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PROTECTION OF POWERED SUPPORTS AGAINST ROCK BURSTS

Summary. In the paper the tests of mechanized support props adapted to work in crumping beds, made by the Author, mainly in Staatliches Materialprüfungsamt in Dortmund, West Germany, have been presented. Comparing the results of measurements taken on the test stand to plastic strains of props destroyed by crumps on the base of observed pressure changes in a prop and of its shortening the conclusions concerning roof convergence during the crump and mechanism of prop destroying have been drawn. Props without any protection against crumps and one- and two-telescopic props with quick-release valves built in have been also tested. It has been found that in the case of high energy crumps ($10^4 \div 10^7$ J) the most important task of quick-release valve is to decrease pressure very rapidly. In the case of crump energy ab. $10^4 \div 10^5$ J the valve should also act rapidly, but release minimum liquid quantity.

The special method of mechanized support tests made in order to evaluate their adaptation to the crump conditions has been proposed.

1. INTRODUCTION

The geological conditions of Czechoslovak part of the Upper Silesian Coal Basin are complicated to such an extent that they endanger efficient coal mining. One of the adverse factors is the occurence of rock bursts. This risk has called for the protection of powered supports. Solving this problem, the designers and testing engineers required from mining engineers data on time dependent dynamic loading of powered supports. An extensive investigation has been carried out to ascertain time dependent loading pattern of supports during rock bursts [1]. The research has advanced in two directions:

1) Long-term in-situ measurements of dynamic loading of the supports using different instruments according to the purpose of the measurement [2].

2) Deformations that occured on the legs during rock burst were simulated on testing rigs.

In the present paper, mostly the second direction of the above mentioned research is described. The results served for the evaluation of protection devices of powered supports which are used in Czechoslovakia at present.

2. DETERMINATION OF VERTICAL COMPONENT OF TIME-DEPENDENT ROOF-TO-FLOOR CONVERGENCE DUE TO ROCK BURSTS

It follows from the evaluation of powered support deformations that during a rock burst the support unit is loaded omnidirectionally, especially if contact surfaces of the canopy and/or the base sink in a plastic material, e.g. in the crushed coal. In that loading, the greatest role is played by vertical component of sudden (dynamic) convergence. To estimate the development of this movement in time, simulation tests at testing rigs were carried out. The first step was to measure all important deformations occured on original E 3/3150 legs without rock burst protection in the most destructive rock burst recorded in Ostrava-Karviná Basin with energy 10^9 J [3]. After this, the same type of legs were subjected to loading on the testing rigs with increasing rate of their closure. The first set of legs were loaded on the Schloemann press with relatively low rate of closure, i.e. in the order of cm s^{-1}. The following conclusions were drawn from these tests:

a) The inner pressure of leg is not limited only by piston packing but also by the strength of the bottom and the weldings between the bottom and cylinder.
b) The argument that the higher the rate of closure, the greater is the widening of the cylinder, was not confirmed in our tests.

In view of these facts, another set of legs was tested with a greater rate of closure - i.e. in the order of m s^{-1}. Tests were carried out at the rig of Staatliches Materialprufüngsamt Dortmund (F.R.G.) the description of which is given by Herms [4]. The criteria for the evaluation of these tests were extended. We have taken into consideration not only the maximum diameter of the deformed cylinder, but also the deformation of the whole leg along its length. Having compared the deformations, we came to the conclusion that the sudden closure did not excced 30 mm in 70% of legs deformed by the rock burst. The maximum sudden roof-to-floor convergence during this rock burst achieved aproximatelly 90 mm. Since the total convergence measured several hours after the rock burst reached about 200 mm, we can make the conclusion that the overall roof-to-floor movement consisted of two phases. The first phase, i.e. sudden (dynamic) movement, was followed by a second, slower phase of displacement of the roof as a whole.

The fact that the sudden roof-to-floor convergence does not excced 30 mm as a rule, explains why a number of powered supports could withstand rock bursts of an energy of $10^7 \div 10^8$ J without greater deformations. The compliance of powered supoorts, particulary of shield types, is of such an extent [5] that vibration of roof of 30 mm amplitude is unable to provoke excessive pressure in the legs.

The second criterion of comparison was the deformation of the whole leg along its length. The legs loaded at the rate of closure of 4,5 and 6,6 m s^{-1} exhibited, as a result of the tests, a large widening of outer tube (cylinder) near the bottom. It was caused by the breaking of the bottom. The flow of emulsion through the cracked weldings or crackes in the bottom was great enough to keep the pressure of 80÷110 MPa for 12 ms. It caused the above mentioned excessive widening of outer tube. Since the widening of such extent has not been found in legs deformed by the rock burst, we can deduce from it that the maximum rate of closure did not surpass 4,5 ms^{-1}. Maximum rate of loading imposed on the legs during the burst was also analysed using a mathematical model in which the vibration of overlying plate of strata was simulated with finite element method [6]. The maximum rate of loading was found to be about 2 ms^{-1}.

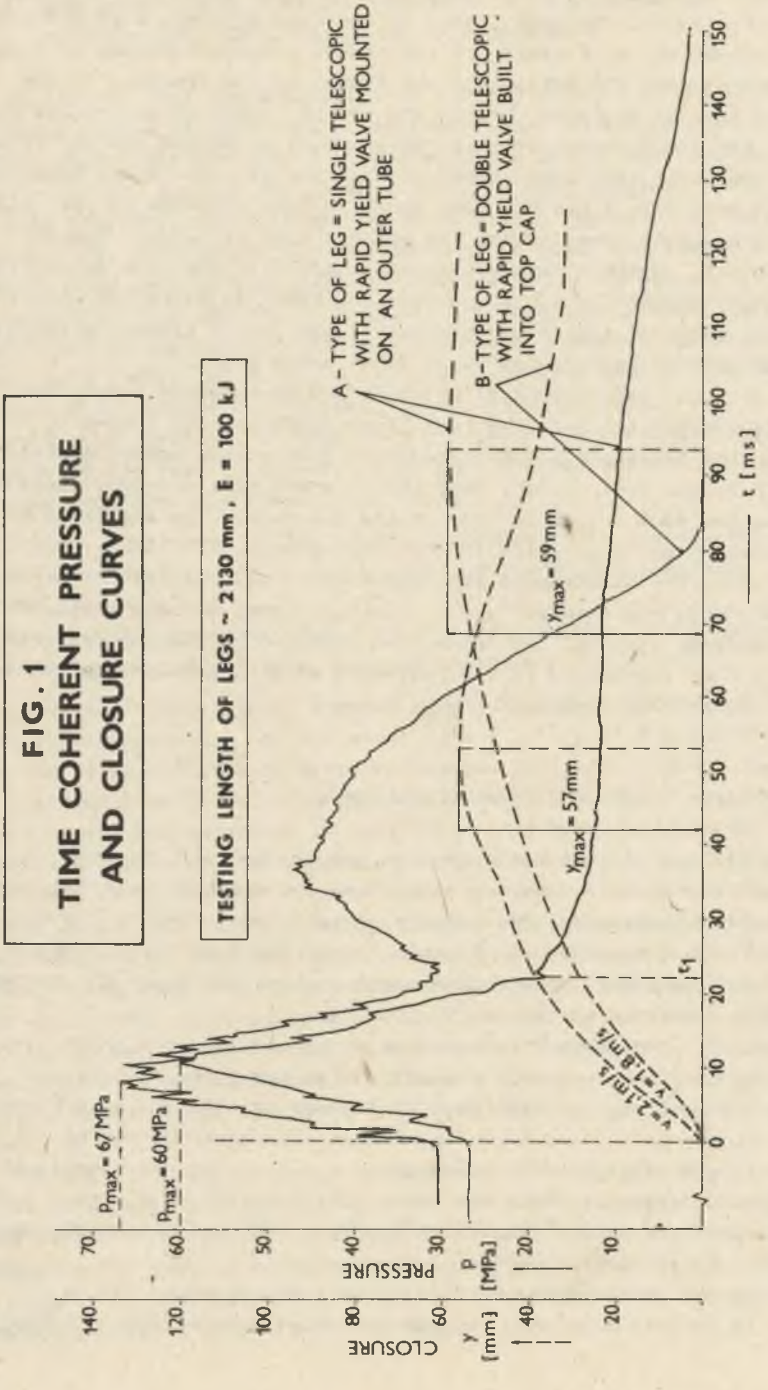
At present, several records of pressure and convergence taken during rock bursts confirm the fact that coal face supports were loaded by vibrations, the amplitude of which resulted from stress energy absorbed elastically by the coal matter. Near the main and tail entries, where the coal matter was more fractured then inside the panel, the amplitude of vibrations was near zero, while in the other places with high stress concentrations, the convergence achieved tens of millimeters. After having summarized the results of our investigations, we have proposed limits of dynamic loading. The respective patterns of loading are shown in table 1. They correspond to the half-wave of undamped oscillation as set up by Chudek and Olaszowski [7].

3. TESTING OF DYNAMIC RESISTANCE OF LEGS

At present, the dynamic tests of legs are carried out, first of all, by external load at three testing rigs. They are operated in F.R.G, Great Britain and Czechoslovakia. The results of tests performed by the manufacturer of mining equipments, the enterprise OSTROJ of Opava, Czechoslovakia, are thoroughly analyzed in paper by Bena and Tkáč [8]. Further analyses are presented in papers [9, 10, 12].

A comparison of different conceptions of powered support protection against rock bursts is possible providing that two types of legs are tested at the same testing rig. Such tests were carried out at the rig of MPA Dortmund. We can see from fig. 1 that time coherent curves of pressure of both legs differ considerable. A - type leg has a uniformly damped surve of pressure while the valve plug movement of B - type leg caused the pressure to oscillate. The closure of both legs was approximately the same, 57 and 59 mm, respectively.

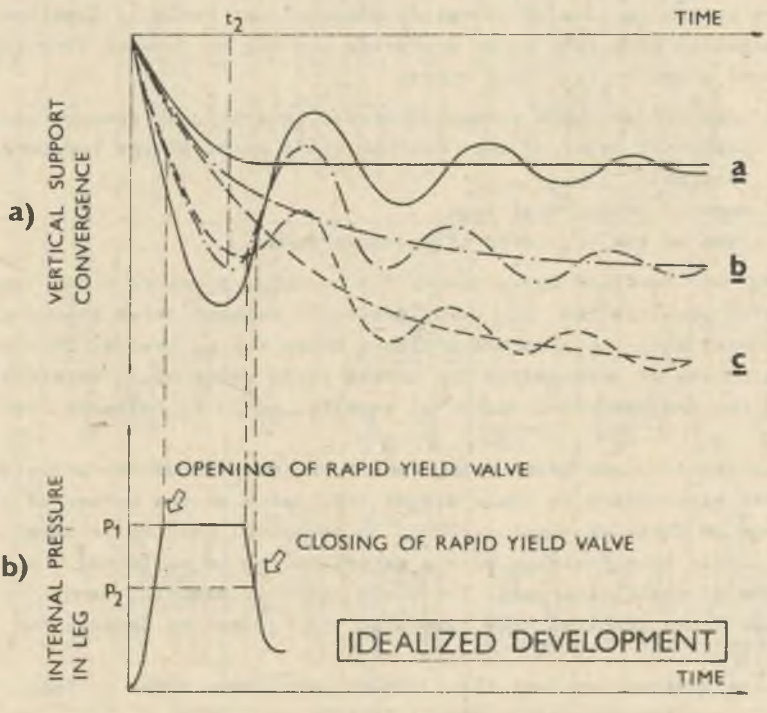
Comparing the time dependences of pressure and closure, it is necessary to have in mind that in rock bursts of a great energy (10^8÷10^9 J),



Rys. 1. Krzywe zamknięcia i czasu ciśnienia koherentnego

Fig. 1. Time coherent pressure and chosure curves

FIG. 2
TIME COHERENT CONVERGENCE (a) AND PRESSURE (b) CURVES



Rys. 2. Krzywe czasu konwergencji koherentnej (a) i ciśnienia (b)
Fig. 2. Time coherent convergence (a) and pressure (b) curves

the most important is the ability of the valve to release the pressure rapidly. Hence, the lower the prpssure peak, the better the valve. When the rock bursts energy is lower, e.g. $10^4 \div 10^7$ J, the most important is not the ability of the valve to release rapidly, but to release only the necessary amount of emulsion and thus keep the closure of lags as small as possible. The ability of the valve to close as soon as possible is shown in Fig. 2a. The curve a presents the vibrations of leg without rapid release valve, the influence of rapid release valve with high and low closing ability is shown in curves b, c, respectively.

4. RECOMMENDATIONS FOR COMPREHENSIVE EVALUATION OF DYNAMIC RESISTANCE OF POWERED SUPPORTS WITH ANTI-ROCK BURST PROTECTION

The legs with rapid release valves and/or accumulators should be tested by kinematic mode of vibration presented at Table 1. Idealized characteristics of a rock burst protected leg may be deduced from time dependences shown in Fig. 2a,b where:

p_1 ..... pressure at which principal stress in critical crossections or points of legs and unit reaches yield point of the respective material

p_2 ..... nominal pressure of legs

t_2 ..... time of the beginning of re-convergence

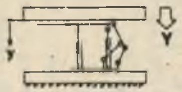
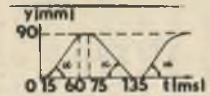
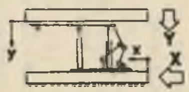
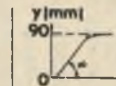
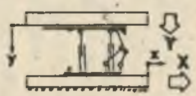
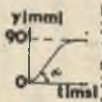
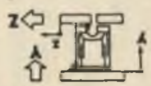
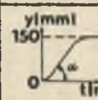
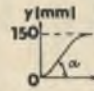
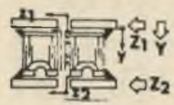
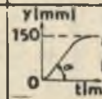
During roof-to-floor convergence, the internal pressure should approach as close as possible the p_1 value and rapid release valve should close at the moment when the internal pressure drops to p_2 value. In this way, the possibility of overloading the normal yield valve would be eliminated and only the indispensable amount of emuslion would be released from the leg.

The ultimate values of materials should be determined for individual components with regard to their direct influcence on the safety of support desing and on their disassebly. Thus, in canopies, shields or bases, even the the margin of plasticity of the materials can be utilized, while in hinge pins of small clearance, the yield point of material cannot be surpassed. These problems have been also pointed out by Szuścik and Zastawny [11].

The time coherent roof-to-floor convergance curve shown in Tabl. 1 has been specified for time interval from 0 to t_2 (Fig. 2) only. The subsequent phase cannot be specified at present because of the lack of knowledge about it. Therefore, a rig should be designed on which performing the cycle of loading with differing frequencies and amplitudes could be simulated. In such tests, the closing capabilities of different desings of rapid yield valves could be evaluated.

Table 1

Proposed methodology of testing of powered supports under impact (dynamic) loading

No. of test	Test desti-ned for	Pattern of loading	Kinematic and dynamic parameters	Criteria for evaluation of test	Initial condi-tions	Measured values
1	All suppo-rts			<u>Tests Nos. 1,2 and 3a</u> - pressure in legs ≤ 1,5 nom. pr. - principal stress in critical sections <0,9 of yield point - force in pulled lemn.link < 0,9 of ultimate strength force - force in pushed lemn. link<0,9 of critical stability force - deformations of hinge pins, if any, must not impede the dis-assembly of the joints - release of fluid from rapid yield valves must not endanger operators <u>Tests Nos. 3b, 4, 5 and 6</u> In these tests, the loading reaches extreme values for which supports have neither been designed nor tested yet. The deformations and destruc-tions produced in these tests will have to be evaluated individually from the points of view of safety and economy (possibility of replacement of components at the face, price of components).	The unit shall be set with 0,8 nominal pressure. It shall be tested with max. and later min. heights and finally at heights with max. forces induced in lemn. links.	- pressure in all legs - stress in all lemn. links - stress in critical sections - closure in y direction - in tests Nos. 2, 3 closure in x direction - in tests Nos. 4, 5 closure in z direction - in test No. 6 closure in z_1, z_2 directions - in test No. 6 pressure in rams of side flaps
2	All suppo-rts		 Forces: X = 0,25 Y			
3	All suppo-rts		 Forces: X = 0,25 Y for supports single slice X = 0,6 Y, for slices			
4	Supports with halved base		 Forces: Z = 0,6 Y			
5	Supports for coal extract. by slices		 Forces: Z = 0,6 Y			
6			 Forces: a) $Z_1 = Z_2 = 0,6Y$ b) $Z_1 = 0$ $Z_2 = 0,6$ Y			

At present, research aimed at determining the protection against rock bursts was based on loads which excceded the capacity of legs and not necessary of the particular support unit. It has become evident that it is necessary to cary out comprehensive tests of the whole powered support unit. The rigs of OSTROJ or MPA Dortmund (made by SCHENCK) comply with these requirements, at least partially. These tests would enable to assess important factors such as non-uniform yielding of legs in unit, loss of stability of a unit etc. We have proposed a method of testing of support units to evaluate the degree of their protection against rock bursts (Tab. 1). The criteria given in this table were deduced from rock bursts with maximum energies recorded so far in CS. In these proposed tests, the loading pattern (No. 2 to 6) correspond to extreme conditions. Powered supports which would satisfy these conditions have neither been designed nor tested yet. The deformations produced in these tests will have to be evaluated from càse to case from the points of view of safety and economy.

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Wpłynęło do Redakcji w kwietniu 1985 r.

ZABEZPIECZENIE OBUDÓW ZMECHANIZOWANYCH PRZED TĄPANIAMI

S t r e s z c z e n i e

W pracy przedstawiono badania stojaków obudów zmechanizowanych przystosowanych do pracy w pokładach tąpiących, prowadzone przez autora, głównie w Staatliches Materialprüfungsamt w Dortmundzie (RFN). Porównując wyniki pomiarów wykonywanych na stanowisku badawczym z odkształceniami trwałymi stojaków uszkodzonych wskutek tąpnięcia na podstawie zaobserwowanych zmian ciśnienia w stojaku i jego skracania wyciągnięto wnioski dotyczące przebiegu konwergencji stropu podczas tąpnięcia oraz mechanizmu niszczenia stojaka. Badaniom poddano stojaki nie wyposażone w urządzenia zabezpieczające przed skutkami tąpnięcia oraz jedno- i dwuteleskopowe stojaki z wbudowanymi zaworami szybkcupustowymi. Stwierdzono, że w przypadku tąpnięć o dużej energii ($10^4 \div 10^7$ J) najważniejszym zadaniem zaworu szybkoupustowego jest zdolność do błyskawicznego obniżania ciśnienia. W przypadku energii tąpnięcia ok. $10^4 \div 10^7$ J zawór szybkoupustowy powinien również działać błyskawicznie, ale wypuszczać minimalne ilości cieczy.

Zaproponowano również metodykę badań ścianowych obudów zmechanizowanych prowadzonych w celu oceny stopnia ich dostosowania do warunków występowania tąpań.

ЗАЩИТА МЕХАНИЗИРОВАННЫХ КРЕПЕЙ ОТ ГОРНЫХ УДАРОВ

Р е з ю м е

В работе представлены исследования стоек механизированных крепей, приспособленных до работы в пластах с горными ударами, проведённые автором в основном в Staatliches Materialprufungsamt в Дортмунде (ФР). Сравнивая результаты измерений, проведённых на измерительном стенде, с остаточной деформацией стоек, повреждённых вследствие горных ударов, на основании наблюдаемых изменений давления в стойке и его сокращение, сделано выводы, касающиеся конвергенции кровли во время горных ударов и механизмов разрушения стойки. Исследовано стойки не оснащённые в устройства предохраняющие перед результатами горных ударов, а также одно- и двутелескопические

стойки с вмонтированными быстроотводными клапанами. Подтверждено, что в случаи горных ударов большой энергии (10^4÷10^3J) наиважнейшим заданием быстроотводного клапана является способность до моментального снижения давления. В слвчае энергии горного удара ок. 10^4÷10^3J быстроотводный клапан должен также действовать моментально, но отводить минимальное количество жидкости.

Предложено также методику лавовых исследований механизированных крепей, проводимых с целью оценки степени их подгонки к условиям горных ударов.