Use of natural the fracture of coal under the regulatory impact of water hammer in the coal-watercoal cluster of utilities sector

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Abstract. The project to establish a prototype coal-coalwater cluster housing involves the use of constructed or existing boilers innovative coal-water-carbon technologies, including recycling and solid types of coal fuel in coal-water fuel slurry followed by burning in specially equipped furnaces. Analysis of the processes of brittle destruction of coal as a fractured rock at the macro and microlevels has shown that directed hydromining with the release of methane contained in coal seams, as well as wet grinding with the production of a certain granulometric composition of watercoal fuel suspension by hydroimpact occurs through macro- and microcracks. Also, as a result of the research, it becomes possible to use natural fracturing of control coal in the framework of creating a pilot site for an innovative coal-watercoal cluster of housing and communal services. A control model for an innovative coal-watercoal technology based on automatic control of the granulometric composition using natural the fracture of coal the regulatory impact of water hammer is proposed. The technological regularities of reducing the negative technogenic impact on geospheres are revealed, including the method of managing the environmental and technological qualities of innovative coal-water suspension based on automatic control of the granulometric composition when grinding coal using the water hammer method.

1. Introduction
The use of innovative technologies in construction and public utilities should aim to reduce the anthropogenic impact on the Geosphere [1]. This corresponds to the tasks of forming an urban life support system compatible with the biosphere [2]. Also, natural-like technologies should be used to solve global geocological problems in the field of mining, including coal [3, 4].

The project to create an experimental coal-watercoal cluster of housing and communal services involves the use of innovative coal-watercoal technology [5, 6] in construction or operating boilers, which includes the processing of solid types of coal fuel into a water-coal fuel suspension with subsequent combustion in specially equipped furnaces.

The developed method of control of innovative coal-watercoal technology based on automatic control of granulometric composition involves the use of natural of coal [7] for the control effect during wet grinding by water hammer [8, 9].
2. Materials and methods
In the article, the authors used the analysis of literature data and theoretical generalization of methods. The methodology of theoretical and practical research is based on the theory and methods of standard mathematical and statistical analysis.

The results obtained by standard mathematical and statistical analysis of the granulometric composition were confirmed by experimental data.

These methods allowed the authors to generate new ideas using the natural fracturing of coal to control the water hammer method within the coal-water cluster of housing and communal services.

3. Results
The effectiveness of innovative watercoal technology directly depends on the production of watercoal mixtures with specified rheological properties. In order to comply with environmental standards in the production of watercoal fuel suspension, much attention is paid to the control of granulometric composition [10, 11].

When obtaining a fine watercoal fuel suspension, the goal is to achieve a uniform granulometric composition that provides stable rheological properties at the stage of preparation, storage and transportation, deep demineralization and reduction of harmful emissions due to almost one hundred percent combustion.

Obtaining various grades of watercoal fuel suspension is provided by the presence of a certain granulometric composition. This was the reason for the study of the possibility of using the natural fracturing of coal for the control effect during wet grinding by the water hammer method.

Hard and brown coals have low strength and low ductility compared to overburden or host rocks of deep geological strata. Therefore, when tectonic deformations occur in coal seams, complex networks of cracks appear.

The main cracks remain perpendicular to the layer, which is typical for sedimentary rocks. To these are added cracks oriented at an angle of 45° to the plane of stratification that occur along the planes of maximum tangential stresses. For example, in some of the coal seams we studied, up to 10 crack systems were observed. As a result, the coal was broken by cracks into visible parts of the order of 1 cm³, which were rubbed to the size of sand by hands [7].

Complex structural construction of spatial crack networks determines the strength, deformation and filtration properties of coal seams. Hard and brown coals as rocks are characterized by a high degree of fracturing and brittle fracture mechanism [12, 13, 14], which ultimately should determine the technology of field development and use of minerals.

The optimal approach today is the use of water hammer technologies [8, 9]. At the same time, the technology of preparation of coalwater fuel suspension is reduced to preliminary crushing of coal in ball mills or vibratory mills to granules of 10...12 mm, wet grinding in a water hammer unit with subsequent homogenization (figure 1).

![Figure 1. Scheme of preparation of coal-water fuel](image-url)
The natural fracturing of coal is the basis of wet grinding in the water environment by water hammer. The operation of a modern wet-grinding water hammer unit is based on the use of a water hammer, the energy of which is transmitted by water to microcracks through which coal is destroyed.

Water hammer technologies for hydro coal mining and wet grinding using water hammer have similarities at the micro and macro levels. The processes of brittle destruction of coal as a fractured rock at the macro and micro levels are of the same nature. The method of vibration action in directed hydraulic mining with the release of methane contained in coal seams is similar to the method of water hammer in wet grinding.

The tasks set by us for managing environmental and technological qualities in the process of preparing innovative watercoal fuel suspension based on statistical analysis of the granulometric composition correlate with the tasks of obtaining micro and ultrafine watercoal suspensions in order to achieve high environmental and technological qualities [15, 16].

Analysis of the processes of brittle destruction of coal as a fractured rock at the macro and micro levels has shown that directed hydromining with the release of methane contained in coal seams, as well as wet grinding with the production of a certain granulometric composition of watercoal fuel suspension by hydroimpact occurs through macro-and microcracks.

Hard and brown coal as rocks are characterized by a high degree of fracturing and the mechanism of brittle fracture through cracks. The complex structural structure of spatial crack networks determines the strength, deformation, and filtration properties of coal layers.

In this case, we are interested in the problem of brittle destruction of extracted coal using control hydro-vibration actions at the level of microcracks for the purpose of crushing in water by water hammer.

A schematic image of a pilot water hammer plant is shown in figure 2.

![Figure 2. Wet grinding in a waterhammer plant [9]](image)

Speaking about coal microfractures, it can be noted that the frequency of cleavage of the split is very high, which makes it possible to direct the impact of water hammer before grinding at microlevels [7].

The authors of the article found that the set tasks of managing environmental and technological qualities in the process of preparing an innovative watercoal fuel suspension based on statistical analysis of the granulometric composition correlate with the tasks of obtaining micro and ultrafine watercoal suspensions in order to achieve high environmental and technological qualities.
Automatic control of the granulometric composition of watercoal suspension at the micro-ultra level with subsequent homogenization allows you to obtain and maintain the environmental and technological properties of watercoal fuel suspension as a non-chemical diesel fuel for an unlimited time.

One of the authors of this article (Chernyshev, 1983) found earlier that when primary cracks are formed in sedimentary rocks, the crack parameters obey the normal distribution law [7].

A normal (Gaussian) distribution is a symmetric distribution of sorting or growth of structures under naturally stable conditions. And the destruction under external influence is characterized by a lognormal left-symmetric distribution. This general pattern was also reflected in subsequent works with co-authors when studying various phenomena using the processes of rock destruction [17, 18].

For mathematical and statistical analysis, we used experimental data from tests of industrial samples of coal-water fuel mixture (figure 3).

![Figure 3](image)

**Figure 3.** Differential and integral distribution curves of the granulometric composition of brown coal B2, crushed in a wet-grinding water hammer plant [8]

Using data from industrial samples obtained together at a pilot plant, we obtained a mass distribution of the granulometric composition of the watercoal mixture (figures 4).

![Figure 4](image)

**Figure 4.** Differential distribution curve of the granulometric composition of watercoal suspension on a natural scale
As a result of the study, it was found that two types of coal were crushed together, which differed in fracturing and, consequently, in strength. One of them gave fragments with an average value of about 1.5...2.0 microns, the second – with a size of 30-35 microns.

Plotted on a Integral curve of distribution of granulometric composition of watercoal fuel suspension by fractions on probabilistic paper in logarithmic scale, we determined an inhomogeneous mixture of three components with their own lognormal distribution for each of them (figures 5).

![Figure 5](image)

**Figure 5.** Integral curve of distribution of granulometric composition of water-coal fuel suspension by fractions on probabilistic paper in logarithmic scale

On the abscissa axis, we set the decimal logarithm d. The \( \lg d \) probability distribution has a form similar to the Gaussian distribution. In other words, the distribution of d is lognormal, which is typical for the distances between tectonic cracks that occur at the stage of rock destruction in the massif under the influence of external stresses. Deformations from internal stresses (drying, shrinkage) lead to the formation of a normal, rather than lognormal distribution.

The presence of three lognormal distributions is confirmed by constructing an integral distribution curve for the granulometric composition of a watercoal suspension on a probabilistic paper, where \( \lg d \) is deposited along the ordinate axis, and the probability of the presence of particles of a specific size on the abscissa axis. The abscissa axis is deformed so that the Gaussian integral curve has the shape of a straight line.

In this case, there are three straight lines on the graph, which indicates the presence in the sample of watercoal fuel suspension of the charge from three statistical samples corresponding to three genetically different coal breeds.

The result obtained can be used in calculations related to the possibility of monitoring and controlling the granulometric composition of innovative watercoal fuel suspension in order to improve its environmental and technological qualities. This is necessary to optimize the choice of water-coal fuel and increase the resource efficiency of watercoal technologies [19-26].
Also, thanks to the conducted research, it becomes possible to use the natural fracturing of control coal in the framework of creating a pilot site for an innovative coal-watercoal cluster of housing and communal services.

4. Conclusions
Mechanical and technological aspects are analyzed within the framework of the project of innovative coal-watercoal cluster of housing and communal services, including the mechanics of destruction of coal as a fractured rock in a hydraulic shock installation.

The results obtained by standard mathematical and statistical analysis of the granulometric composition were confirmed by experimental data.

The results obtained allowed the authors to generate new ideas using natural fracturing of coal for controlling water impact within the coal-watercoal cluster of housing and communal services.

It is proposed to control an innovative coal-watercoal technology based on automatic control of the granulometric composition using natural fracturing of coal for controlling the impact of coal destruction by water hammer.

The technological regularities of reducing the negative technogenic impact on geospheres are revealed, including the method of managing the environmental and technological qualities of innovative watercoal suspension based on automatic control of the granulometric composition when grinding coal using the water hammer method.

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