Basic results of researches of lining and plugging processes at wells construction

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Abstract
The main data on the processes connected with lining and plugging of wells bore are provided. Direct dependence of efficiency of drilling operations on quality of carrying out of prior operations in the lining cycle is shown. The technique and results of carrying out of laboratory researches of active additives impact on technological indicators of grouting solution are described. Basic consistent patterns of impact of clay-slurry pastes on characteristics of grouting stone when modeling borehole conditions of its forming in the trouble intervals are determined. The obtained results of researches can be the basis for creation of effective technology of lining and plugging of well bore with high technical and economic rates; moreover, they are basic for development of rational operating process parameters of well-drilling. The directions of further operation in the field of enhancement of lining technology of wells are specified.
Key words: WELL, CAVITY, SLURRY CONCENTRATIONS, GROUTING SOLUTION, STRENGTH, CLAY, GROUTING STONE

Introduction

The result of whole process of wells construction depends on degree of perfection of works on lining and plugging, and requirements to this stage must be especially accurate due to rather high cost [1].

Without listing of all wide range of purposes of wells lining, it is important to notice that their achievement will be carried out only in case of maximum reliable filling of annular space with grouting solution and subsequent acquisition of predefined set

of technical characteristics by grouting stone. In case of violation of the specified requirements, total negative change of all physical and mechanical properties of grouting stone is observed. There are not only internal reasons, which are always present, but also external ones, among which one of the most widespread and significant is violation of integrity of the well bore, which is expressed in caving [1, 2]. These local broadening are the centers of acquisition of negative characteristics by grouting stone.

Even in case of rather full compliance of all technological requirements of process of wells construction, it is not possible to avoid caving phenomenon. Thus, the emerging trouble intervals become objects of finding of almost motionless volume of the clearing agent, and also of accumulation and formations of clay-slurry concentrations in the process of well deepening [1].

Though the existing methods of preparation of well for plugging aim at cleaning of bore, they are insufficiently effective from the standpoint of removal of content from cave zones. Practice of drilling operations sometimes shows even total absence of grouting stone in cavities intervals in technological aspect of this term understanding.

The objective of these paper is experimental and theoretical study of scale of impact of clay-slurry the caving concentrations on technical characteristics of grouting solutions and stone when modeling borehole conditions of its formation, and also formulation of methodical requirements to preparatory work in lining cycle.

Basic material

Thorough study of problems of wells lining allows classification of this type of operations as rather multiple-factor and dependent on a number of conditions, which can be controlled only partially. According to above mentioned, preparatory activities must be subordinated to main objective, which is removal of the agents, which are capable to mix up with grouting solution, from the well bore; this is not always paid enough attention to [3].

The research of nature of foreign impurity impact on properties of grouting solutions and stone represents an important task, which solution will allow effective control of technology of preparatory work.

It is impossible to reach perfect cleaning of well bore; however, acceptable indicators must be obtained. Identification of structures and concentration of polluting agents as main accumulator of clay and slurry formations, which have catastrophic impact on results of plugging, will give the chance to direct processing of caving zones. Establishment of all range of the influencing factors in foreign impurity is an insoluble problem, at the same time, detection of the general tendencies can and must be carried out.

According to specified data, detailed researches have been conducted. They are based on the problem of obtaining integrated evaluation of extent of influence of foreign impurity on technological parameters of grouting solution and stone in the big range of characteristics.

With regard to borehole conditions of obtaining of grouting stone, it is formed due to passing of grouting solution in an annular gap and penetration of filter cake, clearing agent and slurry caving concentrations into it. In this regard, the conducted researches have been conditionally subdivided into two stages, at the first of which, properties of grouting solution, and at the second stage, the grouting stone formed under certain conditions were studied according to technical regulations.

For control of grouting solutions, properties, which have the most direct influence on acquisition of necessary characteristics by grouting stone, have been selected.

The main material for preparation of grouting solutions is the grouting cement made by GOST B. V. 2.7 - 88 – 99 (interstate GOST 1581 – 96); it was accepted as object of study. Distinctive feature of the described laboratory researches can be their performance under the conditions as close as possible to production that allows definition of results as rather real and technologically applicable.

It is considered that solutions, which water return is close to zero, are the best for plugging of wells [3]. For these purposes, for example, bentonite is used. In general, it is defined as clay; quite different data on impact of this material on water return indicators are provided in literature. However, as it is shown below, influence of clays of various mineralogical structures on water return of grouting solutions is so diverse that requires specification in each case.

It is obvious that the clay phase can get into grouting solution not only by means of its mixing with the boring agent on the basis of this or that drilling mud powder, but also by mixing of products of destruction of the argillaceous varieties crossed by well [1]. It is also necessary to notice that bentonite powders often contain minerals of other clays except montmorillonite, and also application of clays of lower quality is not excluded in the course of preparation of boring agents. Therefore, the given facts require detailed studying.

In Figures 1 – 3, graphic dependences of influence of various mineralogical groups of clays on indicators

of water return of grouting solution, and also results of their chemical processing by reagents on the basis of water-soluble esters of cellulose, lignosulfonates and acrylic polymers, which are widely applied in practice of construction of wells, are shown.

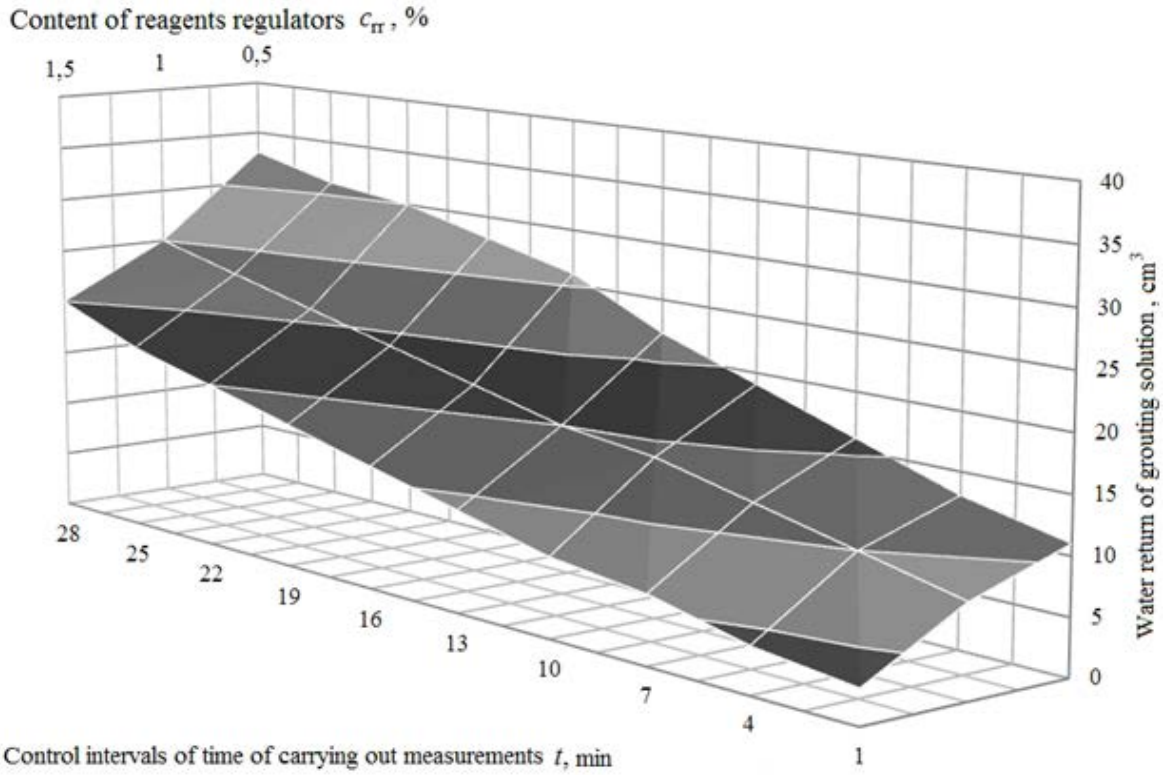

Figure 1. Dependence of indicator of water return at introduction of bentonite clay up to 20% and reagents regulators up to1.5% into grouting solution

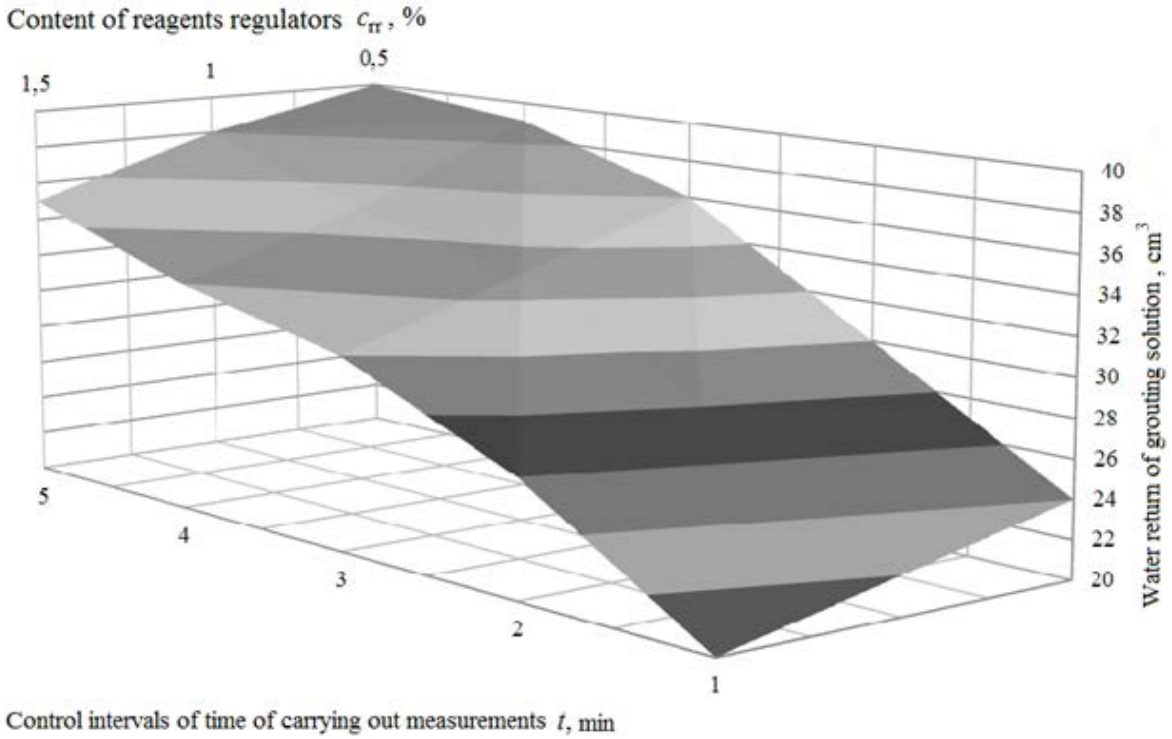

Figure 2. Dependence of indicator of water return at introduction of illite fraction up to 15% and reagents regulators up to 1,5% into grouting solution

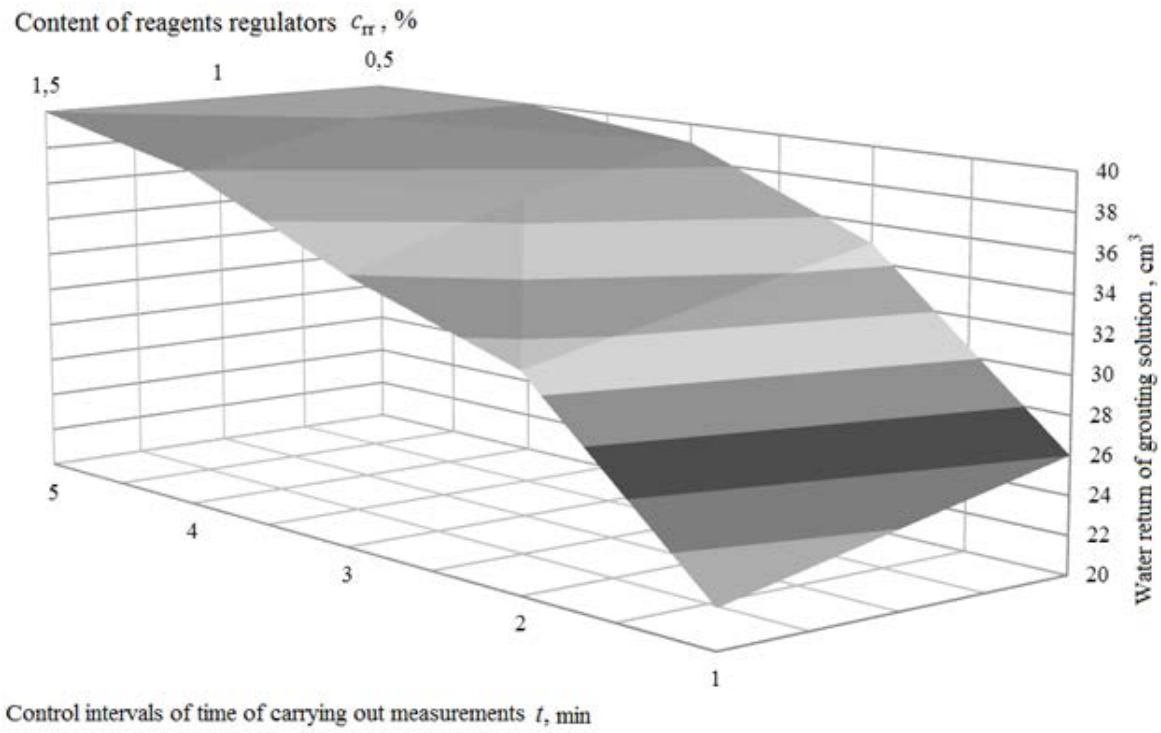

Figure 3. Dependence of indicator of water return at introduction of kaolin clay up to 15% and reagents regulators up to 1,5% into grouting solution

Due to large volume of data, in Figures 1 – 3, only characteristic dependences obtained in course of research of properties of grouting mixes are shown; however, they allow following of certain regularities. First of all, it should be noted that clays of various mineralogical groups have considerable impact on water return. For montmorillonite group, it is expressed in decrease in water return of grouting solution, contrary to illite and kaolin groups, which considerably increase it. At that, such action is shown both in case of introduction in isolated form into solution and in combination with bentonite that is extremely important. In the second case, there is only some reduction of indicator of water return, almost irrespective of a ratio of clays concentration. Also, the mechanism of influence of special reagents is of interest: their application in case of existence of solution of bentonite phase in composition partially reduces the speed of water return and its value. In case of introduction of reagents regulators to grouting solutions containing other clay groups (in combination with bentonite and without it), essential reduction of indicators of water return is not reached. At the same time, use of these reagents is conductive to delay of grouting mixes setting-up that is not always admissible.

At a high speed and considerable absolute value of water return, in volume of grouting solution there are numerous filtration streams; therefore, the grouting stone is penetrated by the channels significantly influencing indicators of its strength. Moreover, the filtrate passing to zone of contact of grouting solution with walls of the well and casing string is conductive to sharp decrease in link of grouting stone with the surfaces surrounding it. In Figure 4, pictures of structure of grouting stone where filtration motion of liquid takes place, are presented.

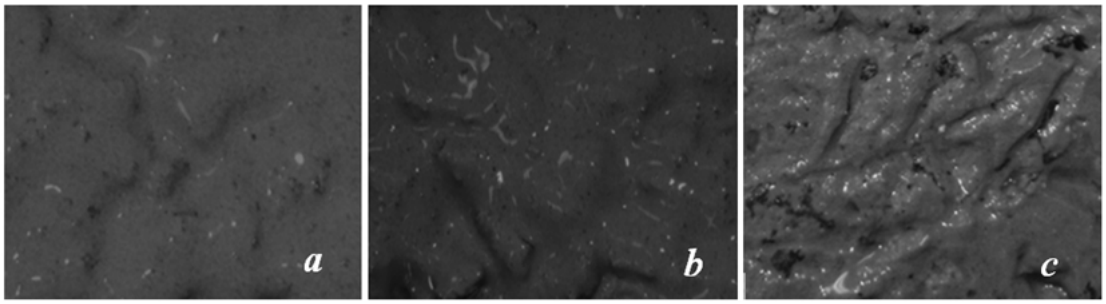

Figure 4. Structure of grouting stone (increased) in case of presence of bentonite, illite (b) and kaolin (c) phases in its structure

When consideration of pictures of structure of grouting stone (Figure 4), regularity of increase in intensity of filtration channel forming in a chain of clays is traced: bentonite → illite → kaolin. With introduction of other argillaceous varieties into composition of grouting solutions, channel forming is at the level of illite, or in the most cases, kaolin phases.

Graphical dependences of increase of plastic strength of grouting solutions in case of introduction of clays of various mineralogical groups into them are shown in Figure 5. The attention is paid at the fact that growth of plastic strength takes place with the intensity changing in time and big degree of unevenness though graphs are similar. In other words, for each grouting mix duration of existence of the period of plastic mobility is long enough; it allows products of destruction and filter cake, which are not removed from a well bore, to get into solution. These factors predetermine unevenness of increase of strength of solution structure in the range of cavity in comparison with the corresponding indicators in annular space that naturally involves emergence of local zones of concentration of tension in transition borders.

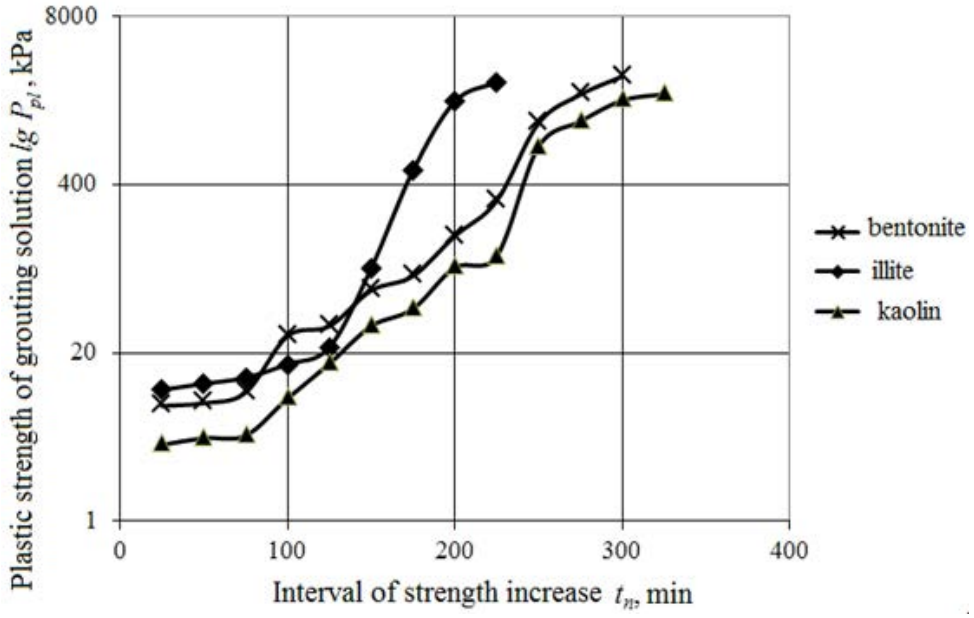

Figure 5. Change of plastic strength of grouting solution at introduction of various clay phases into its structure

Further experimental researches have shown availability of close interrelation between strength of a grouting stone and concentration of foreign impurity in it. In case of passing of grouting solution into a zone of cavity, either weighing of rock waste or filtration flow of mix through the thickness of accumulated destruction products tale place; pictures provided in Figure 6 show this.

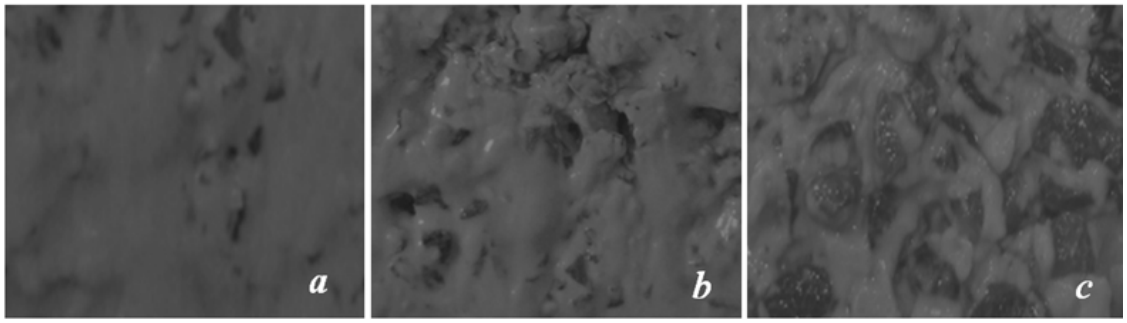

Figure 6. The mechanism of distribution of grouting mix when passing into caving interval (increased)

Figure 6 (a, b) shows that grouting mix is placed in caving interval with washout of slurry deposits and their distribution in volume of the hardening solution. Study of structure of grouting stone throughout the height of cavity has shown its heterogeneity due to existence in structure of rock inclusions, which small fractions are found mainly in the upper sites (Figure 6, a), and large ones in lower sites (Figure 6, b). It is

necessary to notice the following: due to various density of grouting solution and fragments of the broken rocks (considerably larger), they move within the gravity field action; it leads to violation of structure of the grouting mix with increasing strength. At that, intensity of the specified processes is determined by water and cement ratio, which selection, however, is carried out on the basis of conditions of possibility of grouting mix pumping. Distribution of grouting solution in a zone of caving can take place without mixing, but with penetration of stream of solution in the form of the separate streams moving in steam structure of the massif of slurry concentrations (Figure 6, c). It is also necessary to emphasize that the orientation and nature of process of distribution of grouting mix are influenced by the speed of its flow, power of caving interval, particle size distribution of slurry concentrations.

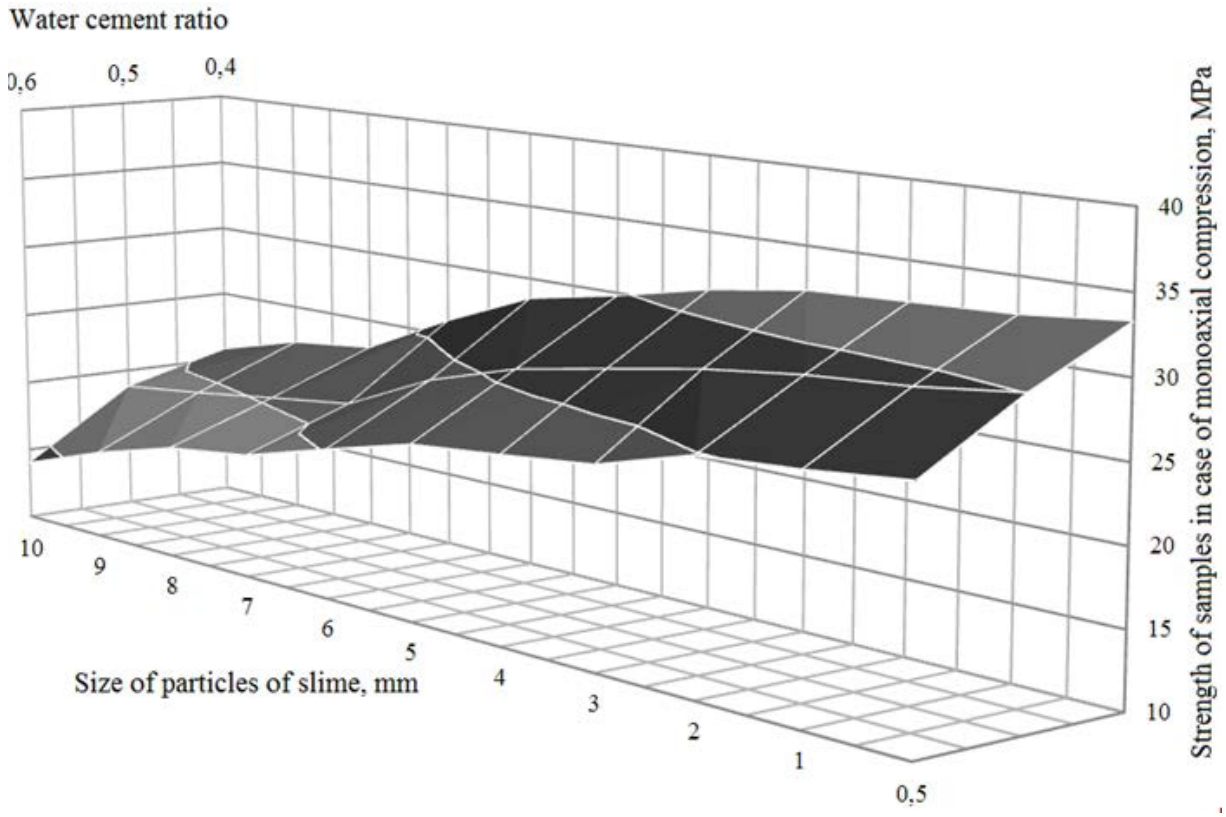

Figure 7. Strength of the samples of grouting stone containing outside impurity of different fractional groups at variable water cement ratio

Figure 7 represents results of researches of grouting stone strength in strict compliance to regulations of GOST B. V. 2.7 - 86 – 99 (interstate GOST 26798.1 – 96).

Concerning strength indicators of the studied samples (Figure 7), it is possible to state that they are much lower than theoretical ones for this grouting material (it concerns a case of distribution of fragments in grouting mix). In case of research of the samples formed as a result of jet distribution of grouting solution in volume of slurry concentrations, it was not succeeded to establish any objective indicators due to low degree of strength of the studied objects.

The data of Figure 7 also confirm very obvious connection between durability of grouting stone, water cement ratio and particle size distribution of inclusions. With increase in the sizes (average fractions and higher) and parallel growth of water cement ratio, the strength of the tested samples on monoaxial compression decreases quite intensively. And, cracks formation under these conditions appears at vertical load of component about 65 - 75% for the samples made of grouting mix without inclusions. As a rule, the break occurs in contact surfaces of separate slurry particles.

Based on results of the conducted detailed researches, it is possible to claim with confidence that process of preparation of wells for plugging must contain measures for removal of concentrations from caving intervals. The best results can be achieved when using the special device initiating the active streams of liquid capable to destroy clay and slurry formations. The process of cleaning should be performed especially carefully when crossing of argillaceous varieties with steadily emerging caving by well. In case of observance of all requirements of technolo-

gical measures of caving zones processing by means of the special device, achievement of high technical and economic rates of construction of wells is possible.

Conclusions

Problems of influence of clays of various mineralogical structures on water return, which is one of the most important technological indicators of grouting solution, were considered. The mechanism of effect of reagents regulators (water-soluble esters of cellulose, lignosulfonates and acrylic polymers) in case of their introduction into composition of grouting mixes was investigated. The reasons and consequences of emergence of filtration streams are studied when forming grouting stone in the caving well intervals. Laboratory methods have shown dependence of strength indicators of grouting stone on availability of active impurity of clay fractions and products of destruction of rocks in its composition. Necessity of implementation of careful preparatory activities when carrying out grouting works was proved.

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