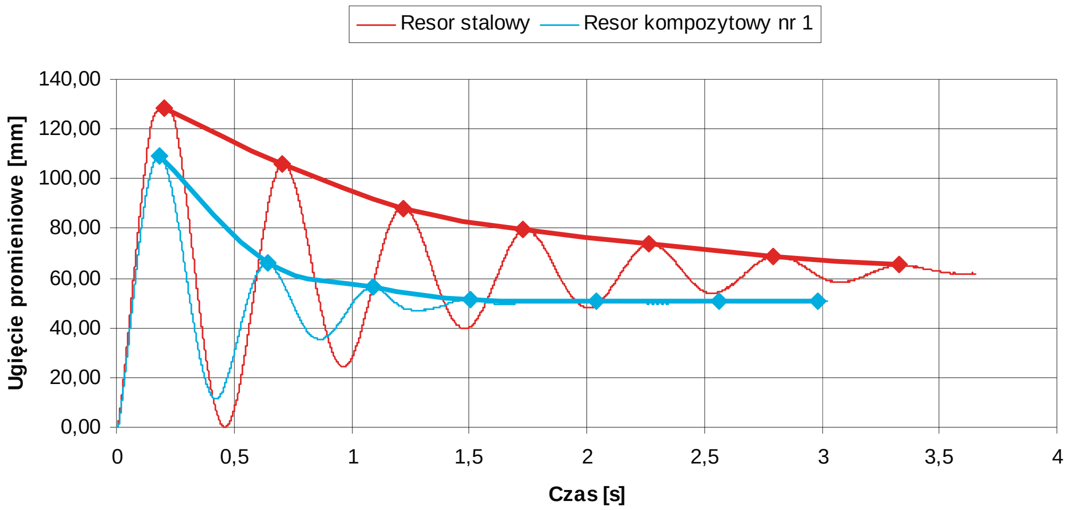

Fig. 6. Tremblings course of chosen steel and composite leaf spring

In Table no 4 was shown coefficient of suppression of vibrations steel and composite leaf springs. Coefficient of suppression of vibrations was calculated using of research dates and equation:

$$\rho = \frac{\ln\left(\frac{a_n}{a_{n+1}}\right)}{T}, \tag{1}$$

$$D = \ln\left(\frac{a_n}{a_{n+1}}\right), \qquad (2)$$

where:

D – logarithmic decrement of suppression,
T – period of vibrations [s],
a_n – first (larger) inclination,
a_{n+1} – next inclination.

Tab. 4. Suppression coefficients of vibrations composite's and steel's leaf springs

Test no	Energy of hitting	Leaf spring coefficients of vibrations	
		composite	steel
0-1	Static load Q= 3500N	2.77	1.12
0-2	Static load Q= 3500N	3.30	1.18
0-3	Static load Q= 3500N	3.07	1.18
20-1	1400 J	2.53	1.05
20-2	1400 J	3.53	1.06
20-3	1400 J	3.63	1.00
30-1	1750 J	2.91	0.83
30-2	1750 J	1.95	0.68
30-3	1750 J	1.84	0.81

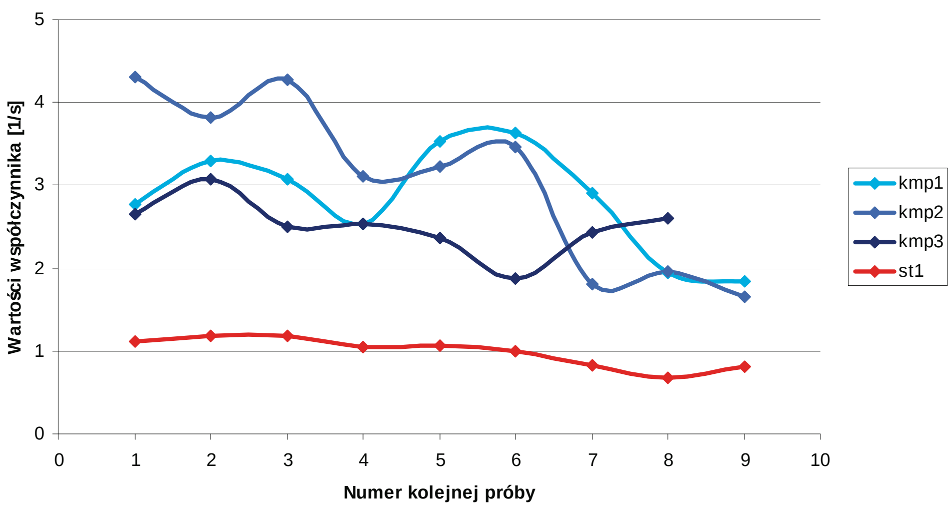

Fig. 7. Suppression coefficients of vibrations composite and steel's leaf springs

Vibration coefficients of suppression of leaf springs are very different. In case of composite springs these values hesitate from 1.65 to 3.63. Similarly coefficients for steel spring do not achieve such differences like for composite springs. These values are from 0.68 to 1.18 [Tab. 4]. Coefficients of vibrations suppression of steel leaf springs hesitate near one, they are about three times smaller than for composite springs. Property of vibrations suppression some composites leaf springs and steel leaf spring was shown on drawing no 7.

Smaller are not only value of vibrations suppression coefficients of steel leaf spring, smaller is sensibility for changing of loadings too. Coefficients of composite leaf springs clearly decrease when load is increasing. At the same of dynamic load, reactions of steel spring are larger than reaction of steel spring. Difference is about 20%.

Conclusion:

- Leaf springs made from glass-epoxy composite has larger than steel ability of vibrations suppression,
- Composite material is given possible make any shape of vehicle suspension components. Therefore possibility is getting of demanded stiffnesses, elasticity and ability of vibration suppression this components,
- Components of vehicle made from glass-epoxy composites are about 5 times lighter than made from steel,
- Use of composite materials to building of vehicle components is way reduction of emission of greenhouses' gases.

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