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METHODS FOR CHANGING THE STRESS FIELD PARAMETERS DURING BLASTING OPERATIONS IN EJECTION-PRONE ROCK

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Wright-Patterson Air Force Base, Ohio

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METHODS FOR CHANGING THE STRESS FIELD PARAMETERS DURING BLASTING OPERATIONS IN EJECTION-PRONE ROCK

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N. I. Myachina, G. P. Meypariani

Ejections of rock in the deep mines of the Donetz coal basin have always been timed to blasting operations. In overstressed rock the equilibrium state is disturbed by the effect of the dynamic loads from the blast, which is displayed in the ejections of rock.

The principle cause of the overstressed state of rock is the combined effect of the following factors: the presence of high stresses from tectonic processes, the hydrostatic pressure of overlying rock layers, the presence of methane gas under pressures of 50 - 100 atm in the rock.

The stress field, which developed as a result of the blast, propagates for significant distances, while the stresses maintain rather high values. The application of methods, which permit controlling the stress field parameters, will permit decreasing the probability of the occurrence of ejections.

The magnitude of the stresses propagating in the interior of the massif depends on the pressure at the shock wave front. The pressure at the shock wave front can be reduced with the help of padding of materials with an acoustic rigidity, sharply differing from the acoustic rigidity of the rock to be blasted, which is placed between the charge and the surrounding walls of the blast hole.

Laboratory experiments have permitted establishing the possibility of changing the stress field parameters during blasting with the help of padding. The blasts were carried out in plastic models. Felt, wood, plastic foam, vacuum rubber, etc. were used as padding. TEN was used as the explosive. The charge was triggered with a batch of lead nitride 10-15 mgm in weight. Recording of the stress field development process was produced in polarized light with the photo-recording device OFR-2m. The stresses are distributed uniformly around the blast hole for a blast without padding. The use of padding permitted the redistribution of the stresses around the blast hole. On the side of the padding the magnitude of the stresses in the model material is less than on the side in direct contact with the explosive. The stress field formation process is delayed on the side of the padding, and the order of the bands characterizing the difference of the main stresses is significantly lower. This indicates the low pressure at the shock wave front on the side of the padding. These experiments permit one to develop only a qualitative picture of the stress distribution around the blast hole.

We have carried out experiments which permit producing a quantitative evaluation of the possibility of decreasing the magnitude of stresses during blasting with the use of padding. The experiments were carried out in rosin models using a magnetic apparatus. The diagram of the model and the arrangement of the shift sensors is presented in Figure 1. Recording of the magnitude of the amf induced in the sensors with their shift was provided by SI-29 oscillographs. Typical oscillograms are presented in Figures 2, 3, 4 and 5.

Calculation of the shift velocity of the particles was performed from the data of the measurements according to the formula:

$$V = \frac{10E}{B\,l\,\sin\alpha},\ \text{m/sec}$$

where E is the emf, mv; B is the magnetic induction, G; l is the length of the wire sensor, m; α is the angle of inclination of the

All figures, graphs, tables, equations, etc. merged into this translation were extracted from the best quality copy available.

U. S. BOARD ON GEOGRAPHIC NAMES TRANSLITERATION SYSTEM

Block	Italic	Transliteration	Block	Italic	Transliteration
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

* ye initially, after vowels, and after ъ, ь; e elsewhere. When written as ё in Russian, transliterate as yё or ё. The use of diacritical marks is preferred, but such marks may be omitted when expediency dictates.

FOLLOWING ARE THE CORRESPONDING RUSSIAN AND ENGLISH DESIGNATIONS OF THE TRIGONOMETRIC FUNCTIONS

Russian	English
sin	sin
cos	cos
tg	tan
ctg	cot
sec	sec
cosec	csc
sh	sinh
ch	cosh
th	tanh
cth	coth
sch	sech
csch	csch
arc sin	$\sin^{-1}$
arc cos	$\cos^{-1}$
arc tg	$\tan^{-1}$
arc ctg	$\cot^{-1}$
arc sec	$\sec^{-1}$
arc cosec	$\csc^{-1}$
arc sh	$\sinh^{-1}$
arc ch	$\cosh^{-1}$
arc th	$\tanh^{-1}$
arc cth	$\coth^{-1}$
arc sch	sech^{-1}
arc csch	csch^{-1}

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rot	curl
lg	log

sensor with respect to the magnetic flux.

By knowing the shift velocity of the particles, one can calculate the magnitude of the maximum stresses at the measurement points from the formula:

$$\sigma = \frac{\rho c V}{98} \text{ kgf/cm}^2 \qquad \text{(a)}$$

where ρ is the density of the sample, gm/cm^3; c is the velocity of the longitudinal wave, m/sec; V is the shift velocity of the particles during the blast, m/sec.

The data on the measurements and the calculated magnitudes of the shift velocity and maximum stresses are presented in the table. The thickness of the sheets was 16 mm. As is seen from the table, the magnitudes of the maximum stresses on the side of the padding are reduced by about 3-4 times with the explosion of lead nitride charges, and by about 1.2 - 1.5 times with the explosion of TEN. This is evidently explained by the characteristics of the explosives themselves. In the case of lead nitride, which has a steeper shock wave, the pressure drops more abruptly, and the duration of the pulsed effect on the wall of the blast hole is less than for TEN.

One of the directions by which rock ejections can be prevented is the application of methods permitting a reduction of the magnitude of the high stresses existing in the massif at the working cut. The production of a relief gap at the working edge is such a method. A gap produced beforehand at the working edge not only permits decreasing the magnitude of high stresses existing in the massif, but also serves as a screen, which prevents the propagation of stresses from the explosive charges beyond the edge of the newly created working face. It is also necessary to take into account that the depth of the gap produced beforehand must be designed so that the stresses, which are generated by the explosive charges and are propagated along the working path, have a minimum value beyond the gap.

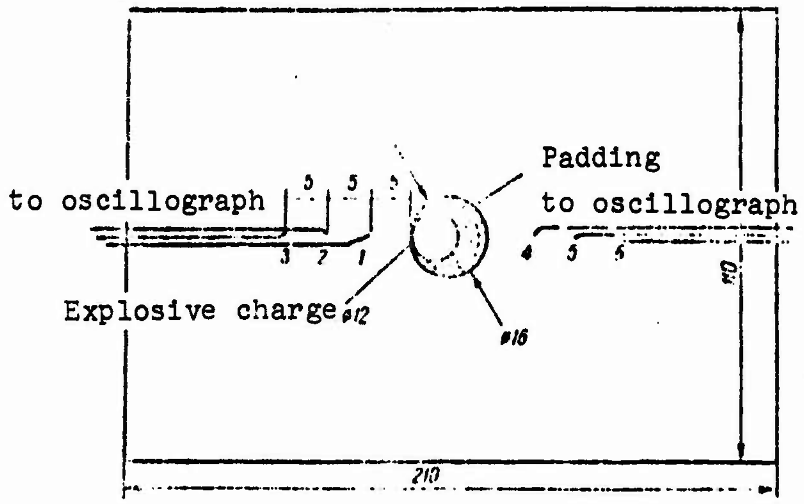

Figure 1. Diagram of rosin model for blasting on the magnetic apparatus.

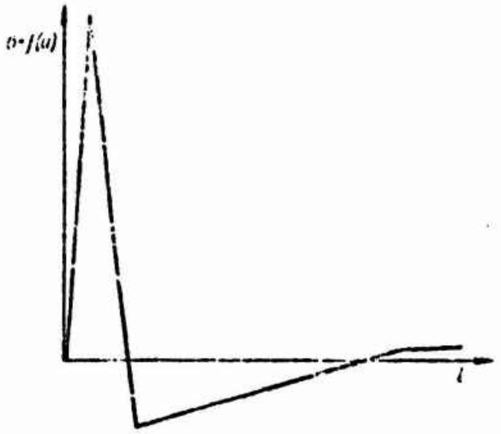

Figure 2. Oscillogram of the shift at point 2 with an explosion of 2 gm of TEN.

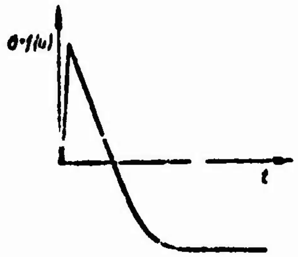

Figure 3. Oscillogram of the shift at point 3 with an explosion of 2 gm of TEN.

TABLE. SHIFT VELOCITIES AND MAXIMUM STRESSES FROM DATA OF EXPERIMENTAL EXPLOSIONS

Sheet No. 1	Sensor No. 2	Shift vel. m/sec. 3	Max. stress kgf/cm^2 4	Type of expl. 5	Wgt. of charge, gm 6	Padding material 7
I	1	80	2310	Lead nitride	2	Wood
	2	30	1030			
	3	35	970			
	4	13	360			
	5	[illegible]	230			
	6	[illegible]	140			
			181			
2	I	182	5060		2	Wood
	2	31	800			
	3	21	560			
	4	18	500			
	5	5	140			
	6	2,6	70			
3	I	460	12700	TEN	2	"
	2	323	8230			
	3	84,5	2360			
	4	281	7810			
	5	133	3700			
	6	78	2170			
4	I	130	3610	"	I	"
	2	52	1440			
	3	39	1080			
	4	47	1290			
	5	27	760			
	6	-	-			
5	I	135	[illegible]	"	I	Plastic foam
	2	114	[illegible]			
	3	65	1870			
	4	-	-			
	5	39	1080			
	6	36	1000			
6	I	150	4170	"	I	Felt
	2	67	1300			
	3	39	1000			
	4	141	3920			
	5	20	810			
	6	21	570			

Figure 4. Oscillogram of the shift at point 5 with an explosion of 2 gm of TEN.

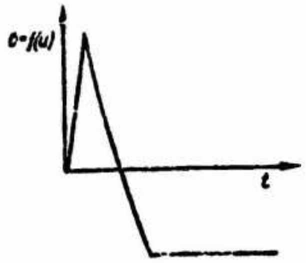

Figure 5. Oscillogram of the shift at point 6 with an explosion of 2 gm of TEN.

We have carried out laboratory experiments to develop the effect of a gap produced beforehand on the distribution of stresses in the massif to be blasted. Models were exploded with a preformed gap without padding and direct triggering with the application of padding at the bottom of the blast hole in an assembly with a preformed gap with direct and reverse triggering of the charges. Analysis of the experiments established that a preformed gap permits a significant decrease of the magnitude of the stresses from the explosion beyond the gap.

In summing up, one can reach the following conclusions:

1. The proposed methods permit changing the stress field parameters and controlling the magnitude of the stresses propagating into the massif.

2. These methods, after testing under mining conditions and establishing the optimum parameters, can be proposed for application in cutting operations in ejection-prone rock and for shaped blasting.