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Abstract. *The article considers the indicators of quantitative assessment of reliability of components operation in the process of dump trucks operation in mining enterprises. The basic concepts, terms and designations of reliability assessment indicators are given, and also formulas and expression determining the reliability of dump trucks are given. The histogram of determining the degree of exploitation of dump trucks at the enterprises is given. In this work, for mechanical, hydraulic and electrical equipment in general, for the investigated dump trucks, the reliable amount of data on failures was determined based on the assumption of exponential law of distribution of operating time between failures. At the same time, estimates of reliability indices of individual elements were obtained with confidence probability.*

Key words: *Dumper truck, reliability, failure, coefficient, element, repair, component.*

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STUDY OF GEOTECHNOLOGICAL WELL CONSTRUCTION TECHNOLOGY

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Annotation. *The article considers the conditions of construction of geotechnological wells for the extraction of minerals by in-situ leaching method taking into account the type of design of production wells. Factors influencing the choice of design designs of production wells are given, as well as typical designs of* *single-column and high-yield production wells of in-situ leaching. Formulas and expressions, which take into account well flow rate, are considered.*

Key words: *Well, mineral, structure, solution, design, casing, filter, flow rate.*

Introduction. The essence of in-situ leaching of a mineral is the selective conversion of a useful component into a liquid phase by controlled movement of a solvent through the ore in the natural occurrence or prepared for dissolution and lifting of a metal-saturated solution to the surface. For this purpose, a chemical reagent capable of converting the minerals of the mineral into a soluble form is injected through wells drilled from the surface into the mineral formation. After passing through part of the ore bed, the solution is brought to the surface through other boreholes and then transported by pipeline to the processing facilities.

Mining (geotechnological) complex - combines technical means, facilities and technological processes related to the extraction of uranium-bearing productive solutions from the subsurface [1].

When selecting the design of production wells for in-situ leaching of minerals using acid solvents, the following should be taken into account: 1) ensuring high resistance of the casing material to chemically aggressive media, as well as mechanical strength of the casing under conditions of mining pressure and hydrodynamic loads; 2) the internal cross-section of the casing should allow for repair and recovery operations, cementing of the wells to create waterproofing of the zones of movement of working and productive solutions and conducting the necessary geophysical and hydrogeological observations of the in-situ leaching process; 3) the possibility of creating a reliable waterproofing of the overburden horizon, especially in the case of exploitation of low-power ore bodies located in the zone of aquifers; 4) during drilling the integrity of the lower water table should not be disturbed, in case of over-drilling of the water table it is necessary to provide for its plugging in the future; 5) the weighting device for running polyethylene casing strings into the well should be made of inert materials or it should be retrievable; 6) when equipping the lower part of the filter with a settling tank with windows to facilitate well development, it is necessary to provide for the possibility of closing the windows after completion of development work; 7) special wellhead equipment should be used to protect the borehole space from penetration of working solutions from the surface; 8) the service life of wells should be not less than the block development period [2,3,7].

When mining mineral deposits using the in-situ leaching method, special requirements are also imposed on borehole filters.

In view of the above, the construction of geotechnological wells has a major role in mineral extraction.

Materials and Methods. The following main factors influence the choice of design structures of production wells of PV: 1) geological and hydrogeological conditions of the field (physical and mechanical properties of the constituent rocks, depth of occurrence of the productive layer, presence of aquifers in the section, etc.); 2) the accepted system of field development and the scheme of placement of production wells; 3) design productivity of production wells; 4) type and design of solution lifting devices; 5) geographical location of the field; 6) purpose of wells, etc.) [4,5,8].

The designs of pumping and injection process wells differ only in the diameter of the production strings used: pumping wells are usually equipped with larger diameter strings. The diameters of wells and production strings are determined by the size of solution lifting devices (e.g., erlifts, submersible pumps, etc.).

The most widely used materials for casing and production strings in in-situ leaching are polyethylene pipes such as PNP, C and T series; PVP, C, T, ST series" fiberglass and metal-plastic pipes, stainless steel casing. Casing pipes are used in acid leaching as casing (protective) columns, and in other leaching methods they can be used as production columns. In the practice of in-situ leaching of metals, single-column and double-column designs of process wells are mainly used.

Fig. 1 shows designs of single-column production wells, which are most widely used in in-situ leaching of reservoir deposits. In some cases, at significant depths of occurrence of productive horizons and presence of unstable rocks in the section, the wellhead can be equipped with a guide pipe and conductor. When constructing production injection and pumping wells with waterproofing of working and productive solutions with the help of collars, the wells are drilled to the ore bed with a diameter of 190 - 243 mm, and re-drilling of the ore bed is carried out with smaller diameter bits (Fig. 1.a).

The 110 - 140 mm diameter production column is equipped with a settling tank, filter, acid-resistant rubber cuff and weighting plates [6,7,9].

At the point of transition to a reduced borehole diameter, the production casing is equipped with a cuff with an elongated body and a metal ring soldered into the base, which provides the necessary strength and rigidity. In cases where the cuff is to be inserted into the upper water table represented by weak clayey rocks, the shoulder should be drilled above the proposed location of the cuff.

The main purpose of the collar is to create waterproofing above the zone of movement of productive solutions. Waterproofing material is poured on top of the collar.

The waterproofing interval, except in special cases, is usually equal to the height from the cuff to the dynamic groundwater level. The rest of the wellbore space can be filled with other material, and the wellhead is cemented to a depth of 2 - 3 meters.

Single-column designs of injection and pumping process wells of in-situ leaching with waterproofing by means of collars are simple and have low costs for their construction. However, such designs of process wells do not allow to use filters with gravel backfill, which reduces productivity and service life of the wells. This process well designs are currently most often used as injection wells.

Recently, process wells of in-situ leaching are equipped with filters with gravel backfill. In order to create a widened contour of gravel backfill at the bottomhole, the bottomhole zone can be pre-expanded (Fig. 1.b).

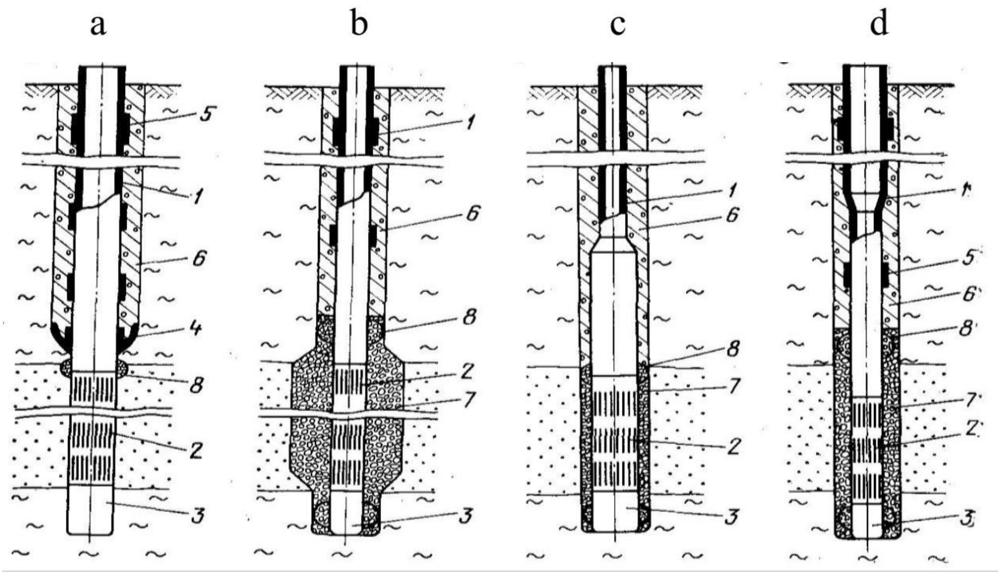

Fig. 1. Typical designs of single-column production wells of in-situ leaching
a - with waterproofing by means of packer (collar); b - with gravel backfill of filters; c - with combined production column and erlift lifting of productive solutions; d - with combined production column and lifting of productive solutions by means of submersible pumps: 1 - production column, 2 - filter, 3 - settling tank, 4 - separating collar with cementing device, 5 - weighting device, 6 - waterproofing material, 7 - sand and gravel backfill, 8 - centralizer

Equipping injection wells with gravel filters increased the injectivity of the well, while also increasing the life of the well and the serviceability of mud lifting devices, especially submersible pumps. Waterproofing of the zones of working and productive solutions movement is carried out after creating a sand and gravel backfill around the filter by pouring waterproofing material over the gravel layer.

The diameters of production strings are selected taking into account the purpose of the wells and the applied production devices (pumping, injection).

When constructing injection wells, the diameter of production casing is selected so as to accommodate inside the string solution feeders and to ensure the necessary injectivity of the wells (the necessary amount of solution must be delivered to the productive formation per unit of time). Currently, when constructing injection wells, the diameter of production strings varies between 70 and 150 mm.

For the well design shown in Fig. 1.b, the diameters of production strings have values of 110 - 225 mm.

In deep wells with high dynamic level of productive solutions the production string can be combined. The upper part of the string is selected of larger diameter for installation of submersible pumps. The length of the upper part of the production string of increased diameter is set taking into account the dynamic level of the solution in the well, the length of the pump, the depth of the pump immersion below the dynamic level (3 - 5 m) and the additional lowering of the level as a result of filter colmatization. This part of the string is assembled in most cases from polyethylene pipes, the length of which is determined by the maximum depth of running of pipes of a given size. The lower part of the production string corresponds to the filter diameter (Fig. 1.d). The material of pipes of the lower and upper parts of the column may also differ, usually more durable pipes are installed in the lower part, e.g. stainless steel, fiberglass pipes, etc. The lower part of the column is made of polyethylene pipes.

In some cases at erlift lifting of productive solutions when using production strings as solution lifting pipes it is possible to reduce the diameter of the string in comparison with the filter diameter (Fig. 1, c). This is established on the basis of calculated ratios of air supply and mud lifting pipes diameter and well productivity.

The diameter of the borehole under the production string for single-column structures depends on the diameter and material of the applied pipes (polyethylene, fiberglass, stainless steel, etc.);

Type, diameter and place of installation of the weighting device for running polyethylene strings, applied cementing methods and waterproofing of the working and productive mud flow zones.

When applying the system of field development, in which the number of pumping and injection wells is selected from the ratio 1:3, 1:4, 1:5, the productivity of pumping wells should be 3, 4 and 5 times higher than the productivity of injection wells, respectively. Fig.2. shows typical designs of high-yield wells. When constructing high-yield pumping wells equipped with filters with sand and gravel filling, there are used constructions, in which the wellbore is cased up to the roof of productive horizon with pipes made of stainless steel, fiberglass plastic and others, the material of which is not subject to destruction under the action of acid solvents (Fig.2.a). The casing shoe is designed with a smaller diameter for more reliable and easy installation of the waterproofing packer [7,8].

Drilling the well and drilling to the productive horizon is usually carried out with 295, 346, 394 mm diameter bits. The casing pipe space is cemented. Further drilling to penetrate the productive horizon is carried out with 190 - 243 mm diameter bits.

The interval of the pay zone, where the gravel filter frame is located, is expanded if necessary.

The filter together with the over-filter spigot and the sump are lowered into the borehole on the drill pipe connected to the over-filter spigot with the help of a special adapter having a left-hand thread. To ensure better centering of the filter at the bottomhole, it is equipped with two guide lights - on the sump and on the overfilter spigot (in the upper part).

The design of production wells used in conditions of great depth (over 300 m) and in the presence of unstable rocks in the upper intervals of the well is shown in Fig.2.b. The unstable part of the wellbore is secured with a casing (protective) string made of metal pipes with subsequent cementation of the annular space. Later the well is equipped with a production casing made of acid-resistant materials, which is isolated from the casing by means of collars (packers), cement, clay or lime mortars.

The depths of in-situ leaching production wells are determined by the position of the productive horizon, the length of the sump, etc. The position of the ore bed is determined by taking geological samples (cores) during advance drilling of small-diameter wells in the process of constructing process wells, as well as by geophysical measurements.

The length of injection well sumps is determined by the amount of suspended solids in the working fluid fed into the well and the time between preventive well repairs. Usually, the length of sumps in filters installed in injection wells is not more than 1% of the nominal well depth, for pumping wells this value does not exceed 2%.

In some cases, at low reservoir mud levels and large depth of wells the use of erlifts as mud lifting means is possible only by increasing the depth of the mixer under the reservoir mud level. For this purpose the depth of wells is increased.

If at re-drilling of the well below the ore horizon the last one opens the aquifer, it is necessary to provide cementation of the backhole space of the sump up to the lower boundary of the filter.

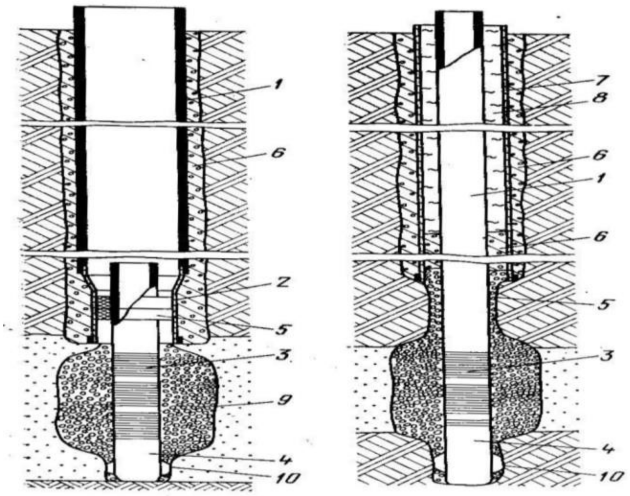

Fig.2. Typical designs of high-yield production wells of in-situ leaching

a – high-rate pumping wells; b – deep wells with unstable borehole intervals: 1 – production string; 2 – liner; 3 – filter; 4 – sump; 5 – packer; 6 – waterproofing layer; 7 – protective string; 8 – clay solution; 9 – gravel; 10 – centralizer.

Process solution front – spatial position at a certain moment of time of simultaneously supplied to the injection well (or to injection wells) portion of the process solution.

Well flow rate (Q) – the amount of water produced by the well per unit of time in m^3/hour, l/sec[9]:

$$Q = 2.73 \cdot K_f \cdot M \cdot S/(\lg R - \lg r) \quad (1)$$

where: K_f - filtration coefficient

M - thickness of the horizon

S - depression (H_d-H_s).

R- radius of influence of the well at water withdrawal

r- radius of the well

Lowering - decrease of water level in the well at water withdrawal:

$$S=(H_d-H_s) \quad (2)$$

where: H_d - dynamic level;

H_s - static level.

Specific flow rate - amount of water produced by the well at lowering one meter

$$q=Q/S \quad (3)$$

Pump capacity - amount of water pumped by the pump per unit time (well flow rate should be more or equal to pump capacity).

Interaction of pumping wells - increase of level cutoffs (increase of dynamic level) in each well during operation of a number of wells.

When a number of wells interact, the level slices from the influence are summed up.

For this reason, the flow rate of wells during development is higher than during operation:

$$Q=q(S-t) \quad (4)$$

where t - is the reduction in level from the operation of a neighboring well.

Conclusions. Various designs of geotechnological wells are proposed depending on the type of field mining and geological conditions, depth and purpose of the well.

The research established the technology and sequence of works on construction of geotechnological wells.

Typification of deposits by mining and geological characteristics has been made.

The main technological parameters of wells and spatial location of production cells, well flow rate, as well as the limits of dynamic and static levels were determined.

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