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# LABORATORY RESEARCH OF VIBRATION IMPACT PARAMETERS ON THE COAL SEAM THROUGH HOST ROCKS

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# ЛАБОРАТОРНІ ДОСЛІДЖЕННЯ ПАРАМЕТРІВ ВІБРАЦІЙНОГО ВПЛИВУ НА ВУГІЛЬНИЙ ПЛАСТ ЧЕРЕЗ ВМІЩУЮЧИ ПОРОДИ

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# ЛАБОРАТОРНЫЕ ИССЛЕДОВАНИЯ ПАРАМЕТРОВ ВИБРАЦИОННОГО ВОЗДЕЙСТВИЯ НА УГОЛЬНЫЙ ПЛАСТ ЧЕРЕЗ ВМЕЩАЮЩИЕ ПОРОДЫ

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**Abstract**. The article is devoted to the stand tests research of the hydraulic vibrator systems and the establishment of their main parameters for influencing the coal-rock massive through the host rocks.

Based on the struts of mechanized supports, hydraulic systems of the vibrators working as compact vibratory machines are selected and improved. They carry out the controlling function of the coal-rock massive state through the host rocks in the longwall, working out hazardous flat-falling coal seams with hard-to-break roofs, often represented by hazardous sandstones. Stand tests of vibrator systems of two and three racks of hydraulic supports, which operate in continuous and pulsed modes with automatic and manual control, are carried out. In this case, the frequency-amplitude characteristics are obtained. Namely: the time of the liquid pressure relief and the synchronous operation of the hydraulic racks is determined. For this purpose, the laboratory stand is equipped with strain gauge pressure sensors and manometers. The study of the characteristics of hydraulic vibrator systems is carried out at various initial pressures, volumes of the piston cavities, rotation of the air motor, etc. Evaluation of the measurement results made it possible to establish that the true values of the measured quantities are in the necessary intervals. The main parameters of hydraulic vibrator systems, the frequency and amplitude of the impact are determined, and the fundamental possibility of their operation as compact hydraulic machines in the lavas of mines hazardous by sudden emissions of coal and gas and rock emissions is proved. Measurement of sound level, vibration pressure (up to 12 m/s$^2$) and vibration velocity (up to 1.4 m/s) meets safety requirements. When conducting stand tests, there were no significant malfunctions in the operation of the hydraulic vibrator system, which indicates its high reliability.

The principal possibility of using hydraulic systems as compact hydraulic machines has been established for controlling the condition of the coal and rock massif, moving the reference pressure zone from the bottom of the clearing generation and controlling the rock pressure of a hard-to-reach roof.

**Keywords:** hydraulic vibrator systems, hydraulic machines, coal-rock massive, vibration pressure, vibration velocity.

**Introduction.** Currently, vibratory machines and mechanisms are widely used in almost all industries and national economy. Their widespread use is due to the specific impact of vibrations on the various properties of solids, dry and liquids material.

The introduction of vibrotechnics in the industry assists to the intensification of technological processes increases the economic efficiency of enterprises, increases labor productivity. It also greatly simplifies and facilitates the automation of many technological processes, creates convenience when moving gassing and dusty materials, simplifies devices for intermediate loading and unloading coals, allows combining technological processes, etc.

For the coal industry is relevant when the mining complex was combined and safe. Namely, it included operation to reduce the outbreak of reduce fortresses bottomhole zone coalbed seam, on the management of the hard-to-fall roof, including outburst hazardous, enclosing rocks, that is make the coal mining process uniform and safe. Thus, several schemes of vibrator systems for vibration impact on the coal-rock massive were considered which took into account the possibility of using hydraulic equipment commercially produced by the machine-building industry of Ukraine.

Of all the systems considered, the most appropriate were selected as compact hydraulic machines as follows:

1) systems of hydraulic vibrators operating in continuous vibration mode;

2) systems of hydraulic vibrators operating in pulsed mode.

For their use in working gas mines it is necessary to establish the fundamental possibility of the operation of such systems as compact vibrating machines to control the condition of the coal and rock massive.

Therefore, the aim of the work is to conduct stand tests of the systems of hydraulic vibrators and the establishment of their main parameters for impact the coal-rock massive through host rocks.

**Methods**. When conducting research on vibrator systems on the stand, the following main tasks were solved:

1) verification of the performance of the proposed designs of the systems of vibrators;

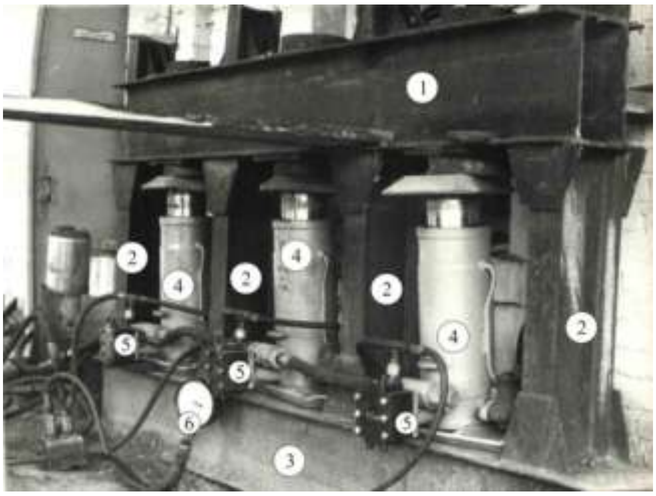
2) the study of the characteristics of the systems of vibrators (the frequency of oscillations of the rods of hydraulic props, the time of the pressure in the piston cavity, the time of unloading, the shape and amplitude of the oscillations, etc.);

3) the accumulation of experience with systems of hydraulic vibrators with regard to their use in gas mines.

Studies of the proposed systems of vibrators [1] were carried out on a laboratory stand (Fig. 1), which consisted of the upper support 1, racks 2 and the base 3. The base and upper supports were made of I-beams № 33 and the racks of I-beams № 20.

The change in pressure in the piston cavities of the hydraulic racks 4 was recorded using tensometric pressure sensors 5. Measuring equipment was connected to the sensors: a tensometer amplifier and a light beam oscilloscope. For visual observation, as well as for the calibration of strain gauges, a tensometer 6 was used.

Research of the characteristics of the systems of vibrators were carried out in the following order: using a crane beam, were installed hydraulic props on the stand; the power supply of the vibrator systems was installed; connected instrumentation; registration of characteristics of systems of vibrators; dismantling of vibrator systems; processing of measurement results.



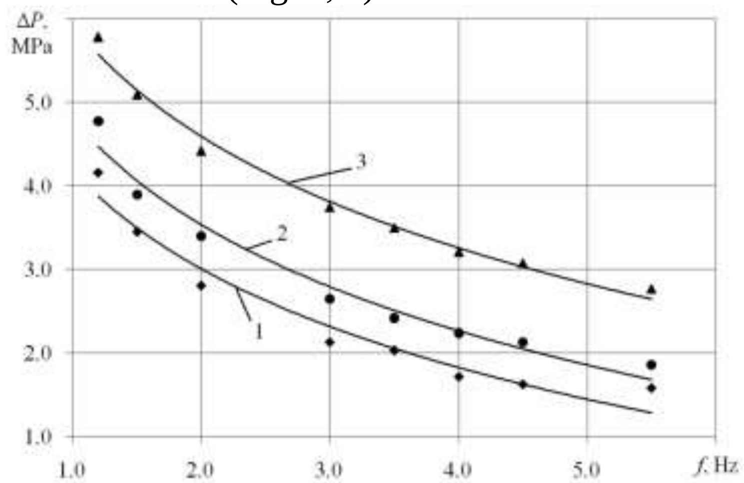

1 - upper support; 2 - stand; 3 - lower support; 4 - hydraulic racks;
5 - tensometric pressure sensors; 6 – manometer

Figure 1 - Laboratory stand for testing vibrator systems

The research of the systems characteristics of vibrators was carried out in continuous vibration and pulsed modes of operation at different initial pressures, volumes of piston cavities, rotational frequencies of the pneumatic engine, etc. The evaluation of the measurement results made it possible to establish that the true value of the measured values is in the required interval.

**Results and discussion**. The dependence of the change in the pressure amplitude in a hydraulic prop on the oscillation frequency of the rod and its variable volumes of piston cavities in the continuous vibration mode was determined [2, 3].

At the beginning, the tests were carried out on three hydraulic prop, and after the breakdown of one prop - on two props. The data obtained during waveform processing are presented in tables 1 and 2. On the basis of their built graphs of pressure changes in the piston cavities of hydraulic props on the oscillation frequency under different initial conditions (Fig. 2, 3).

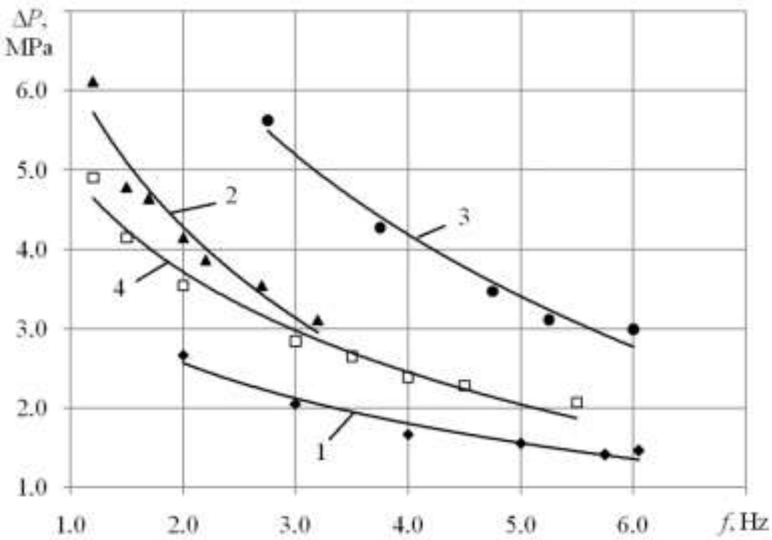



1 - hydraulic prop #1; 2 - hydraulic prop #2; 3 - hydraulic prop #3

Figure 2 - Pressure change in piston cavities as a function of the oscillation frequency for three hydraulic props

Table 1 - The change in pressure in the piston cavities of three hydraulic props depending on the initial pressure, initial volume and frequency of oscillation of the piston

| Piston oscillation frequency, *f*, Hz | Hydraulic props pressure, MPa | | Pressure change in hydraulic props, Δ*P*, MPa | Initial conditions | |
|---|---|---|---|---|---|
| | min | max | | Props pressure, $P_0$, MPa | The volume of the piston cavity prop, $V_0$, $m^3$ |
| 1.20 | 2.69 | 6.85 | 4.16 | 8.00 | 0.00095 |
| 1.20 | 2.34 | 7.12 | 4.78 | 8.00 | 0.00095 |
| 1.20 | 2.15 | 7.93 | 5.78 | 8.00 | 0.00095 |
| 1.50 | 2.58 | 6.03 | 3.45 | 8.00 | 0.00095 |
| 1.50 | 2.28 | 6.18 | 3.90 | 8.00 | 0.00095 |
| 1.50 | 2.03 | 7.12 | 5.09 | 8.00 | 0.00095 |
| 2.00 | 2.83 | 5.64 | 2.81 | 8.00 | 0.00095 |
| 2.00 | 2.58 | 5.98 | 3.40 | 8.00 | 0.00095 |
| 2.00 | 2.03 | 6.45 | 4.42 | 8.00 | 0.00095 |
| 3.00 | 2.67 | 4.80 | 2.13 | 8.00 | 0.00095 |
| 3.00 | 2.28 | 4.93 | 2.65 | 8.00 | 0.00095 |
| 3.00 | 2.01 | 5.76 | 3.75 | 8.00 | 0.00095 |
| 3.50 | 2.49 | 4.52 | 2.03 | 8.00 | 0.00095 |
| 3.50 | 2.19 | 4.61 | 2.42 | 8.00 | 0.00095 |
| 3.50 | 1.64 | 5.14 | 3.50 | 8.00 | 0.00095 |
| 4.00 | 2.76 | 4.48 | 1.72 | 8.00 | 0.00095 |
| 4.00 | 2.33 | 4.57 | 2.24 | 8.00 | 0.00095 |
| 4.00 | 1.89 | 5.10 | 3.21 | 8.00 | 0.00095 |
| 4.50 | 2.39 | 4.02 | 1.63 | 8.00 | 0.00095 |
| 4.50 | 2.15 | 4.28 | 2.13 | 8.00 | 0.00095 |
| 4.50 | 1.84 | 4.92 | 3.08 | 8.00 | 0.00095 |
| 5.50 | 2.07 | 3.65 | 1.58 | 8.00 | 0.00095 |
| 5.50 | 1.95 | 3.81 | 1.86 | 8.00 | 0.00095 |
| 5.50 | 2.12 | 4.89 | 2.77 | 8.00 | 0.00095 |




1 - two hydraulic props with $V_0$ = 0.00207 $m^3$ and $P_0$ = 7.5 MPa;
2 - two hydraulic props with $V_0$ = 0.00207 $m^3$ and $P_0$ = 11.0 MPa;
3 - two hydraulic props with $V_0$ = 0.00142 $m^3$ and $P_0$ = 13.0 MPa;
4 - three hydraulic props with $V_0$ = 0.00095 $m^3$ and $P_0$ = 8.0 MPa

Figure 3 - Dependence of average values of pressure change in piston cavities on the oscillation frequency for two and hydraulic props under different initial conditions

Table 2 - The change in pressure in the piston cavity of two hydraulic props, depending on the initial pressure, initial volume and frequency of oscillation of the piston

| Piston oscillation frequency, *f*, Hz | Hydraulic props pressure, *P*, MPa | | Pressure change in hydraulic props, Δ*P*, MPa | Initial conditions | |
|---|---|---|---|---|---|
| | min | max | | Props pressure, $P_0$, MPa | The volume of the piston cavity prop, $V_0$, m$^3$ |
| 2.00 | 3.95 | 7.00 | 3.05 | 7.50 | 0.00207 |
| 2.00 | 0.94 | 3.22 | 2.28 | 7.50 | 0.00207 |
| 3.00 | 3.68 | 6.11 | 2.43 | 7.50 | 0.00207 |
| 3.00 | 0.85 | 2.52 | 1.67 | 7.50 | 0.00207 |
| 4.00 | 3.56 | 5.59 | 2.03 | 7.50 | 0.00207 |
| 4.00 | 0.63 | 1.93 | 1.30 | 7.50 | 0.00207 |
| 5.00 | 3.27 | 5.07 | 1.80 | 7.50 | 0.00207 |
| 5.00 | 0.42 | 1.72 | 1.30 | 7.50 | 0.00207 |
| 5.75 | 3.27 | 4.84 | 1.57 | 7.50 | 0.00207 |
| 5.75 | 0.29 | 1.54 | 1.25 | 7.50 | 0.00207 |
| 6.05 | 3.74 | 5.21 | 1.57 | 7.50 | 0.00207 |
| 6.05 | 0.58 | 1.83 | 1.35 | 7.50 | 0.00207 |
| 2.75 | 5.02 | 10.99 | 5.97 | 11.00 | 0.00207 |
| 2.75 | 2.00 | 7.28 | 5.28 | 11.00 | 0.00207 |
| 3.75 | 5.02 | 9.65 | 4.63 | 11.00 | 0.00207 |
| 3.75 | 2.11 | 6.03 | 3.92 | 11.00 | 0.00207 |
| 4.75 | 5.43 | 9.23 | 3.80 | 11.00 | 0.00207 |
| 4.75 | 2.42 | 5.57 | 3.15 | 11.00 | 0.00207 |
| 5.25 | 1.58 | 5.11 | 3.53 | 11.00 | 0.00207 |
| 5.25 | 0.00 | 2.70 | 2.70 | 11.00 | 0.00207 |
| 6.00 | 1.65 | 5.02 | 3.37 | 11.00 | 0.00207 |
| 6.00 | 0.22 | 2.84 | 2.62 | 11.00 | 0.00207 |
| 1.20 | 5.94 | 12.30 | 6.36 | 13.00 | 0.00142 |
| 1.20 | 6.64 | 12.51 | 5.87 | 13.00 | 0.00142 |
| 1.50 | 5.74 | 10.88 | 5.14 | 13.00 | 0.00142 |
| 1.50 | 7.02 | 11.45 | 4.43 | 13.00 | 0.00142 |
| 1.70 | 5.53 | 10.86 | 5.33 | 13.00 | 0.00142 |
| 1.70 | 7.22 | 11.17 | 3.95 | 13.00 | 0.00142 |
| 2.00 | 5.53 | 10.15 | 4.62 | 13.00 | 0.00142 |
| 2.00 | 6.76 | 10.44 | 3.68 | 13.00 | 0.00142 |
| 2.20 | 5.53 | 10.04 | 4.51 | 13.00 | 0.00142 |
| 2.20 | 6.99 | 10.21 | 3.22 | 13.00 | 0.00142 |
| 2.70 | 5.53 | 9.63 | 4.10 | 13.00 | 0.00142 |
| 2.70 | 6.53 | 9.52 | 2.99 | 13.00 | 0.00142 |
| 3.20 | 4.92 | 8.61 | 3.69 | 13.00 | 0.00142 |
| 3.20 | 5.84 | 8.37 | 2.53 | 13.00 | 0.00142 |

Graph analysis in Figure 2 for three hydraulic props confirms that with an increase in the oscillation frequency the change in pressure in the piston cavities of the hydraulic props decreases which corresponds to the theoretical studies carried out [4]. So, with the frequency of oscillations of the rod $f$ = 1.2 Hz, the average value of the pressure change in the hydraulic props is 4.9 MPa, and at $f$ = 5.5 Hz – 2.1 MPa. The maximum oscillation frequency of the pistons of the three props was 5.5 Hz.

The graph is described by the following logarithmic equations: for hydraulic prop № 1

$$P(f) = -1.92 \cdot \ln(f) + 5.928,$$

with accuracy of approximation $R^2 = 0.99$;
- for a hydraulic prop #2

$$P(f) = -1.83 \cdot \ln(f) + 4.804,$$

with accuracy of approximation $R^2 = 0.97$;
- for a hydraulic prop #3

$$P(f) = -1.7 \cdot \ln(f) + 4.189,$$

with accuracy of approximation $R^2 = 0.96$.

The graphs of the pressure change in the hydroelectric piston cavities for the average values of the experimental studies results are shown in Figure 3.

Analysis of the graphs shows that the character of the established dependencies is similar to that obtained for a system of three hydraulic props. When reducing the flow area in the drain line is observed shift of the reference point of the pressure amplitude in the direction of its increase.

It was determined that with increasing pressure, the impact force generated by the vibrator system increases, the maximum value of which was at *P* = 13 MPa for a system of two hydraulic props ~ 710 kN and at *P* = 8.0 MPa for a system of vibrators from three hydraulic props ~ 600 kN.

The graphs are described by the following logarithmic equations:
- graph 1

$$P(f) = -1.1 \cdot \ln(f) + 3.331,$$

with accuracy of approximation $R^2 = 0.96$;

- graph 2

$$P(f) = -2.82 \cdot \ln(f) + 6.237,$$

with accuracy of approximation $R^2 = 0.94$;
- graph 3

$$P(f) = -3.94 \cdot \ln(f) + 9.024,$$

with accuracy of approximation $R^2 = 0.98$;

- graph 4

$$P(f) = -1.81 \cdot \ln(f) + 4.974,$$

with accuracy of approximation $R^2 = 0.98$.

When analyzing the oscillograms, the synchronicity and phase shift of forced oscillations of the pistons of hydraulic props are established. The phase shift with increasing frequency of oscillation of the pistons increases from φ=3° at $f$ = 1 Hz to φ=26° at $f$ = 6.5 Hz. The phase shift is influenced by the difference in pressure losses on the resistance of pipelines after the hydraulic control valve spool.

After testing the system of vibrators in continuous mode, the system was tested to operate in a pulsed mode. Initially, tests were conducted with a manual control system. At the same time, frequency-amplitude characteristics, time of discharge of fluid pressure were obtained, the synchronous operation of hydraulic props was determined.

In processing the oscillograms of pressure changes in the piston cavities of hydraulic props (Table 3) and a graph of pressure change versus time is presented (Fig. 4).

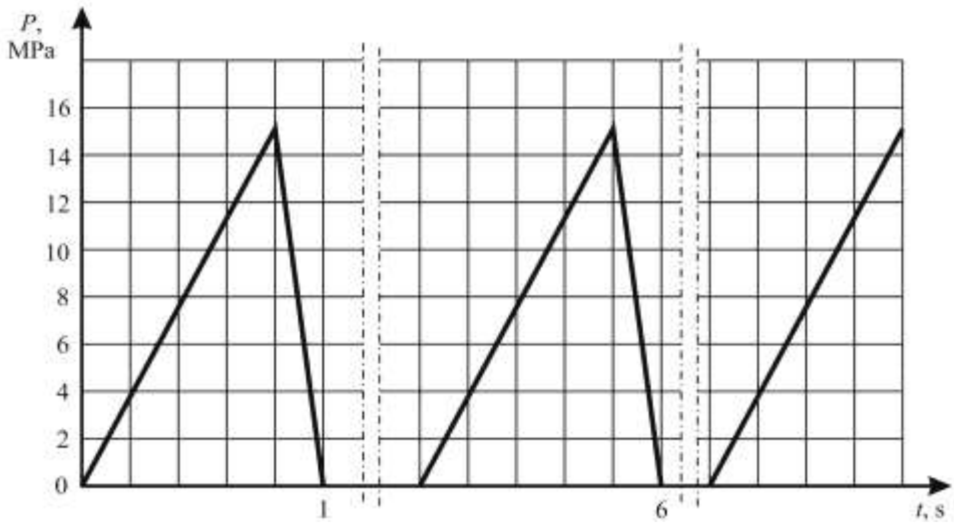



Figure 4 - The dependence of the pressure change in the piston cavities hydraulic props from time

Analyzing the dependence obtained shows that the maximum amplitude of pressure oscillations is 15 MPa, the rise time of the pulse from zero to a maximum is 7–9 s, and the fall time is 0.10–0.15 s. The minimum pulse repetition period is 15-20 s. Hence, the pulse repetition rate is $f$ = 0.06 Hz. The pulse shape is triangular.

In analyzing oscillograms, which were obtained by testing a system of vibrators from three poles, they were synchronized at a pulse repetition rate of $f$ = 0.05 Hz. The phase shift of the forced oscillations of the pistons of the hydraulic props was φ = 5°. This is influenced by the difference between the efforts of the spring action of the main valves of the hydraulic lock.

The maximum force of impact, which is created by a system of vibrators from three hydraulic legs, was 900 kN. During the testing of significant problems in the system of vibrators did not occur. This indicates a high system reliability.

The characteristics of the vibrator system operation in a pulsed mode with automatic control on the experimental equipment were determined.

Table 3 - The change in pressure in the piston cavity hydraulic props depending on time

| Pressure change in hydraulic prop $\Delta P$, MPa | Pressure recession time in hydraulic prop, $t$, s |
|---|---|
| 18.50 | 0.18 |
| 12.00 | 0.12 |
| 12.00 | 0.20 |
| 12.00 | 0.13 |
| 19.00 | 0.20 |
| 12.00 | 0.18 |
| 18.50 | 0.20 |
| 11.50 | 0.11 |
| 19.00 | 0.22 |
| 11.00 | 0.15 |
| 19.50 | 0.21 |
| 12.50 | 0.13 |
| 18.00 | 0.17 |
| 13.00 | 0.14 |
| 19.70 | 0.21 |
| 13.50 | 0.15 |
| 20.00 | 0.19 |
| 14.00 | 0.15 |
| 18.50 | 0.20 |
| 11.00 | 0.10 |

The data obtained are identical to the characteristics of the operation of the vibrator system in a pulsed mode with manual control. The pulse repetition period was 15–20 s.

Measurement of sound level, vibration acceleration and vibration velocity was carried out by the noise and vibration meter VSHV-003. The results showed in tables 4 and 5. It’s showed that the proposed vibrohydraulic device meets the safety requirements (does not exceed the allowable, for vibration acceleration - 12 m/s$^2$, for vibration velocity - 1.4 m/s), workable and can be used as a means of influence to control the state of a coal-rock massive [5].

The determination of the oscillation frequency of the piston rod was carried out according to the data obtained during experimental tests of oscillograms. Frequency determination was performed for each value (Table 1-3).

Confidence probability $\alpha = 0.90$, which is sufficient for mechanical tests.

The measurement of pressure in the piston cavities of the hydraulic props was carried out with a manometer MT, accuracy class 1.5 % of the final measurement scale $\eta = 40 \cdot 0.015 = 0.6$ MPa.

Table 4 - Dependence of the noise level on the oil station pressure

| Oil station pressure, MPa | Dynamic interval lower limit | | | | Frequency interval, Hz |
|---|---|---|---|---|---|
| | *A* | *B* | *C* | Line | |
| 8 | 25 | 30 | 30 | 35 | 69 |
| 9 | 27 | 32 | 33 | 38 | 72 |
| 10 | 28 | 35 | 35 | 40 | 74 |
| 11 | 30 | 37 | 38 | 43 | 75 |
| 12 | 32 | 39 | 40 | 45 | 76 |
| 13 | 35 | 43 | 42 | 48 | 80 |
| 14 | 40 | 46 | 45 | 52 | 85 |
| 15 | 44 | 49 | 48 | 55 | 90 |

Table 5 - Dependence of vibration acceleration, vibration velocity on the oil station pressure

| Oil station pressure, | Vibration acceleration, | Vibration velocity, m/s |
|---|---|---|
| 8.0 | $5.0 \cdot 10^{-2}$ | 0.10 |
| 9.0 | $6.5 \cdot 10^{-2}$ | 0.13 |
| 10.0 | $7.8 \cdot 10^{-2}$ | 0.18 |
| 11.0 | $8.9 \cdot 10^{-2}$ | 0.21 |
| 12.0 | $9.8 \cdot 10^{-2}$ | 0.26 |
| 13.0 | $10.6 \cdot 10^{-2}$ | 0.33 |
| 14.0 | $10.8 \cdot 10^{-2}$ | 0.38 |
| 15.0 | $11.2 \cdot 10^{-2}$ | 0.45 |

and the probability of finding deviations in the interval $\pm \varphi$ is 50 %.

The standard deviation $\tau$ of the instrument readings is calculated by the formula

$$\tau = \frac{0.707}{\eta} = 1.2 \text{ MPa}.$$

In this case, the probability that the deviations will be within the allowable interval is 68.2 % ($\delta$ = 6.0 %).

Thus, 68.2 % of all counts with a calibrated value of 20 MPa are in the interval from 18.8 to 21.2 MPa, and half of all counts are between 19.2 and 20.8 MPa.

The evaluation of the measurement results allows us to conclude that the true value of the measured values is in the required interval.

**Conclusions**. The principal possibility of using hydraulic systems as compact hydraulic machines has been established for controlling the condition of the coal and rock massif, moving the reference pressure zone from the bottom of the clearing generation and controlling the rock pressure of a hard-to-reach roof.

The basic parameters of the vibration systems operating in continuous and pulsed modes with manual and automatic control are determined. It was established that the maximum amplitude of pressure oscillations is 15 MPa, the rise time of the pulse from zero to a maximum is 7–9 s, and the fall time is 0.10– 0.15 s. The minimum pulse repetition period is 15-20 s.

The operation of the vibrator systems in pulsed mode is characterized by hyperbolic dependence. With increasing pressure increases the force that creates a system of vibrators. The maximum force is 710 kN for a system of two hydraulic rails at $P$ = 13 MPa and 600 kN for a system of three hydraulic rails at $P$ = 8 MPa.


REFERENCES

1. Sofiyskiy, K.K., Zhitlenok, D.M., Petukh, A.P., Gavrilov, V.I., Zolotin, V.G., Kryshnev, A.S. (2014). *Sposoby intensifikatsii degazatsii ugolnykh plastov i predotvrashcheniya vybrosov uglya i gaza (*Methods to intensify the degassing of coal seams and prevent outbursts of coal and gas*)*, Skhidniy vidavnichiy dim, Donetsk, Ukraine.

2. Kryshnev, A.S. (2012). "The results of laboratory studies when exposed to a coal seam system of hydraulic vibrators through the host rocks", *Geo-Technical Mechanics*, no. 104, pp. 18-23.

3. Zhytlonok, D.M., Kryshnev, A.S., Petukh, A.P., Zolotin, V.G. (2012). "The results of experimental studies of the control of the state of the massif during vibration impact to coal seams through the host rocks", *Geo-Technical Mechanics*, no. 101, pp. 276-283.

4. Zhytlonok, D.M., Kryshnev, A.S. (2012). "The physical essence and mathematical model of controlling the state of the extremely stressed mining massive by vibration impact on it", *Geo-Technical Mechanics*, no. 97, pp. 145-151.

5. Zhytlonok, D.M., Kryshnev, A.S., Vlasenko, V.V. (2012). "Development of hydraulic vibrator systems for impacting a coal seam through host rocks", *Geo-Technical Mechanics*, no. 113, pp. 113-122.

СПИСОК ЛІТЕРАТУРИ

1. Способы интенсификации дегазации угольных пластов и предотвращения выбросов угля и газа: монография / Софийский, К.К., Житленок, Д.М., Петух, А.П. и др., Донецк: «Східний видавничий дім», 2014, 458 с.

2. Крышнев А.С. Результаты лабораторных исследований при воздействии на угольный пласт системой гидравлических вибраторов через вмещающие породы / Геотехническая механика. Днепропетровск: ИГТМ НАНУ, 2012. № 104. С. 18-23.

3. Житлёнок Д.М., Крышнёв А.С., Петух А.П., Золотин В.Г. Результаты экспериментальных исследований управления состоянием горного массива при вибрационном воздействии на угольные пласты через вмещающие породы /Геотехническая механика. Днепропетровск, 2012. № 101. С. 276-283.

4. Житлёнок Д.М., Крышнёв А.С. Физическая сущность и математическая модель управления состоянием предельно-напряженного горного массива вибрационным воздействием на него / Геотехническая механика. Днепропетровск ИГТМ НАНУ, 2012. № 97. С. 145-151.

5. Житлёнок Д.М., Крышнёв А.С., Власенко В.В. Разработка систем гидравлических вибраторов для воздействия на угольный пласт через вмещающие породы / Геотехническая механика. Днепропетровск: ИГТМ НАНУ, 2012. № 105. С. 113-122.



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**Анотація**. Стаття присвячується дослідженням стендових випробувань систем гідравлічних вібраторів і встановлення їх основних параметрів для дії на вуглепородний масив через вміщуючі породи.

На основі стійок механізованих кріплень підібрані та доопрацьовані гідравлічні системи вібраторів, які працюють, як компактні вібромашини. Вони виконують функцію управління станом вуглепородного масиву через вміщуючі породи в лавах, що відпрацьовують викидонебезпечні похилопадаючі вугільні пласти з важкообвалювальними покрівлями, які часто представленими викидонебезпечними пісковиками. Проведено стендові випробування систем вібраторів з двох і трьох стійок гідравлічних кріплень, які працюють в безперервному та імпульсному режимах з автоматичним і ручним способом управлінням. При цьому були отримані частотно-амплітудні характеристики. А саме: час скидання тиску рідини та визначена синхронність роботи гідростійок. Для цього лабораторний стенд був оснащений тензометричними датчиками тиску та манометрами. Вивчення характеристик систем гідравлічних вібраторів проводились при різних початкових тисках, обсягах поршневих порожнин, обертання пневмодвигуна та ін. Оцінка результатів вимірювань дозволила встановити, що істинні значення вимірюваних величин знаходяться в необхідних інтервалах. Визначено основні параметри систем гідравлічних вібраторів, частота і амплітуда впливу, а також доведено принципову можливість їх роботи, як компактних гідромашин в лавах шахт небезпечних за раптовими викидами вугілля й газу та викидів породи. Вимірювання рівня звуку, вібротиску (до 12 м/с$^2$) і віброшвидкості (до 1,4 м/с) відповідає вимогам техніки безпеки. При проведенні стендових випробувань істотних несправностей в роботі системи гідравлічних вібраторів не спостерігалось, що свідчить про її високу надійність.

Встановлено принципову можливість застосування гідравлічних систем, як компактних гідромашин для управління станом вуглепородного масиву,переміщення зони опорного тиску від вибою очисної виробки та управління гірським тиском важкокерованої покрівлі.

**Ключові слова:** гідравлічні вібраційні системи, гідравлічні машини, вуглепородний масив, тиск вібрації, швидкість вібрації.

**Аннотация.** Статья посвящается исследованиям стендовых испытаний систем гидравлических вибраторов и установление их основных параметров для воздействия на углепородный массив через вмещающие породы.

На основе стоек механизированных крепей подобраны и доработаны гидравлические системы вибраторов работающие как компактные вибромашины. Они выполняют функцию управления состоянием углепородного массива через вмещающие породы в лавах отрабатывающих выбрасоопасные пологопадающие угольные пласты с труднообрушаемыми кровлями зачастую представленными выбросоопасными песчаниками. Проведены стендовые испытания систем вибраторов из двух и трех стоек гидравлических крепей, которые работают в непрерывном и импульсном режимах с автоматическим и ручным способом управлением. При этом были получены частотно-амплитудные характеристики. А именно: время сброса давления жидкости и определена синхронность работы гидростоек. Для этого лабораторный стенд был оснащен тензометрическими датчиками давления и манометрами. Изучение характеристик систем гидравлических вибраторов проводились при различных начальных давлениях, объёмах поршневых полостей, вращения пневмодвигателя и др. Оценка результатов измерений позволила установить, что истинные значения измеряемых величин находятся в необходимых интервалах. Определены основные параметры систем гидравлических вибраторов, частота и амплитуда воздействия, а также доказана принципиальная возможность их работы как компактных гидромашин в лавах шахт опасных по внезапным выбросам угля и газа и выбросов породы. Измерение уровня звука, вибродавления (до 12 м/с$^2$) и виброскорости (до 1,4 м/с) отвечает требования техники безопасности. При проведении стендовых испытаний существенных неполадок в работе системы гидравлических вибраторов не возникло, что свидетельствует о её высокой надежности.

Установлена принципиальная возможность применения гидравлических систем как компактных гидромашин для управления состоянием углепородного массива, перемещения зоны опорного давления от забоя очистной выработки и управления горным давлением трудноуправляемой кровли.

**Ключевые слова:** гидравлические вибрационные системы, гидравлические машины, углепородный массив, давление вибрации, скорость вибрации.

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