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## PNEUMATIC DAMPERS AS TOOLS FOR PROTECTION HYDRAULIC SYSTEMS AGAINST DYNAMIC LOADS

**Abstract:** The scope of the paper is to present the application of the pneumatic dampers for protection the hydraulics system against dynamic loads. This solution on the constructional methods of making the whole system more flexible. One of the possible solution is the application of the pneumatic damper that function as safety devices when the permissible pressure is exceeded.

### 1. Introduction

Hydraulic systems, in conditions of dynamic loads, are very vulnerable what is consider with high rigidity of the hydraulic medium. In the case of hydraulic systems applied in hard coal mines it is the water-oil emulsion. Taking into account these facts it is possible to lower the vulnerability by making the whole system more flexible. Its flexibility depends on the following factors [1]:

- discharge speed of the hydraulic medium,
- material flexibility of the hydraulic cylinder and cables,
- flexibility of the hydraulic medium,
- energy transformation capacity of the hydraulic system.

The first three mentioned elements have limited energy dissipation capacity related with their physical characteristics. In the case of the first factor the limiting elements are: the diameter of the outflow, the difference of pressures and the throttling at the outflow. In the case of the second one the flexibility is determined by material parameters. However, in the case of the third one crucial are fluid parameters. The situation is different in the case of energy transformation. The properly designed hydraulic system may be capable of absorbing and scattering, by the execution of work, any energy derived from the external load. However, for this purpose the hydraulic system must be design unconventionally.

### 2. Roof support with hydraulic dampers

Taking into account presented above factors, considered with the flexibility of the hydraulic system, it was proposed the construction of a powered roof support, in which hydraulic cylinders were equipped with special inner pneumatic dampers [2]. In the Figure 1

is presented the schematic view of the support. The dampers were design as special inertial inserts, reacting only in the situation when the pressure of the hydraulic medium exceeds the regulated value. Moreover the utilization of the inertia effects allows to reduce the reaction time to a minimum.

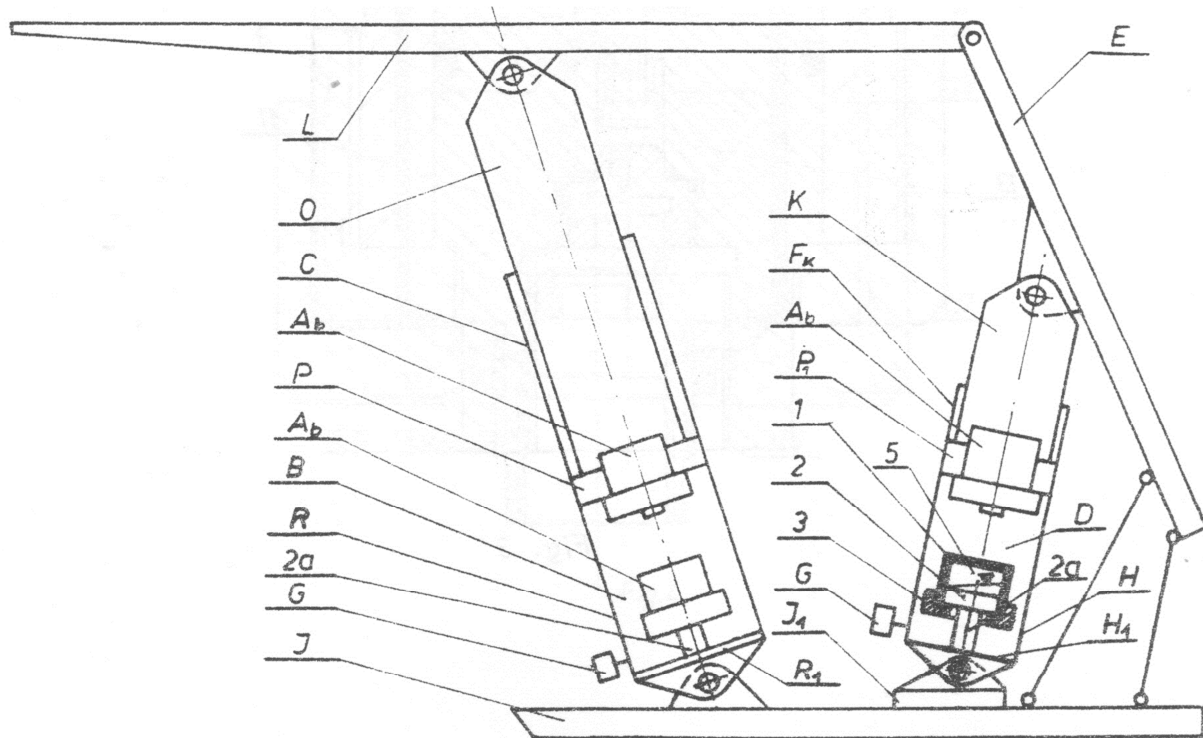


Fig.1. Powered roof support with inner pneumatic dampers [2]

In the Figure 1 the symbols mean:  $A_b$  - pneumatic damper, B - space under the piston in the main hydraulic cylinder, C - hydraulic cylinder, D - space under the piston in the correctional hydraulic cylinder, E - gob shield,  $F_k$  - correctional cylinder, G - safety valve, H - correctional cylinder body,  $H_1$  - main cylinder body bottom, J - base,  $J_1$  - correctional cylinder holder, K - correctional cylinder rod, L - canopy, O - main hydraulic cylinder rod, P - main hydraulic cylinder piston,  $P_1$  - correctional hydraulic cylinder piston, R - main hydraulic cylinder body, 1 - pneumatic damper body, 2 - pneumatic damper piston, 2a - pneumatic damper holder, 3 - pneumatic damper nut, 5 - pneumatic damper work space.

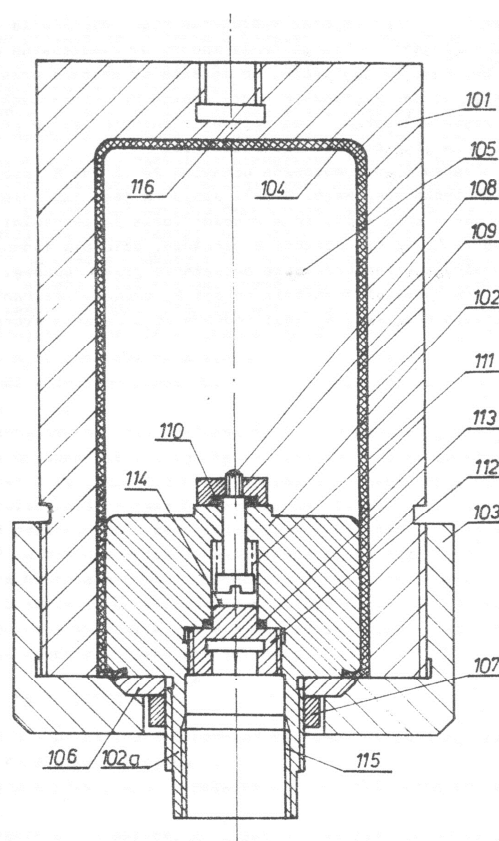
These inserts act as hydraulic shock absorbers. They are designed to respond only when an external load exceeds the normal working conditions of the hydraulic system of a support. This is possible by the determination of the gas pressure in the damper a level higher than the operating pressure of the hydraulic system. Thus, the dampers in normal working conditions behave as rigid elements, and at the moment when the dynamic load excess the operating conditions they become flexible.

The presented design solution modifies the understanding of the problem of flexibility of hydraulic systems. Instead of elements regulating pressure of hydraulic medium it is applied a structural element that work as an energy accumulator. So the proposed solution can therefore be used in any typical hydraulic cylinder. Thus, it is the a very versatile solution.

The damper itself, mounted in the cylinder space, below the piston, allows the system to carry the load from any direction. In addition, the presented in Figure 1 design of the support shows the advantage over the traditional support design. The new position of the correctional cylinder causes that during a dynamic load this cylinder is compressed (what is in accordance with the cylinder work direction) and not stretched, as in the case of a classical support design.

### 3. Dampers design

The following cross-section (Fig. 2) presents the structure of the pneumatic insert (it is one of the developed variants). Its operating principle is considered with its position in the hydraulic cylinder. In work conditions the piston remains motionless while the moving element is its cylinder.



*Fig. 2. Design of the pneumatic insert*

In the Figure 2 the symbols mean: 101 - cylinder of the pneumatic insert, 102 - piston of the pneumatic insert, 102a - holder of the pneumatic insert, 103 - nut of the cylinder of the pneumatic insert, 104 - element of low friction coefficient, 105 - work space of the pneumatic insert with pressed gas, 106 - pad mounting the element 104, 107 - nut mounting the pad 106, 108 - screw of non-return valve, 109 - cap of the non-return valve, 110 - seal of the non-return valve, 111 - spring of the non-return valve, 112 - plug closing the non-return valve, 113 - seal of the plug closing the non-return valve, 114 - space over the plug 112, 115 - thread linking the pneumatic insert with elements of the cylinder or prop (connection from the bottom),

116 - thread linking the pneumatic insert with elements of the cylinder or prop (top connection).

The element deciding about the flexibility of the pneumatic insert and about the possibility of energy accumulation, in this case, is a compressed gas. As it was mentioned earlier the idea of pneumatic insert functioning is based on the use of a gas "spring". Under the influence of increased pressure in the hydraulic system the piston or cylinder of the insert moves pressurizing gas. This increases the volume of the space under the cylinder piston (by reducing the volume of the insert), which allows the sliding of the canopy. Thanks to this the work is done. This work dissipates the energy generated by the roof rocks. Thus, the time of load rising is strongly elongated through the use of the pneumatic insert as an energy accumulator. It thereby dramatically decreases the power of a load. After the load ceasing the piston or cylinder of the hydraulic insert returns to its starting position causing the reduction of the volume of the space under the piston of the hydraulic cylinder. It resulting in raising of the support canopy. Thus, in this solution it is possible to maintain the continuous contact with the roof of a support while maintaining its flexibility.

The use of a gas "spring" is considered with the fact that a normal spring used in such devices would have to have a very large size to generate forces of needed values. In the case of a gas "spring" it is simply to adjust the value of the gas pressure. Thus, it is the device which can be freely mounted in the working space of a hydraulic cylinder. It should be also mentioned that double mounting system of the pneumatic insert arises from the fact that it should be attached inside the hydraulic cylinder that the piston of the insert would be in the lower position. Thus, it results that any leaks will be located in the lower part of the insert, and they will be sealed by the hydraulic medium. Thus, the proper positioning of pneumatic insert eliminates one of the main disadvantages of gas "springs", and namely, a gradual loss of a gas pressure generated due to the lack of a leak tightness.

Analyzing the extent of requirements satisfied by the proposed design solution indicate the following characteristics:

- continuous supporting the roof,
- the vulnerability of the construction,
- protecting the support work space,
- durability,
- costs decreasing.
- operational simplicity.

The presented design solution characterizes by some advantages that could be used in other design solution what is presented in the next chapter.

#### **4. Hydraulic prop with the pneumatic insert**

The presented design solution helped to solve the problem of construction flexibility and the continuous support of the floor at the same time. There is also an universal solution because it can be used in any type of a hydraulic cylinder, thus it allows the use of standard components. This solution is characterized by construction simplicity and low maintenance costs. Pneumatic inserts, from the viewpoint of cost is also inexpensive one. They increase the cost of a support by about 10%. The such secured support has increased the service lifetime on the one hand and the higher level of security on the other. Durability is extended by lowering the average value of the maximum pressure occurring during a dynamic load. However, security is increased by the

ability to dissipate and absorb the energy generated during a dynamic load. This advantages causes that this solution was used to the development of the more advanced solution in the form of a hydraulic prop equipped with the pneumatic insert. The idea is based on such design of the hydraulic prop that the pneumatic insert is the integral part of the prop piston (Figure 3).

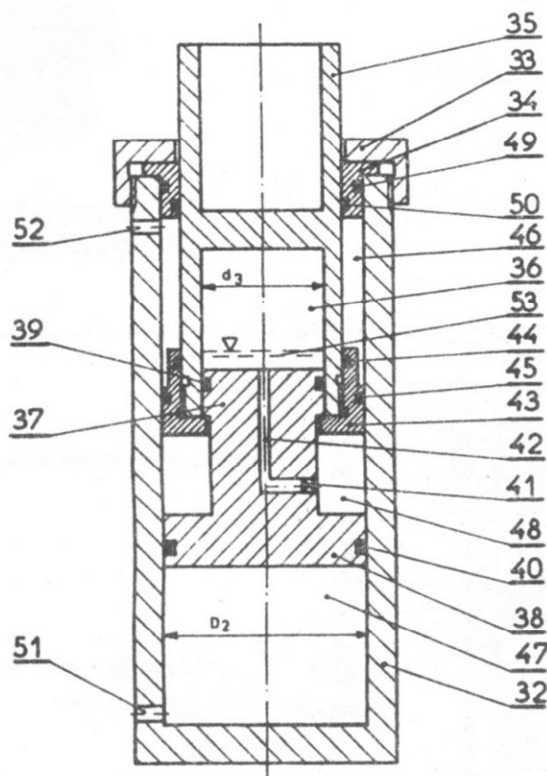


Fig. 3. Design of the hydraulic-pneumatic prop [2]

In the Figure 2 the symbols mean: 32 - cylinder of the hydraulic prop, 33 - nut mounting the gland, 34 - gland, 35 - piston rod of the hydraulic prop, 36 - high-pressure chamber, 37 - piston closing the high-pressure chamber 36, 38 - piston of the hydraulic prop, 39 - seal of the piston of the high-pressure chamber, 40 - seal of the piston of the hydraulic prop, 41 - cut-off valve of the high-pressure chamber, 42 - passage linking the valve 41 and the chamber 36, 43 - nut closing the high-pressure chamber, 44 - seal between the nut 43 and the gland 35, 45 - seal between the nut 43 and the cylinder 32, 46 - space over the piston, 47 - space under the piston, 48 - space between the piston 38 and the nut 43, 49 - seal between the gland 34 and the cylinder 32, 50 - seal between the gland 34 and the piston rod 35, 51 - hole linking the space under the piston with the hydraulic control system, 52 - hole linking the space over the piston with the hydraulic control system, 53 - oil layer.

The presented solution integrates the whole concept outlined in the previous solution. It contains a completely new design solution of a hydraulic prop in which the piston and piston rod are the integrated components of the hydraulic prop. This allows for the simplifying of the prop construction, as in the case of this design there is only one pneumatic element. Thus, the structural stability is increased from less likelihood of failure of the components.

The presented prop is practically maintenance-free. It only requires repeated periodically checking of the gas pressure in the high-pressure chamber, which could be functionally difficult. The solution is so versatile that it can be used to design any hydraulic prop, however it should to operate in a vertical position. The construction of the pro is based on the use of the best available materials and plastics. However, the prop itself must be realized by the manufacturer.

## 5. Conclusion

In the paper was presented the analysis of the pneumatic insert used as the energy accumulator to protect hydraulic systems against dynamic loads. Such efforts have been already undertaken I Polish mining industry [3]. However the presented solution allows solving some disadvantages considered with the application of other design solutions. The main advantage is the leak tightness of the gas “spring”. Test prove that after the period of 6 months the pressure in the gas “spring” do not changes.

The experiences gathered in the design process of gas accumulators as the protection devices in hydraulic systems show that it is possible to innovate by linking together design solutions from different technical areas. In this case the energy accumulators have been used as shock absorbers in hydraulic systems instead of classical safety valves. The analysis of functioning of elaborated solutions helped to deeply understand the theory of hydraulic systems itself.

## References

1. Gwiazda A.: Designing of technical means using the integrative methodological approach. Katowice: Wydawnictwo GIG, 2013 (in Polish).
2. Gwiazda J., Gwiazda A.: Mining powered support for crump beds. Polish patent No 162788 (in Polish).
3. Mazurek K., Szveda S.: The range of the control of a technical condition of the hydraulic prop with a gas accumulator, conducted in the wall heading. “Maszyny górnicze”, No 3, 2006, pp. 3-7 (in Polish).