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# Concrete Activation in Disintegrator During Mine Shaft Fixing

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**Abstract:** They noted the urgency of the solutions which allow to reduce the consumption of scarce and costly materials during the construction of mining facilities. The method of concrete compound module increase was described at the impact of high mechanical energy on it in a disintegrator. The experience of disintegration phenomenon use was outlined in the mining practice. A new disintegrator design was proposed. The possibility of a disintegrator use for cement saving was proposed during the mounting of a constructed vertical shaft.

**Key words:** Concrete, mechanical energy, disintegrator, design, economy, cement, mine shaft

## INTRODUCTION

New enterprises are built and old enterprises are reconstructed during the restoration of the mining industry in Russia from the crisis of the 90's. A special position is occupied by vertical shafts, being the main linking the underground and surface facilities into a single system at mining enterprise process facilities. The depletion of mineral reserves, localized in relatively comfortable conditions for the operation, increases the relevance of mineral resource development in the areas of permafrost, an increased mountain high pressure, in geological fault zones, etc., (Bakhtavar and Shahriar, 2007; Matthews, 2015).

The development of industrial enterprises requires the maximum concentration of own capabilities which do not have the ability to self-realization and the need of support from the outside. Within the market conditions the search of internal reserves for the survival of mining enterprises becomes a relevant one, one of which is the minimization of costs for the most costly element passing from the complex of mountain processes-the capital opening shafts (Stradanchenko *et al*., 2013).

Most part of metal deposits is localized in structurally inhomogeneous, stress-strain arrays weakened by disintegration processes. Such arrays are characterized by the quantity and the quality of faults and the rock plot sizes with development of shift and collapse processes, requiring the application of measures for the strengthening of an array at all stages of the company existence especially, during the stage of a new field development (Adibi *et al*., 2015; Golik *et al*., 2015a).

Therefore, the relevance of technical solutions providing the necessary strength of supports is increased reducing the consumption of scarce and expensive materials.

## MATERIALS AND METHODS

During the underground mining of mineral deposits the supports based on conventional concretes do not provide the rational use of materials. As a rule, they are accompanied by capital work increase and the increase of load on the supports that can't be compensated always by concrete layer thickness increase.

A more effective improvement of the support bearing capacity can be achieved at the maintaining of its volume parameters by concrete modularity change. The thickness of the concrete layer during the construction of a main support can be reduced using high modular concretes to the position at which the load increase on the support is compensated by the use of the mixture component properties at a layer thickness decrease.

The increase of concrete mixture module is achieved at the adjustment of its component properties by high mechanical energy. This is based on theoretically grounded and experimentally proven phenomenon by Hint (1981) concerning the changes of a matter state in a disintegrator. The mechanical energy appears which is greater than in the mills by an order during the processing with an impact velocity of 250 m $sec^{-1}$ and the acceleration is greater than the acceleration of gravity in millions of times (Golik *et al*., 2015b; Hint, 1981).

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For the first time this phenomenon is used in the field "Shokpak" (North Kazakhstan) in the mining practice, where DU-65 unit was operated for 10 years (Golik and Bryukhovetsky, 2007). The acid tails of the Karaganda metallurgical plant served as raw material. Total 4 kg of activated tails were the equivalent of 1 kg of standard cement M-400 by binding capacity.

The activation in disintegrator provided the increment concrete compound strength based on activated products which is 25-30% more than the processing in a mill. The output of an active class up to 55% in combination with the vibration mill increased the yield of the active fraction up to 70% which made it possible to reduce the consumption of commodity cement and make the production of concrete mixtures cheaper sufficiently.

The activation phenomenon is confirmed in related industries during the treatment in a disintegrator. For example, clinker Portland cement ensures the uniform strength of concrete after 16 days versus 28 days during the processing in a mill and the production of artificial stone from silicalcite costs 2 times less than at energy consumption decreases by 50%.

The important aspects of disintegrator technology is a compound strength increase because of active fraction increase up to 50% the size of which makes up to 0.076 mm and the increase of compound homogeneity and mobility (Golik *et al*., 2015c).

The used phenomenon is based on a known position, that physical-chemical and technological processes in solid substances take place more quickly and more completely the larger the surface of a the substance involved in the process. Each new opening surface is an active one with the destruction of a substance. The range of changes caused by the mechanical activation of substance change depends on material structure, the mechanical forces, the amplitude and the frequency of vibrations and oscillations acting on it.

The sticking of concrete compound grains during the preparation is prevented by the fact that it is affected by the vibration additionally in the horizontal plane and by tossing with the oscillations from 30-1500 Hz and the horizontal vibration amplitude from 2-50 mm and the vertical tossing amplitude up to 30 mm in during the process of disintegration (Fig. 1) (Golik *et al*., 2012).

We proposed a disintegrator design (2), comprising a body (1) inside of which the pins are placed on the shafts facing each other (2), fixed to the discs (3) in concentric rows, each of which is located between the adjacent pins of an other disk and external wheels (4). One of the disks is rigidly attached to the electric motor shaft and the second one is mounted through the control

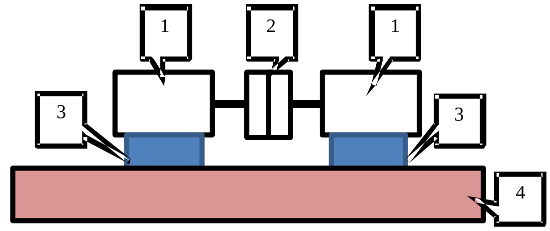


Fig. 1: The scheme of mechanical activation in a disintegrator: 1; engines; 2; A working basket with rotors, 3; vibration dampers, 4; basis

mechanism (5) regulating the gap between the outer discs (4), the system of nozzles (6) in the inlet pipe (7), the container with liquid (8) equipped with a heating element (9) and the outlet (10) (Golik *et al*., 2015d). Using the control mechanism (5) they make a gap between the outer disks so that its value does not exceed the desired maximum size of a final product particles (Fig. 2).

The container is filled with liquid and its temperature adjusted to 90-95°C using a heating element. Raw material is fed through an inlet where it is mixed with the liquid sprayed from a nozzle system into the disintegrator main chamber. Under the influence of centrifugal forces the compound of mineral and liquid passes sequentially through the series of pins and is thrown away to external disks in a particulate form. The particles smaller than the set size of a gap pass out and fall into the outer perimeter of a housing, where through which they are removed through an outlet. The particles larger than the gap between the outer disks are delayed and then crushed by the rotation of external disks, the collision with the newly incoming particles, or by the return to the main workspace of a disintegrator and then they are removed.

A homogeneous mixture is developed during processing. It improves the quality of products, for example, hardening mixtures. The differences of activation technology in a disintegrator include the use of a new kind of impact on mineral raw materials-high-energy, as well as the occurrence of the synergy that creates the opportunities for the development of breakthrough technologies during the preparation of concretes.

We studied the possibility of disintegrator technology use in the process of a vertical mine shaft passing (Golik *et al*., 2015e).

The traditional scheme of concrete compound supply in containers on a sinking platform followed by the placement behind the formwork limits the possibility of a concrete module increase. This disadvantage is eliminated through the creation of a sinking platform design which allows to improve the support quality quickly using the disintegrator technology.

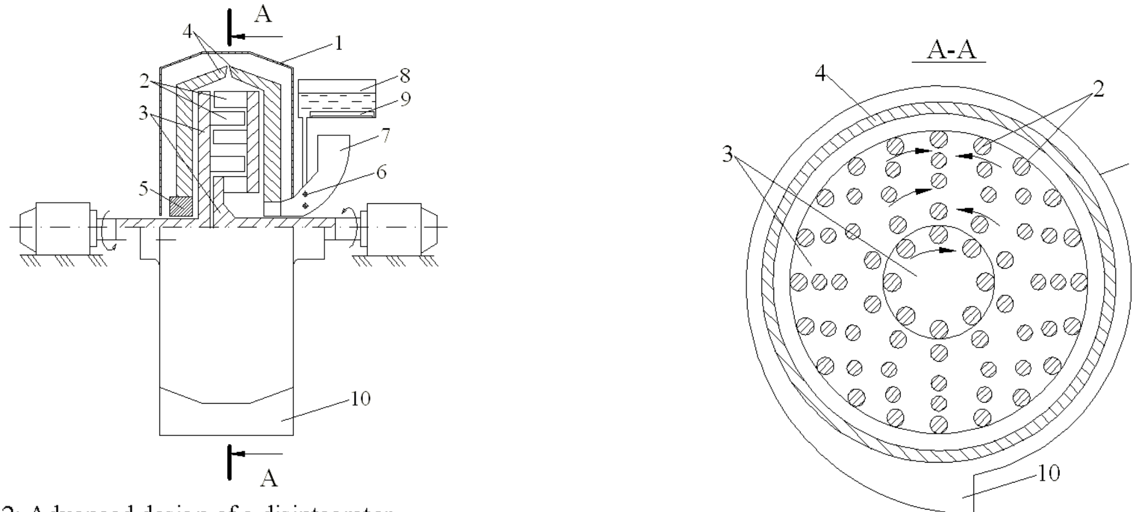


Fig. 2: Advanced design of a disintegrator

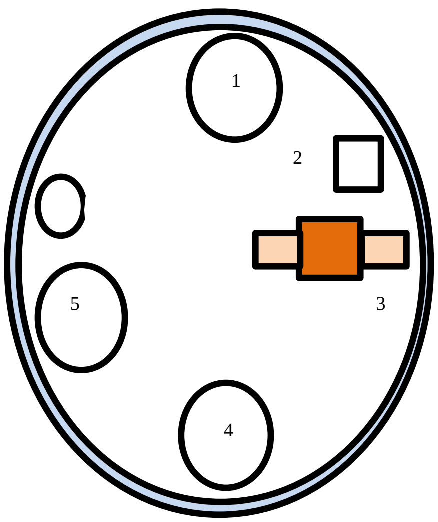


Fig. 3: The disintegrator in the construction circuit of a vertical shaft concrete lining: 1, 4-sockets; 2; receiving hopper; 3-disintegrator; 5-mixer; 6; ventilation tube

A sinking platform includes bucket mouths, receiving hoppers for mortar and inert materials, a disintegrator unit, a mechanical stirrer, a storage tank and a distribution line located on three floors (Fig. 3).

The concreting process begins with the mixing of cement on the surface. The obtained solution in containers is poured into a receiving hopper and activated in a disintegrator. The activated solution is loaded into a mixer drum where with the addition of sand and gravel. The resulting concrete mixture is transferred into a storage bin from which it is supplied behind a formwork through distribution pipelines. Sand and gravel iare sent into a hopper through a pipeline.

The mechanical activation changes the type and the number of defects in the cement structure. At that it accumulates energy the volume of which is comparable with the energy volume spent on processing. The varying of exposure intensity (the rotor rotation frequency, the number of treatment cycles) is controlled by the process electrical activity and the quality of resulting point defects in compound surface layers.

The compound ingredients accumulate special type of energy the action of which changes its structure and improves the mechanical properties of concrete. The mechanical activation of cement compound increases the strength of concrete 1.2-1.3 times by increasing the rate of strength increment 1.5 times. An optimized mounting technology may reduce significantly the work content by reducing the volume of a removable rock mass and increasing the rate of penetration due to the ability of work organization improvement.

The replacement of conventional concrete with a high modular one depending on accepted constructive solutions allows to reduce its consumption 1.5-2.7 times, at that the use of a more expensive cement-sand mortar is compensated by concrete volume decrease. The additional costs for the erection of supports with a high deformation modulus are repaid. The cost-effectiveness of production support using a disintegrator (Golik and Hasheva, 2015):

$$\Pi = \left[\frac{З_б}{А_б} + \left(\frac{Э_б + Э_б}{А_б}\right) - \frac{З_в}{А_б}\right] А г$$

Where:

- $\Pi$ = The profit from the combination of the concrete compound compositions
- $з_б$ = The costs of fixing at the basic technology
- $з_в$ = The costs of mounting using a disintegrator

$э^б$ = Operating and capital costs of a basic version
$э^б$ = Reduced operating and capital costs of mounting using a disintegrator
$A_б$ = The volume of mounting using a basic technology
$A_б$ = The volume of mounting using a disintegrator
A = Annual volume of shaft fastening; r- risk ratio for market operations

## RESULTS AND DISCUSSION

The demographic processes and the need to increase mineral production will increase the relevance of mining operations including the excavations opening fields. The improvement of mining technologies will be implemented by mobilizing its own reserves without an outside support.

The capital revealing mines are developed in relatively little-known structurally inhomogeneous stress-deformed and disintegrated arrays. Thus, technical solutions designed to reduce the consumption of scarce and expensive materials at the provision of necessary support strength, deserve some attention and implementation.

Mine shafts are built on new enterprises for the extraction of mineral raw materials in uncomfortable conditions or reconstructed on existing plants. Their construction involves the expenditure of scarce and expensive cement. Therefore, the minimization of costs for the construction of capital revealing shafts is one of mining economy priority areas.

The relevance of technical solutions which allow to provide the necessary strength of supports at the reduction of scarce and expensive materials consumption will be increased in the future, taking into account the world economy trends.

The ability of the binding concrete compound consumption reduction provides the use of high-modular concretes to adjust the properties of its components by a large mechanical energy in disintegrator activators. The activation efficiency can be increased by improving the disintegrator design and their integration into the process chain of shaft construction.

Under certain conditions, the costs of shaft construction technology upgrade is compensated by the decrease of scarce binding material consumption. The technology recommended by authors allows to engage a number of adjacent production tails in industry, the keeping of which is harmful to the environment.

## CONCLUSION

- The minimization of costs for the construction of capital mines is one of the priority trends for mining industry development
- The reduction of cement consumption is achieved by using high modular concretes
- The adjustment of concrete compound properties is performed by a high mechanical energy in activators
- The process efficiency increases with the activator location on a sinking platform of a constructed shaft
- The efficiency of shaft construction technology modernization is determined by the decision of the economic and mathematical model

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