Activation of the Grinding Process by Using the Adsorption Effect When Grinding Materials

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ABSTRACT

The article discusses methods for reducing energy consumption for grinding building materials, saving electricity, and activating the grinding process by reducing its strength when using adsorption action, which is a physical and chemical method during grinding.

Keywords: Grinding, adsorption effect, amorphous, crystal, phase, micro, macro, local damage, defect, ion, atom, molecule, gravity, energy, elector, element, elastic, plastic.

Introduction

According to engineering practice, the failure of any materials present in a specimen or structure will depend on various local damage or defects in them. However, the answer to the question of to what extent the presence of one or another defect in the material reduces their strength remains open [1-3].

The structure of building materials has a great influence on their properties and durability. The structure means the distribution and combination of gaseous, glassy (amorphous) and crystalline phases, their physicochemical nature and quantitative relationships. The structural properties of any building material are evaluated by its micro and macrostructure. The microstructure is determined by the nature of the crystalline phase, the glassy phase and the combination with pores and their structural character. The macrostructure determines the size, structure, shape, and mutual arrangement of pores in the material [4-9].

In most cases, the properties of inorganic materials are expressed by the structural properties of the phase and the structural character of the phase. Based on the phase composition, the structural character and nature of the crystalline phase and their quantitative relationship with glassy phases are assumed.

Methodology

For materials with organic content, the factor that determines their main properties is the presence of an amorphous phase and its connection with crystalline and glassy phases (fillers). Properties are mainly determined by microstructure for dense materials and macrostructure for porous materials (Figure 1).

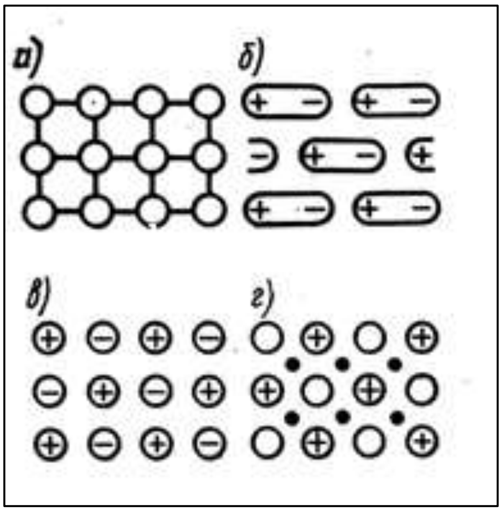

Figure 1. The main types of structures

The strength of concrete materials should be compared with solid bodies with an ideal structure, whose density (theoretical density) is determined by calculation [10-14]. The theoretical strength is such that the ideal defect-free material is fed slowly at sufficiently low temperatures to avoid dissociation of the irreversible material. The density of solids is based on the final calculation, which represents the forces of interaction of the atoms and ions that make up the solid [15-19]. Solids, as a rule, have a crystal structure that contains atomic, and ionic elements and molecules consist of molecules located at the nodes of a crystal lattice that form a regular repeating spatial structure of a geometric shape. Solids that do not have a crystalline structure have a state closer to this structure. According to the nature of the force that holds the molecules, atoms, and ions around the centre of equilibrium, crystal structures are usually divided into 4 types: atomic, molecular, ionic, and metallic. The nodes of ionic crystals contain oppositely charged ions, each of which is in perfect proportion to the surrounding ions of opposite sign. Ions move among themselves according to Coulomb's law. The attraction of differently charged particles is influenced by the repulsive force between the same charged electron shells [20-24].

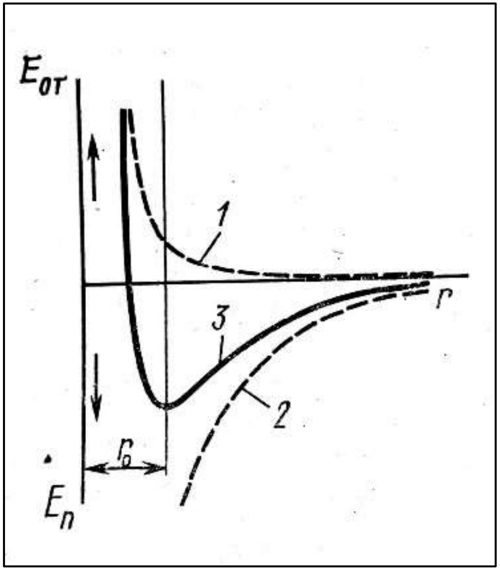

Figure 2. Energy scheme of attraction and repulsion forces.

Figure 2 shows the energy dependence graph for ionic crystals. When the curvature is 3 r=r0, the character of the resulting energy will have the minimum apparent magnitude. It is this quantity that is understood as the distance r0 between the ions in the molecule, which holds the elements of the solid body in the centre of equilibrium. When r=r0, the force of gravity is equal to the force of repulsion, and the force of mutual effect of particles is equal to 0 [25-31].

1- pushing energy;
2-gravitational energy;
3-resultant energy;
r0 is the equilibrium distance.

Gravitational energy can be calculated according to Coulomb's law.

$$E=\frac{-e^2}{\left(4\text{л}\varepsilon_0 r\right)} \qquad (1)$$

here:
e-ionic charge; e0- electrical constant; distance between r-ions.

Gravity will be equal to

$$F_n=\frac{-\partial E}{\partial r}=\frac{-e^2}{\left(4\text{л}\varepsilon_0 r\right)} \qquad (2)$$

The force of attraction is calculated according to Born:

$$E=\frac{B}{r^n} \qquad (3)$$

where B and n are constant quantities;
thrust force will be equal to

$$F_n = \frac{-\partial E_{om}}{\partial r} = \frac{nB}{r^{n+1}} \quad (4)$$

The resulting interaction energy of the ions is as follows:

$$E = E_n + E_{om} = \frac{B}{r^n} - \frac{e^2}{\left(4\text{л}\varepsilon_0 r\right)} \quad (5)$$

Ionic bonding is characteristic of NaCl, KCl, NaBr and other types of salts with a crystal lattice.

In atomic bonding, electrons simultaneously belong to the type of dinuclear molecules such as H_2, O_2, N_2. If the forces of the generalized electrons are directed in the opposite direction, then attraction occurs and the binding energy is calculated according to the London equation:

$$E_s = 2E_0 + \frac{\left(K + W\right)}{\left(1 + S^2\right)} \quad (6)$$

where 2E0 is the total energy of two separate atoms; K-electrostatic energy dependence; S- is a non-orthogonal integral varying from 0 to 1.

Atomic bonding is characteristic of silicate materials and many rocks. According to equation (4), the character of the energy graph is similar to that presented in Figure 2, but it forms a potential depth with a larger magnitude.

A metallic structure is characterized by a relatively small bond with the outer valence electrons in the nuclei of metal atoms. Atoms in the liquid and solid states of substances are located so close to each other that valence electrons leave their atoms and move freely within the lattice. Bonding in a metal lattice occurs as a result of the interaction of positive ions with gas electrons. Electrons are located between ions and try to attract them from the interaction between positively charged ions, to balance the force of attraction [32-37].

Due to the decrease in the distance between the ions, the electron density of the gas increases, which leads to an increase in the gravitational force. On the other hand, due to the decrease in the distance between the positively charged ions, the gravitational force that tries to separate the ions from each other increases. When the forces of attraction and repulsion are balanced, the lattice is stable due to the distance between such ions.

Metal connection should be suitable for valence. These bonds are based on the generalization of external electron valences, but valence bonds involve pairs of electrons from nearby pairs of atoms, and metallic bonds involve all atoms of the crystal, in which free electrons are located not in their own atoms, but in the entire lattice.

The general view of the bonds formed between atoms and molecules is based on van der Waals forces. They arise between electrically neutral systems that do not have an electric moment.

3 types of Van-Der-Waals interactions between molecules are distinguished: directed dipole in the molecular state; induced - in the creation of directed electric moments; dispersion-electrons from the synchronous movement between neutral molecules and in the opposite direction of spins [38-41].

A different type of van der Waals interaction is the higher hydrogen bond, which has a higher energy dependence, compared to another type of molecular bond.

The character of the interaction between the molecules in the van der Waals bond is also small enough for the magnitude of the potential depth in hydrogen bonding, according to Figure 5. Thus, the character of curvatures is characterized by the action of interaction between solid bodies in all types of connections presented in this graph.

Due to the vapour energy interaction of atomic energy in solids, it is difficult to determine the strength of two isolated atoms, so it is not possible to perform an adequate theoretical strength calculation.

According to the following formula, Orovan recommended calculating the theoretical strength:

$$\sigma_m = \left(\frac{E\alpha_{\text{пов}}}{r_0}\right)^{1/2} \quad (7)$$

where E- Young's modulus tension; a_{pov}- free energy surface of a solid body; Distance equilibrium between r0-atoms.

All the above points apply to ideal materials. Real composite materials have a variety of defects associated with crystal lattice defects and Griffiths microcracks.

Defects in crystals are divided into a point, one- and two-dimensional.

Point defects are divided into energetic, electronic and atomic types. Correction of deformation of the crystal lattice is caused by light, X-ray and other radiations, i.e. defects caused by various radiation or heat are energy defects. Electronic defects include vapour defects and excess electrons, consisting of an electron and a hole bound by Coulomb forces. Figure 3 shows three types of atomic defects. They appear in the form of vacant nodes, the displacement of an atom to an intermediate node, and the introduction of a foreign atom or ion into the lattice.

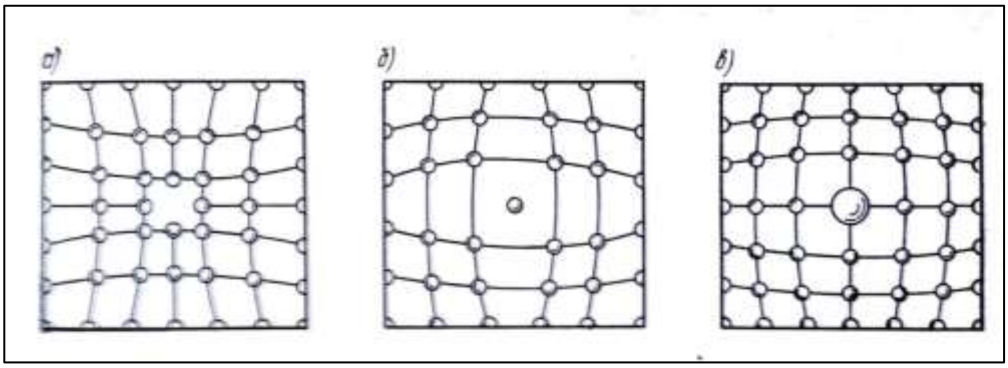

Figure 3. Atomic defects in the crystal lattice

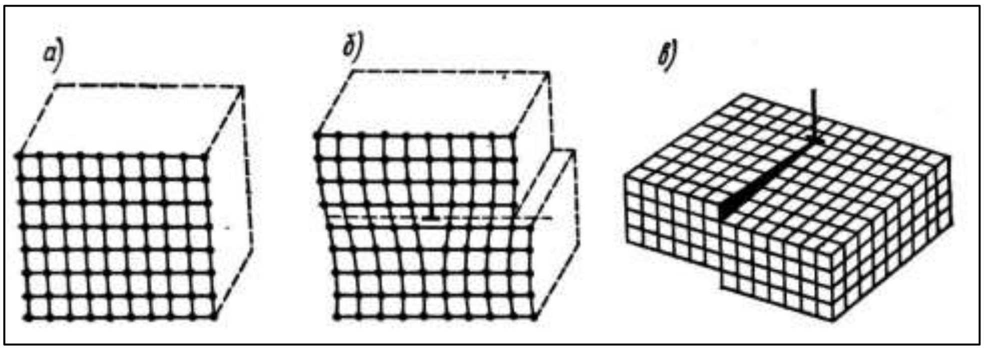

Figure 4. Location scheme:
α-ideal crystal structure; b,s-corneal location; v-screw arrangement; nuclear location

One-dimensional (linear) defects include dislocations. There are shear and screw types of simple dislocation. Figure 4 shows the structure of an ideal crystal with atomic formations parallel to each other in view a. If one of them is broken in the crystal, an edge dislocation is formed in place of the broken place. At maximum proximity, lattice distortion is quickly absorbed by the size of its loss (Fig. 4b). In the case of a screw dislocation, there is no discontinuity in the atomic structures inside the crystal, but the atomic structures themselves reflect a spiral staircase system. In practice, this single atom is twisted into a plane helical line. Disorientation can be reflected in the form of blocks (Fig. 4, c) in a screw dislocation. The area adjacent to the location axis is represented by two blocks, in which one of them moves one step forward in relation to the neighbouring block. Distortion of a large portion of the lattice is known as nucleation. Any exact location is provided in the form of a screw and screw location [42-47].

Two-dimensional (planar) defects include the boundary between crystal grains of linear arrangement paths. The surface of a crystal can be considered a two-dimensional defect.

Vacancy-type point defects are present in each lattice, which disappear under the influence of thermal fluctuations and appear continuously. The equilibrium concentration of vacancy n_v in the lattice at a specified temperature T is determined according to the Boltzmann formula as follows:

$$n_в = ne^{-Eв/(RT)} \qquad (8)$$

where: n is the number of atoms per crystal volume unit; EV-vacancy generating energy; R-Boltzmann's constant.

For most crystals, EV=1 eV. RT≈0.025 eV at room temperature, from which

$$n_в / n = e^{-1/0,025} \approx 10^{-14}$$

As the temperature increases, the relative vacancy concentration increases rapidly and reaches 10-5 at T=600K and 10^{-2} at T=900K.

Applying similar considerations to relative concentration, the energy of Frenkel defects is 3...5 эВ.

Even if the relative concentration of atomic defects is not very large, it can become large with changes in the physical properties of the crystal.

Dislocation is the displacement of crystal defects, involving much larger knots than atomic defects. Dislocation energy is estimated as $4 \cdot 10^{-19}$ Dj per dislocation length of 1 m. Such a large energy to create dislocations puts them in an athermal state, practically independent of temperature. For the entire interval in the crystalline state of the substance, the appearance of dislocations from thermal fluctuations is less lost than in the case of vacancies.

A dislocation in a real crystal is formed by its growth in a mixture or solution. From the study of the structure of real crystals, it can be seen that their structure is different from the structure of ideal crystals. Real crystals are made up of blocks of regular structure that are closely parallel to each other. It should be said that real crystals have a mosaic structure. Block sizes range from 10-4 to 10-6. Figure 5 shows two blocks that are spread out at an angle φ to each other and grow opposite each other. In addition, the crystal lattice has a different orientation in the formation resistance. Therefore, a transition layer occurs, in which the grid from one direction in a block passes to another direction block [47-50]. In a non-deformed crystal, the source of dislocation leads to the accumulation of vacancies (Fig. 6).

The formation of a shift in the crystal develops under the influence of an external force, shows the effect of sliding on the formation and goes to the surface of the crystal. If the displacement occurs only due to dislocation growth, the plastic deformation will decrease and the crystal will become perfect.

It can be seen from the experiment that with the increase of the deformation, the disorder of the lattice increases, and the dislocation density also increases. For example, the dislocation density in well-burnt metals is 107...108 cm^{-2}. After cold treatment, the dislocation density increases to 1011...1012 cm^{-2}. In this dislocation, all the energy absorbed by the metal during plastic deformation is concentrated.

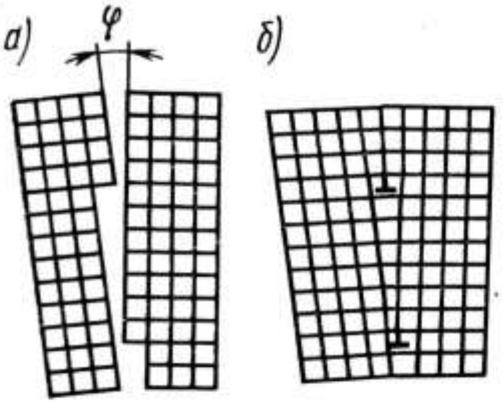

Figure 5. a-blocks growing opposite each other; φ is the angle between them; Dislocation resulting from the fusion of b-blocks.

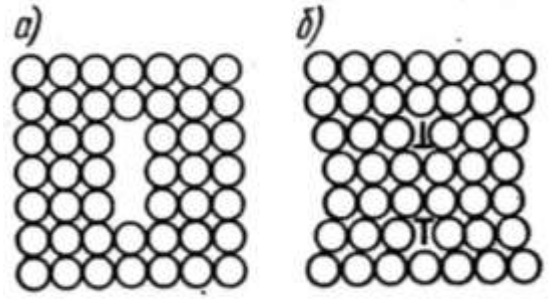

Figure 6. Accumulation of vacancies in α-crystal; b-vacancies formed from this accumulation.

Currently, a dislocation appears in the process of creating a shift under the influence of external forces. On the other hand, it is known that according to the size of the development of plastic deformation, the amount of growth of crystal defects is strengthened. The essence of this strength is the interaction of dislocations with each other and defects in other lattices, which make it difficult to move in the crystal lattice. A dislocation breaks the lattice tension, creates a force field around itself, and exhibits net stress and normal stress at each point. Forces are formed from the impact of another dislocation on it, which ensures that the dislocations move closer together or tend to each other. If the dislocation is located in one formation, then the dislocations of the same direction push each other, and the dislocations of different directions attract each other.

At the expense of temperature, the atoms in front of the crack try to avoid each other or approach each other at the expense of kinetic energy. This process consumes energy to overcome the potential energy E and E_1 barriers. The kinetic energy of particles is active energy, which brings atoms closer together or creates chemical bonds and regeneration processes. The difference $E\text{-}E^1$ is the potential energy of the plane, with some deviations, it can be said that it is a function between the particle and compressive stress, i.e. $f(x) - f(x^1)$.

In an unloaded body $X=\gamma_0$ and $X^1=\gamma_0^1$, in this case, the distance between the atoms in the plane layer is uniformly distributed. The maximum potential energy on the curve occurs as the breaks in the separation of atoms affect the neighbouring atomic bonds. In the case of the charge, the maximum particle is greater in the X zone than in the X1 zone when the particle is at rest. After the load is removed, the crack returns to its original crack position.

At present, there are 2 options for explaining the mechanism of crushing bodies:

- at the first initiation of cracks, atoms try to move away from each other or move closer to each other due to kinetic energy in front of the cracks:
- the second is because the growth of cracks depends on the elastic properties of solid bodies and the presence of stored energy in them:

According to Griffiths, the theory that the grinding process does not depend on temperature and the molecular theories of grinding of modern scientists unanimously say that the beginning of grinding is the presence of a crack on the plane surface of the material. It is not known how these cracks were formed. There are probably several reasons. The main ones are:

a) Mechanical damage received in the process of obtaining finished products;
b) Variation of thermal expansion coefficient of polycrystalline material phases;
c) Chemical corrosion during the use and production of materials;
d) In the process of plastic deformation of the material, the addition of dispersion, (mixing);

To get a truly finished product, preliminary mechanical processing begins. In the preparation of raw materials, quarrying is the process of digging, then crushing and sorting, and material formation is the process of mixing components and moulding them. As a result of all this sequence, the components are mechanically damaged, as a result of which micro and sometimes macro cracks appear.

Here we are not talking about the cracks that are formed in the technology of obtaining the finished product, but about the cracks that occur in the product organizers, that is, in the components. Often, when obtaining building materials, they are thermally treated. Cracks appear on the surface of the product due to differences in the coefficients of thermal expansion of the components involved in the processing process, but once again, we are talking about cracks in the components that make up the product, rather than cracks in the formation of the product.

It is known that newly formed particles increase the chemical activity of minerals in the plane of the surface. During the adsorber process, foreign ions or molecules on this surface may cause chemical corrosion.

We will dwell in more detail on the cracks formed due to dislocation: let the crystal not get a defect through the disposition process. Let's suppose that we want to absorb two rows of crystal atoms in the first layer, one atomic distance from the second (Fig. 7). To do this, we move the atoms in that row over each other in the plane of rounding along the row.

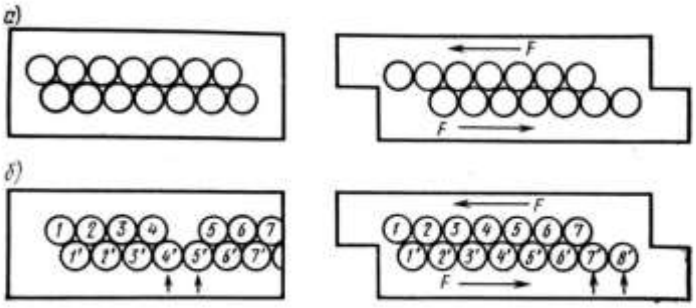

Figure 7. Scheme of displacement of ideal crystals (a) and crystal with dislocation (b).

A completely different situation occurs in crystals with dislocations (Fig. 7b). Based on this, it should be said that there is a disposition in the line above the two lines, a linear disposition, a linear space is formed.

At the edges of the lower (compressed) plane, an excess of atomic arrays is formed, resulting in high compression under the vacuum.

In a particular case, the vacancy is between 4 and 5, and atoms 41 and 51 are compressed. We squeeze 4 and 5 by force F and push them into the gap. What happens? The entire disposition shifts to the right and continues to shift. When the disposition continues until it leaves the crystalline. As a result, one atom moves out, just like an ideal crystal row, in this case, that is, in the second case, the displacement force is very small, in the first case, it was necessary to move a row of atoms in the crystal state. In the next second case, a part just moves the atoms.

Displacement of dispositions in a row can cause them to mix, which can lead to the formation of a crack. Based on this, we can say that mechanical damage in the starting plane, variation of the coefficient of thermal expansion in the structure of solid phases, presence of chemical corrosion and decomposition can cause the crack to appear.

Splitting cracks, as we have seen above, cause a decrease in the mechanical strength of the material. This, in turn, leads to a decrease in the power required for grinding.

It is possible to reduce the energy consumption for grinding and save electricity. Physico-chemical activity during grinding. It is possible to activate crushing by reducing the strength of solid bodies using the adsorption effect. This effect was proposed by A. Ribender and has been widely used in practice.

Results

Any solid body has defects on the surface and inside the flat surface. If we put a load on the body, it strengthens existing cracks and forms new ones as a result of elastic and plastic deformations. If we develop existing cracks in some ways, it becomes easier to crush the solid body. The adsorptive effect reduces the strength, which increases the size of cracks with low stress. A small crack on the surface of the material can be shown as a gap in the diagram. As a result of the gradual penetration into the micro gap, the free energy of the plane decreases until the end of the crack, where it can be reduced to 0.α

The medium surrounding the micro tab in the material can slowly penetrate the planar layer. If the surrounding medium is liquid, it can penetrate into the crack and form a thin film, and the free energy can greatly increase. To reduce the free energy, it is necessary to thicken the liquid film in the crack, that is, it is necessary to create a pore-like pressure. This pressure reaches its maximum value at the end of the crack. In the case of Pona, the pressure of the entrained liquid reaches a large value (250 MPa for water at the narrowest point of the crack) and creates wetting energy in this body. θ capillary pressure P_k characterizes the absorption of force.

$$P_k = 2\alpha_c \cos\frac{\theta}{r} \qquad (9)$$

here: - boundary angle damping;θ

g-space radius;

Absorption kinetics depends on the viscosity of the liquid.

$$\frac{dl}{dt} = \left[\frac{r^2\rho}{8\mu}\right]\cdot\left[(\rho l) - \mathrm{g}\sin\varphi\right] \qquad (10)$$

where: length of liquid tube in capillary 1; t-sucking time; r-liquid density; - is the deviation angle between the horizon and the capillary, as it becomes much larger than the average voltage. If high stress occurs, the crack will quickly develop and split into two, with theoretical strength near the dangerous crack.$\varphi\sigma$

The average stress in this case becomes equal to the critical stress, if the stress k increases, but is lower than the theoretical stress, the crack does not grow, and as a result, the material does not crack. The concentration stress coefficient is equal to the micro-crack front.

$$\sigma\beta = \frac{\sigma^*}{\sigma}$$

It depends on the following: the shape, size and position of the crack in relation to the applied force. To explain his formula, Griffiths stated that when calculating the critical stress, the following should be considered:

a) vitreous materials do not depend on temperature when grinding.

b) the increase of microcracks in the material occurs when the elastic energy in the body is equal to the energy in the free plane, the reduction of the newly formed particle surface area.

-da=dε

where: da - free plane energy; dε - increase in elastic energy;

c) the length of the microcrack is much smaller than the cross-section of the sample and the stress in the crack is much smaller than the average stress calculated with normal strength

Here is Griffiths' formula for determining the critical stress

consists of the melody.

$$\sigma_\kappa = \sqrt{2\alpha E / l_0} \qquad (11)$$

where: α-energy of the free plane of the elastic body; E-module of elasticity; 10 is the length of the crack at the edge of the object.

Disadvantages of Griffiths' theory compared to modern times:

1) when calculating with critical stress, the fact that the change in elastic energy and the energy of the free plane are equal (-da=dε), is wrong, because according to the law of conservation of energy, it is necessary to take into account the loss of mechanical energy when crushing a vitreous body,

$$da = d\varepsilon + dQ$$

2) Griffiths's theory is that consistency is temporary;

3) Failure to consider the molecular structure.

The essence of Griffiths' theory is that the formation and development of microcracks in materials are represented by the dependence on the number of cracks on the surface. It is said to determine the reasons for their formation. Here are the main ones:

a) mechanical damage to the surface during the extraction of finished materials;

b) hole expansion at different coefficients in separate phases of polycrystalline material;
c) when a hole is processed on materials with a multiphase structure formed between fireclay and clay particles, it leads to the formation of surface microcracks due to the difference in the coefficient of thermal expansion of each of them.

References

1. Хакимов, А. А. (2022). Технология Получения Качественных Брикетов С Использованием Горючих Вяжущих Компонентов. *Central Asian Journal of Theoretical and Applied Science*, *3*(6), 459-463.
2. Xakimov, A., Voxidova, N., & Rajabov, B. (2021). Analysis of collection of coal brickets to remove toxic gas. *Barqarorlik va yetakchi tadqiqotlar onlayn ilmiy jurnali*, *1*(5), 85-90.
3. Xakimov, A., Voxidova, N., Rustamov, N., & Madaminov, U. (2021). Analysis of coal bricket strength dependence on humidity. *Barqarorlik va yetakchi tadqiqotlar onlayn ilmiy jurnali*, *1*(5), 79-84.
4. Xakimov, A., Voxidova, N., Rajabova, N., & Mullajonova, M. (2021). The diligence of drying coal powder in the process of coal bricket manufacturing. *Барқарорлик ва Етакчи Тадқиқотлар онлайн илмий журнали*, *1*(5), 64-71.
5. Xakimov, A., Voxidova, N., & Xujaxonov, Z. (2021). Analysis of main indicators of agricultural press in the process of coal powder bricketing. *Barqarorlik va yetakchi tadqiqotlar onlayn ilmiy jurnali*, *1*(5), 72-78.
6. Akhmedovich, K. A. (2021). The Diligence of Drying the Coal Dust in the Process of Obtainig the Coal Brickets. *International Journal of Innovative Analyses and Emerging Technology*, *1*(5), 111-115.
7. Xakimov, A., & Vohidova, N. (2021). Relevance of the choice of binders for coal briquettes. *Scientific progress*, *2*(8), 181-188.
8. Ergashev, N. A., Khalilov, I. L. (2021). Hydraulic resistance of dust collector with direct-vortex contact elements. *Scientific progress*, *2*(8), 88-
9. Karimov, I., & Halilov, I. (2021). Modernization of the main working shovels of the construction mixing device.
10. Karimov, I., Xalilov, I., (2021). Barbotage absorbation apparatus. *Barqarorlik va yetakchi tadqiqotlar onlayn ilmiy jurnali*, *1*(5), 35-41.
11. Ergashev, N., Ismoil, K., (2022). Experimental determination of hydraulic resistance of wet method dushanger and gas cleaner. *American Journal Of Applied Science And Technology*, *2*(05), 45-50.
12. Ikromali, K., & Ismoiljon, H. (2021). Hydrodynamics of Absorption Bubbling Apparatus. *Бюллетень науки и практики*, *7*(11), 210-219.
13. Ergashev, N., & Halilov, I. (2021). Experimental determination length of liquid film in dusty gas cleaner. *Innovative Technologica: Methodical Research Journal*, *2*(10), 29-33.
14. Хакимов, А. А. (2021). Определение показателей качества угольного брикета. *Universum: химия и биология*, (5-2 (83)), 40-44.
15. Ахунбаев, А. А., Ражабова, Н. Р., & Вохидова, Н. Х. (2020). Исследование гидродинамики роторной сушилки с быстровращающимся ротором. *Экономика и социум*, (12-1), 392-396.
16. Хакимов, А. А., Вохидова, Н. Х., & Нажимов, Қ. Кўмир брикети ишлаб чиқаришнинг янги технологиясини яратиш. *ўзбекистон республикаси олий ва ўрта махсус таълим вазирлиги Заҳириддин Муҳаммад Бобур номидаги Андижон давлат университети*, *264*.
17. Хакимов, А. А. (2020). Связующее для угольного брикета и влияние его на дисперсный состав. *Universum: химия и биология*, (6 (72)), 81-84.
18. Вохидова, Н. Х., Хакимов, А. А., Салиханова, Д. С., & Ахунбаев, А. А. (2019). Анализ связующих из местного сырья для брикетированния углольной мелочи. *Научно-технический журнал ФерПИ*, 69-74.
19. Ахунбаев, А., Ражабова, Н., & Вохидова, Н. (2021). Механизм движения дисперсного

материала при сушке тонкодисперсных материалов. *Збірник наукових праць SCIENTIA*.

20. Nasiba, V. (2022). High-pressure coal dust pressing machine. *Universum: технические науки*, (7-4 (100)), 17-19.
21. Хакимов, А. А., Салиханова, Д. С., & Каримов, И. Т. (2019). Кўмир кукунидан брикетлар тайёрлашнинг долзарблиги. *Фарғона политехника институти илмий техника журнали.-2019.-№*, *23*(2), 226-229.
22. Axmedovich, X. A., & Saidakbarovna, S. D. (2021). Research the strength limit of briquette production. *Asian journal of multidimensional research*, *10*(5), 275-283.
23. Хакимов, А. А., Салиханова, Д. С., Абдурахимов, А. Х., & Жумаева, Д. Ж. (2020). Использование местных отходов в производстве угольных брикетов. *Universum: химия и биология*, (4 (70)), 17-21.
24. Хакимов, А. (2020). Технология брикетированного угля. *Матеріали конференцій МЦНД*, 76-78.
25. Хакимов, А. А. (2020). Совершенствование технологии получения угольных брикетов с использованием местных промышленных отходов: Дисс.… PhD.
26. Khakimov, A. A., Salikhanova, D. S., & Vokhidova, N. K. (2020). Calculation and design of a screv press for a fuel briquette. *Scientific-technical journal*, *24*(3), 65-68.
27. Saidakbarovna, S. D., Akhmedovich, K. A., & Abdusattor oʻgʻli, D. A. (2022). The current state of technologies for the production and activated clay adsorbents. *International Journal of Advance Scientific Research*, *2*(04), 25-28.
28. Saidakbarovna, S. D., Akhmedovich, K. A., & OʻG, E. U. T. L. (2022). The study of the composition and properties of water-oil emulsions formed from local oils and methods for their destruction. *European International Journal of Multidisciplinary Research and Management Studies*, *2*(04), 143-146.
29. Saidakbarovna, S. D., Akhmedovich, K. A., & Ziyovutdin oʻgʻli, A. S. (2022). The Flotation Methods of Industrial Wastewater Treatment. *Eurasian Research Bulletin*, *7*, 80-85.
30. . *Innovative Technologica: Methodical Research Journal*, *2*(10), 29-33.
31. Alizafarov, B., Madaminova, G., & Abdulazizov, A. (2022). Based on acceptable parameters of cleaning efficiency of a rotor-filter device equipped with a surface contact element. *Journal of Integrated Education and Research*, *1*(2), 36-48.
32. Gulmiraxon, M., Muhammadqodir, Y., Ravshanbek, M., & Nikita, L. (2022). Analysis of the dispersion composition of dust particles. *Yosh Tadqiqotchi Jurnali*, *1*(6), 70-79.
33. Ikromaliyevnab, M. G. (2022). New design of wet method wet cleaning blade-drum device. *American Journal Of Applied Science And Technology*, *2*(05), 106-113.
34. Мадаминова, Г. И. (2022). Исследования по определению контактных поверхностей пыли. *Universum: технические науки*, (5-7 (98)), 63-67.
35. Karimov, I., Tojiyev, R., Madaminova, G., Ibroximov, Q., & Xamdamov, O. T. (2021). Wet method dust remover black drum device. *Barqarorlik va yetakchi tadqiqotlar onlayn ilmiy jurnali*, *1*(5), 57-63.
36. Karimov, I., Tojiyev, R., Madaminova, G., Ibroximov, Q., & Xamdamov, O. T. (2021). Hydrodynamics of wet dush powder black drum equipment. *Barqarorlik va yetakchi tadqiqotlar onlayn ilmiy jurnali*, *1*(5), 49-56.
37. Isomidinov, A., Madaminova, G., Qodirov, D., & Ahmadaliyeva, M. (2021). Studying the Effect of Interior Scrubber Hydraulic Resistance on Cleaning Efficiency. *International Journal of Innovative Analyses and Emerging Technology*, *1*(5), 87-93.
38. Isomidinov, A., Madaminova, G., & Zokirova, M. (2021). Analysis of modern industrial dust gas cleaning devices. *Scientific progress*, *2*(8), 137-144.
39. Домуладжанов, И. Х., & Мадаминова, Г. И. (2021). Вредные вещества после сухой очистки в циклонах и фильтрах.

Universum: технические науки, (6-1 (87)), 5-10.

40. Мадаминова, Г. И., Тожиев, Р. Ж., & Каримов, И. Т. (2021). Барабанное устройство для мокрой очистки запыленного газа и воздуха. *Universum: технические науки*, (5-4 (86)), 45-49.
41. Тожиев, Р. Ж., Исомиддинов, А. С., & Ахроров, А. А. У. (2021). Исследование пленочного слоя на рабочей поверхности роторно-фильтрующего аппарата. *Universum: технические науки*, (7-1 (88)), 42-48.
42. Тожиев, Р. Ж., Ахунбаев, А. А., & Миршарипов, Р. Х. (2018). Сушка тонкодисперсных материалов в безуносной роторно-барабанном аппарате. *Научно-технический журнал ФерПИ,-Фергана,(2)*, 116-119.
43. Ахунбаев, А. А., & Ражабова, Н. Р. (2021). Высушивание дисперсных материалов в аппарате с быстро вращающимся ротором. *Universum: технические науки*, (7-1 (88)), 49-52.
44. Ахунбаев, А., Ражабова, Н., & Сиддиков, М. (2021). Математическая модель сушки дисперсных материалов с учётом температуры материала. *Збірник наукових праць SCIENTIA*.
45. Тожиев, Р. Ж., Миршарипов, Р. Х., & Ражабова, Н. Р. (2022). Гидродинамические Режимы В Процессе Сушки Минеральных Удобрений. *Central asian journal of theoretical & applied sciences*, *3*(5), 352-357.
46. Rajabova, N. R., & Qodirov, A. B. (2022). Drying tonkodisperse materials in an unsuccessed rotary-druming machine. *International Journal of Advance Scientific Research*, *2*(06), 35-39.
47. Ражабова, Н. Р., Агзамов, С. У., & Ёқубжонов, А. Т. (2022). Извлечении редких металлов в барботажном экстракторе. *Eurasian journal of academic research,* 2(5), 893-895.
48. Tojiyev, R., & Rajabova, N. (2021). Experimental study of the soil crust destruction mechanism. *Scientific progress*, *2*(8), 153-163.
49. Tojiyev, R., Erkaboyev, X., Rajabova, N., & Odilov, D. (2021). Mathematical analysis application of the gas-dynamic principle for deep cooling of the underway soil layer. *Scientific progress*, *2*(7), 694-698.
50. Axunboev, A., Rajabova, N., Nishonov, A., & Ulmasov, I. (2021). Hydrodynamics of the rotor dryer. *Barqarorlik va yetakchi tadqiqotlar onlayn ilmiy jurnali*, *1*(5), 144-148.