VIBRATION ISOLATORS TEST BENCH

Arkadiy Pobedin, Oleg Kosov
Kirill Shekhovtsov

Volgograd State Technical University, Faculty of Auto-tractor
Lenin Avenue 28, 400131, Volgograd, Russia
tel.: +7 8442 248162, fax: +7 8442 248182
e-mail: ts@vstu.ru, atd@vstu.ru, rip9@mail.ru

Abstract

The description of the scheme and design of the test bench for testing vibration isolators intended for use in the vehicles' cabin suspension. Test bench construction allows to implement a wide range of loadings on vibration isolator of the vehicle cabin, to investigate the impact of the loadings' arm changing and to perform analysis of the vibration isolator's elastic and damping characteristics changing impact on cushioning quality. Variant of the test bench construction modernization, which can allow applying typical exploitation loads, which include vertical and lateral components, is described. We propose a scheme of forced oscillations excitation system on the test bench by cam-eccentric mechanism. It includes a DC motor with stepless frequency regulation and with cams of different shape on its shaft, which affect the contact surface of the test bench's vertical H-beam of a rocker arm. We also propose a scheme of forced oscillations excitation system on the test bench by inertial exciter. It includes a DC motor with stepless frequency regulation with inertial vibration exciter on its shaft, which consists of a mass, placed eccentrically relative to the shaft axis. There are two variants of the test bench scheme – with the forced oscillations excitation device and without it.

Keywords: *vibration isolator, test bench, vehicle cabin, suspension, testing, elastic and damping characteristic*

ATS department of VSTU developed a test bench for the study of dynamic characteristics of vibration isolators, being used in vehicles' cab suspension.

Vibration isolators test bench (Fig. 1) contains a horizontal H-beam 1 of a frame, a stanchion 2 of a trunnion 3, a vertical H-beam 4 of a rocker arm with a load 5 placed on it, a stanchion 6 of a recording unit 7, a trigger 8, vibration isolator's upper support 9 with feet 10, vibration isolator's lower support 11 with feet 12, vibration isolator 13 and foundation fastening bolts 14.

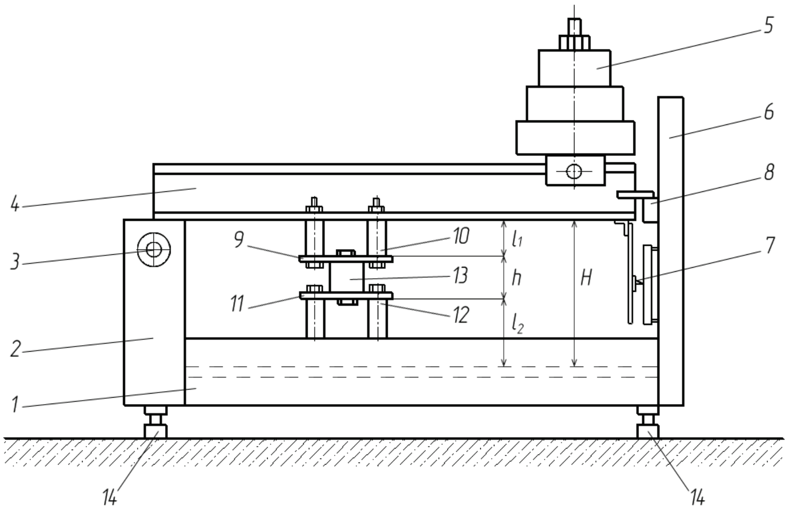

Fig. 1. Vibration isolators' test bench scheme

Pairs of holes 15 for vibration isolator's 13 lower support 11 feet 12 fastening are made along the longitudinal axis of H-beam 1 of a frame (Fig. 2). Pairs of holes 16 for vibration isolator's 13 upper support 9 feet 10 fastening are made along the longitudinal axis of H-beam 4 of a rocker arm (Fig. 3). Load 5 (Fig. 1 and Fig. 3) includes a set of metal discs 17 of different diameters and different heights (and therefore different masses), which have a central hole with a diameter equal to the tightening bolt 18 diameter, whose lower end is rigidly connected to the load support 19, which has holes 20 for its fastening to the top shelf of H-beam 4 of a rocker arm. Nut 21, which fastens a set of metal discs, is placed at the upper end of the tightening bolt 18.

Usually several vibration isolators are being installed in a real suspension of the technical object (e.g., cabin suspension of the vehicle) (Fig. 4) and the proportion of the loading force P_{zi} from the sprung object's weight Q per single vibration isolator depends on the distance L_i from the axis Z passing through center of gravity of the sprung object to the vibration isolator's vertical axis of symmetry Z_i and may vary during the suspension work process (i.e. the arm of the loading force, that influences upon the vibration isolator can vary). Due to the fact that the test bench design allows to set the vibration isolator 13 at different distances from stanchion 2 of a trunnion, test bench allows to reproduce the vibration isolator's 13 working conditions with wide range of loading force arm value variation with the same mass of a load 5.

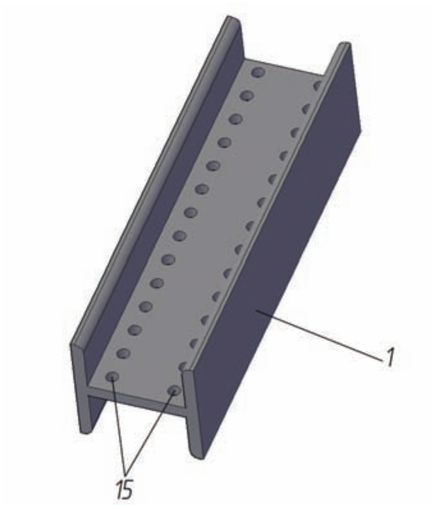

Fig. 2. H-beam of a frame

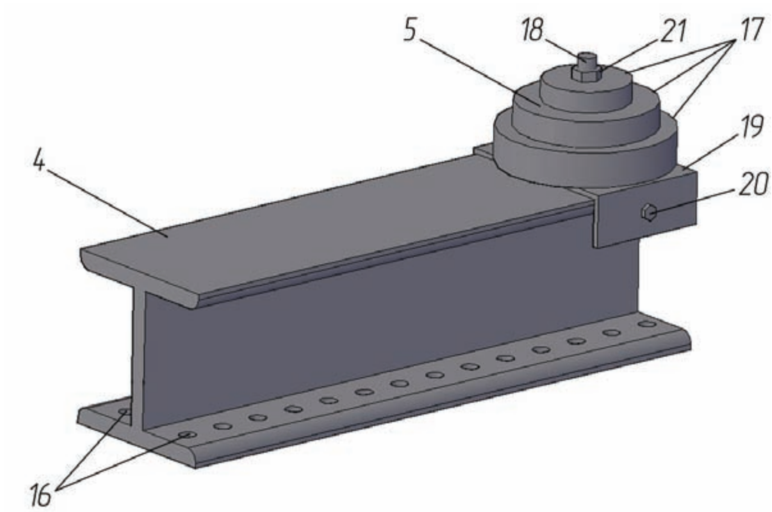

Fig. 3. H-beam of a rocker arm

Vibration isolators of the same construction can be used in the technical objects' suspensions with different sprung masses. Thus for different technical objects the proportion of the loading force to the weight of these masses for each vibration isolator can vary greatly. Due to the fact that the load 5 consists of a set of metal disks (Fig. 1 and Fig. 3), the number, size and weight of which can vary in a wide range, test bench allows to simulate the impact on the vibration isolator 13 with different loading forces. That provides the ability to reproduce the vibration isolators' loading conditions in technical objects' suspensions with various sprung masses.

In accordance with the sprung mass value, vibration isolators with proper rigidity are being set into the real technical objects' suspensions. The value of this rigidity depends on the vibration isolator's design, on the elastic element or elastic elements' combination being used and on vibration isolator's overall dimensions. Test bench (Fig. 1) provides the possibility to change the vibration isolator's 13 vertical position by installing the vibration isolator's upper support 9 feet 10 of various length l_1 and lower support 11 feet 12 of various length l_2, while the total length of the vibration isolator's 13 upper 9 and lower 11 supports' legs 10 and 12 must be equal to the vertical distance H from the vertical H-beam 4 of a rocker arm to the horizontal H-beam 1 of a frame minus vibration isolator's 13 height h. Due to this test bench allows to test vibration isolators with various rigidity and dimensions.

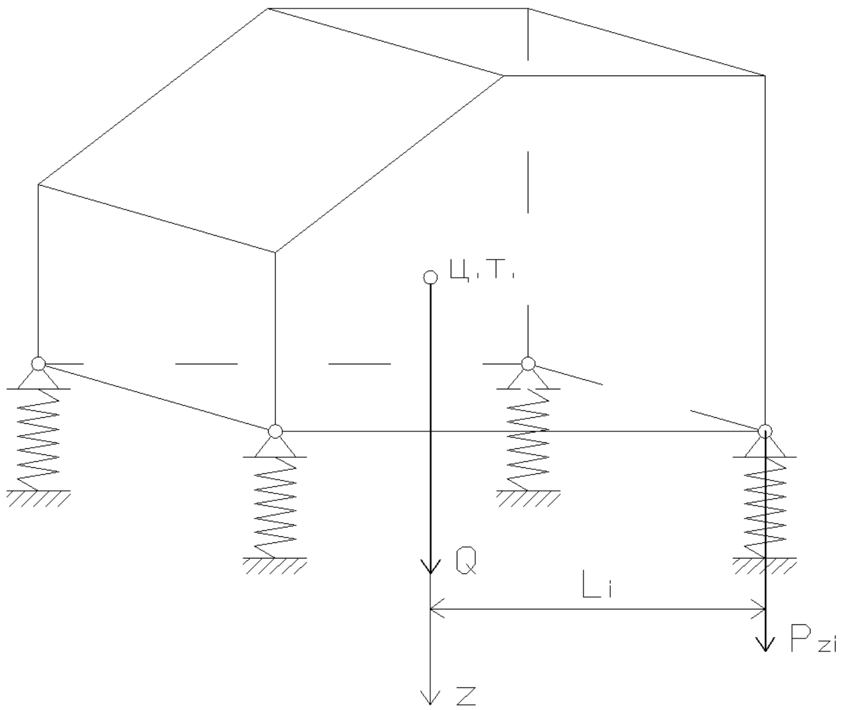

Fig. 4. Scheme of vibration isolators installation in the real technical object's suspension

Vibration isolators' test bench works as follows. Vibration isolator 13 is being set between the upper 9 and lower 11 supports at a specified distance from stanchion 2 of a trunnion 3. While the trigger 8 is closed, load 5 with specified mass is being set on the vertical H-beam 4 of a rocker arm on specified distance from the stanchion 2 of a trunnion 3. The load mass is determined by the total mass of the metal discs set. When the trigger 8 opens, vertical H-beam 4 of a rocker arm rotates relative to the trunnion 3 under the weight of the load 5 and loads the vibration isolator 13 with pulse force through the vibration isolator's 13 upper support 9. Oscillations of the vertical H-beam 4 of a rocker arm, which are transmitted to it through the vibration isolator's 13 upper support 9, are registered with the recording unit 7, relaxation oscillations graph is recorded on computer disc. Computer software determines a number of basic vibration isolator's parameters (dynamic and static rigidity, damping value, natural frequency etc.) and evaluates its vibroisolation qualiries.

Thus the test bench is a mechanical oscillating system, which uses the vibration isolator as the elastic element. Elastic element's deformation and loading is converted into electrical signal (with tensometric sensors) and are submitted to computer processing and analysis. Computer calculates the system's natural frequency, damping value, vibration isolator's dynamic and static rigidity and shows the data together with relaxation oscillations graph on the screen.

The advantage and novelty of the test bench design is that it allows to determine a range of vibration isolator's parameters from relaxation oscillations recording and to produce its comparative assessment. The test bench as opposed to the other models, allows to vary in wide range the dynamic and static loading on the vibration isolator (up to 3000 N) and natural frequency of vibration (up to 160 rad/s), to test the vibration isolators up to 140 mm, to vary the excitation pulse value.

For the test bench modernization we propose a design of the device for loading the vibration isolator with vertical and lateral loads combination (Fig. 5). It includes an angle mounted base slab 1, which is pivotally connected with the plate, that contacts with the vibration isolator's upper base, and one of the stanchions (stanchion 2) is able to move trough the base plate and to be fixed with the bolts in the slots made in the plate (view A). This changes the position of base slab 1, which allows to reproduce the loads, that act on the vibration isolator angularly.

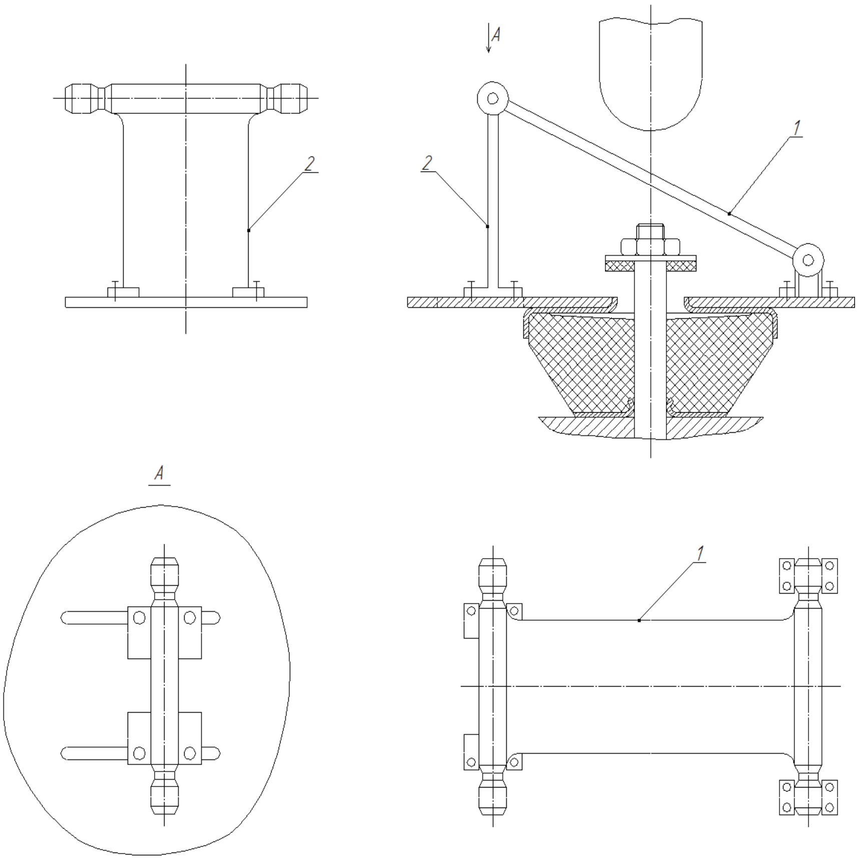

Fig. 5. Design of the device for loading the vibration isolator with vertical and lateral loads combination

We propose a scheme of forced oscillations excitation system on the test bench by cam-eccentric mechanism (Fig. 6). It includes a DC motor with stepless frequency regulation and with cams of different shape on its shaft, which affect the contact surface of the test bench's vertical H-beam of a rocker arm.

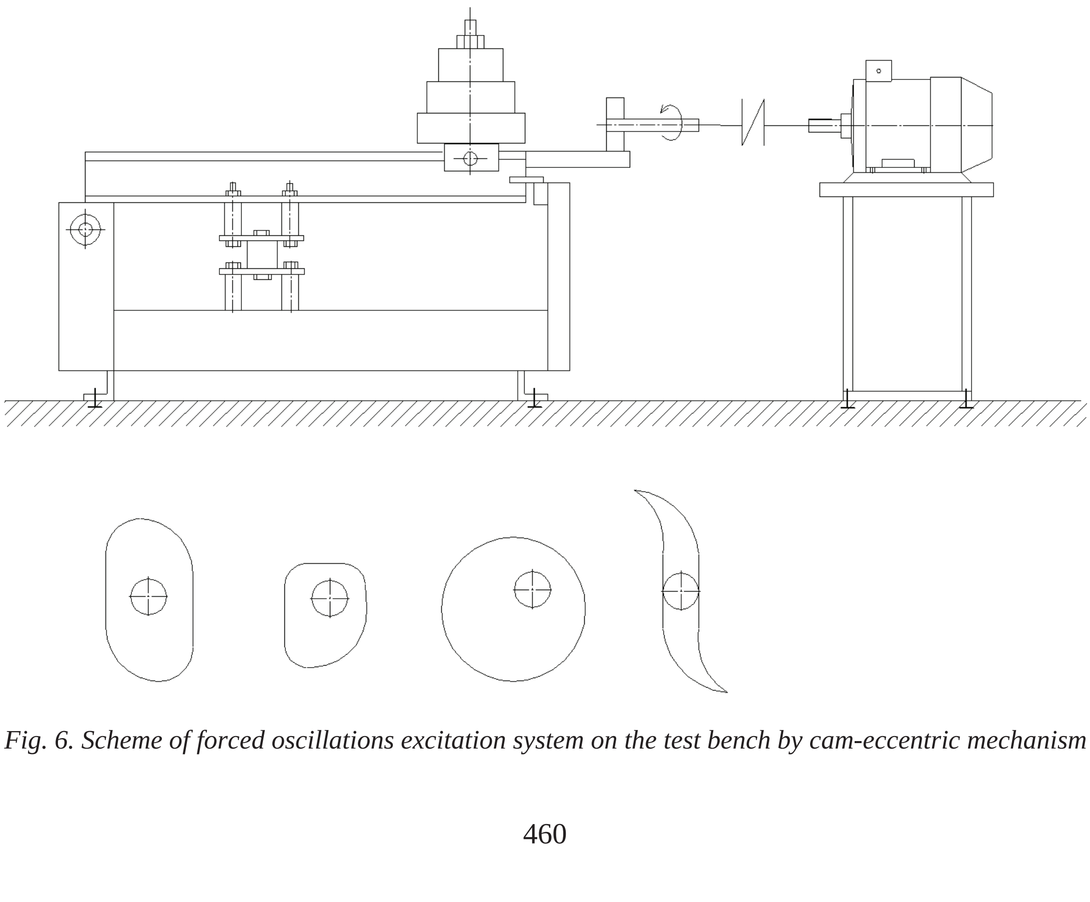

Fig. 6. Scheme of forced oscillations excitation system on the test bench by cam-eccentric mechanism

We also propose a scheme of forced oscillations excitation system on the test bench by inertial exciter (Fig. 7). It includes a DC motor with stepless frequency regulation with inertial vibration exciter on its shaft, which consists of a mass, placed eccentrically relative to the shaft axis. There are two variants of the test bench scheme – with the forced oscillations excitation device and without it.

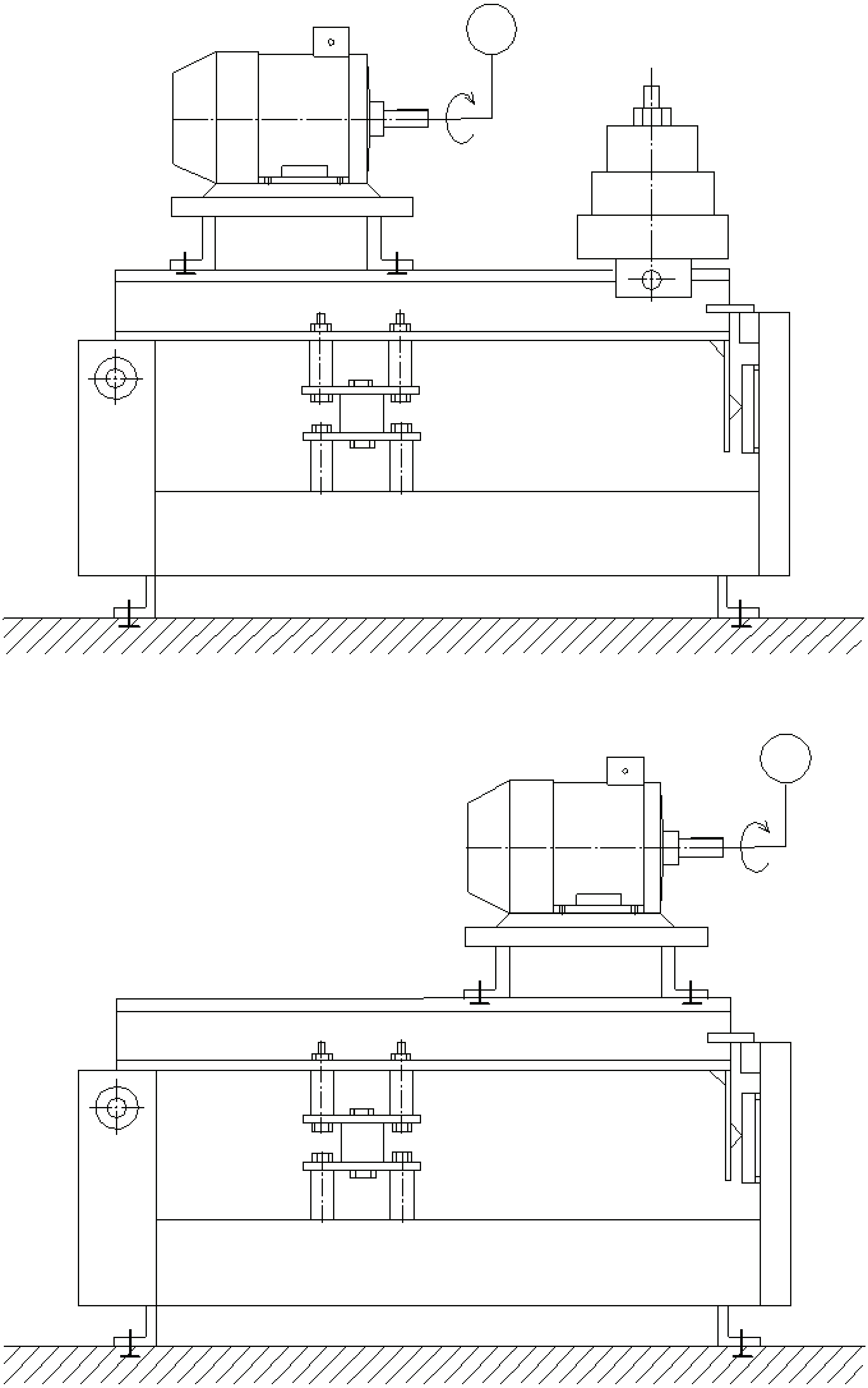

Fig. 7. Scheme of forced oscillations excitation system on the test bench by inertial exciter

References

[1] Pobedin, A. V., Kosov, O. D., Shekhovtsov, V. V., Shekhovtsov, K. V., *Analiz tekhnicheskikh rescheniy vibroizolyatorov*, Progress transportnykh sredstv i sistem - mater. mezhdunar. n.-pr. konf, Volgograd, 13-15 okt. 2009 g.: v 2 ch. Ch. 1 / VolgGTU, s. 210-211, Volgograd 2009.

[2] Pobedin, A. V., Kosov, O. D., Shekhovtsov, V. V., Shekhovtsov, K. V., *Model` podveski kabiny traktora*, Progress transportnykh sredstv i sistem - mater. mezhdunar. n.-pr. konf, Volgograd, 13-15 okt. 2009 g.: v 2 ch. Ch. 1 / VolgGTU, s. 222-223, Volgograd 2009.

[3] Shekhovtsov, V. V., Pobedin, A. V., Kosov, O. D., Shekhovtsov, K. V., *Analiz i klassifikaciya tekhnicheskikh resheniy vibroizolyatorov podveski kabiny,* Proyektirovaniye kolyosnykh mashin: mater. vseros. nauch.-tekhn. konf., posvyashch. 100-letiyu nachala podgot. inzh. po avtomobil`noy special`nosti v MGTU im. N.E. Baumana (25-26 dek. 2009 g.) / GOU VPO "MGTU im. N.E. Baumana", s. 181-184, Moskva 2010.

[4] Pobedin, A. V., Shekhovtsov, V. V., Shekhovtsov, K. V., *Analiz skhem i konstrukciy, raschyotnye issledovaniya uprugo-dempfiruyushchikh ustrojstv podveski kabiny traktora*, Innovacionnyye tekhnologii v obuchenii i proizvodstve: mater. VI vseros. nauch.-prakt. konf., g. Kamyshin, 15-16 dek. 2009 g. V 6 t. T. 1 / GOU VPO VolgGTU, KTI (filial) VolgGTU, s. 127-130, Volgograd 2010.

[5] Shekhovtsov, V. V., Pobedin, A. V., Liashenko, M. V., Shekhovtsov, K. V., *Razrabotka modeli i raschyotnyye issledovaniya podveski kabiny transportnogo sredstva*, Proyektirovaniye kolyosnykh mashin: mater. vseros. nauch.-tekh. konf., posvyashch. 100-letiyu nachala podgot. inzh. po avtomobil`noy special`nosti v MGTU im. N.E. Baumana (25-26 dek. 2009 g.) / GOU VPO "MGTU im. N.E. Baumana", s. 184-188, Moskva 2010.

[6] Pobedin, A. V., Shekhovtsov, V. V., Shekhovtsov, K. V., *Raschyotnyye issledovaniya dlya sovershenstvovaniya podveski kabiny avtomobilya*, Kakoy avtomobil` nuzhen Rossii?, mater. 69 mezhdunar. nauch. tekhn. konf. Assotsiatsii avtomobil`nykh inzhenerov (AAI) / GOU VPO "Sibirskaya gos. avtomob.-dor. akademiya (SibADI)" [i dr.], s. 112-117, Omsk 2010.

[7] Shekhovtsov, V. V., Pobedin, A. V., Liashenko, M. V., Shekhovtsov, K. V., *Classification and Analysis of the Ways of Cabin Suspension Vibroinsulators` Characteristic Formation*, XXIX Seminarium Kol Naukowych "Mechaników", s. 449-452, Wojskowa Akademia Techniczna, Warszawa 2010.

[8] Shekhovtsov, V. V., Pobedin, A. V., Liashenko, M. V., Shekhovtsov, K. V., *Development and Calculation Researches of the Vehicle`s Cabin Suspension Model*, XXIX Seminarium Kol Naukowych "Mechanikow", s. 453-458, Wojskowa Akademia Techniczna, Warszawa 2010.

[9] Shekhovtsov, V. V., Pobedin, A. V., Shevchuk, V. P., Liashenko, M. V., Shekhovtsov, K. V., *P.m. 93477 RF, MPK F 61 F 7/12. Vibroizolyator*, GOU VPO "VolgGTU" 2010.