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THE FEATURES OF WORK OF CARBIDE-TIPPED DRILL IN CRUMBLING ROCKS

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The drill bit in the oil and gas industry plays a key role in the drilling process, but its operation in the field, filled with difficulties and dangers, emphasizes the need for careful study of its behavior. This equipment, which is the head of the well, is forced to face various challenges during drilling, where danger can await at every step. However, special attention should be paid to those cases when the drill bit collides with crumbling rocks.

In conditions of high pressure and friction associated with drilling, the drill bit is subjected to significant loads. These conditions can lead to damage and breakage of equipment, which in turn creates additional risks for workers on site. Understanding the behavior of a drill bit in crumbling rock is becoming an extremely important aspect to ensure the efficiency and safety of field work.

The analysis of the technical characteristics and mechanisms of the impact of the drill bit on crumbling rocks makes it possible to develop more reliable and durable tools capable of withstanding extreme conditions. This, in turn, increases drilling efficiency, reduces the risk of industrial accidents and ensures safer working conditions in the oil and gas industry.

KEY WORDS: *drill bit, crumbling rock, carbide-tipped, drilling crown, core, cutter, drilling process, well.*

ҰНТАҚТАЛҒАН ЖЫНЫСТАРДАҒЫ ҚАТТЫ ҚОСПАЛАРДЫ БҰРҒЫЛАУ ЖҰМЫСТАРЫНЫҢ ЕРЕКШЕЛІКТЕРІ

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Мұнай және газ өнеркәсібіндегі бұрғылау қашауы бұрғылау процесінде шешуші рөл атқарады, бірақ оның қиындықтар мен қауіптерге толы даладағы жұмысы оның жұмыс істеу принципін мұқият зерттеу қажеттілігін көрсетеді. Ұңғыманың бас бөлігі болып табылатын бұл жабдық бұрғылау кезінде әр түрлі қиындықтарға тап болуы ықтимал, мұнда қауіп әр қадамда күтілуі мүмкін. Дегенмен, бұрғылау қашауы ұсақталған жыныстарға тап болған жағдайларға ерекше назар аудару керек.

Бұрғылаумен қатар жүретін жоғары қысым мен үйкеліс жағдайында бұрғылау қашауы айтарлықтай жүктемелерге ұшырайды. Бұл жағдайлар жабдықтың зақымдалуына және бұзылуына әкелуі мүмкін, бұл өз кезегінде жұмысшылар үшін қосымша қауіп тудырады. Ұсақталған жыныстағы қашауының әрекетін түсіну дала жұмыстарының тиімділігі мен қауіпсіздігін қамтамасыз етудің өте маңызды аспектісіне айналады.

Бұрғылау қашауының қираған жыныстарға әсер етуінің техникалық сипаттамалары мен механизмдерін талдау экстремалды жағдайларға төтеп бере алатын сенімді және берік құралдарды жасауға мүмкіндік береді. Бұл өз кезегінде бұрғылау тиімділігін арттырады, өндірістік апаттар қаупін азайтады және мұнай және газ өнеркәсібінде қауіпсіз жұмыс жағдайларын қамтамасыз етеді.

ТҮЙІН СӨЗДЕР: *бұрғылау қашауы, ұнтақталған тау жынысы, қатты қоспа бұрғысы, бұрғылау негізі, өзек, кескіш, бұрғылау процесі, ұңғыма.*

ОСОБЕННОСТИ РАБОТЫ ТВЕРДОСПЛАВНОГО СВЕРЛА В КРОШАЩИХСЯ ПОРОДАХ

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Буровое долото в нефтяной и газовой промышленности играет ключевую роль в процессе бурения, но его работа в полевых условиях, наполненных сложностями и опасностями, подчеркивает необходимость внимательного изучения его поведения. Это оборудование, представляющее собой головную часть скважины, вынуждено сталкиваться с различными вызовами в ходе бурения, где опасность может поджидать на каждом шагу. Однако особое внимание следует уделить тем случаям, когда буровое долото сталкивается с крошащимися породами.

В условиях высокого давления и трения, сопутствующих бурению, буровое долото подвергается значительным нагрузкам. Эти условия могут привести к повреждениям и поломкам оборудования, что в свою очередь создает дополнительные риски для рабочих на месте. Понимание поведения бурового долота в крошащейся породе становится крайне важным аспектом для обеспечения эффективности и безопасности полевых работ.

Анализ технических характеристик и механизмов воздействия бурового долота на крошащиеся породы позволяет разработать более надежные и прочные инструменты, способные выдерживать экстремальные условия. Это в свою очередь повышает эффективность бурения, снижает риск производственных аварий и обеспечивает более безопасные условия работы в нефтяной и газовой промышленности.

КЛЮЧЕВЫЕ СЛОВА: *буровое долото, крошащаяся порода, твердосплавное сверло, буровая коронка, керн, резец, процесс бурения, скважина.*

Introduction. The causes of frequent fracture of bit while destroying types of tool bits at the time of drilling of crumbling rocks were considered. It is established that shock loads occurs at the intersection of cracks by bit due to their participation in two motions: circumferential rotation and falling into the Riesz space. Recommendations are given to reduce the dynamic loads on the drill bits.

Hard alloy which consists of carbide, tungsten and cobalt is widely used for armaments of the destroying of crumbling rocks such as drill bits and chisels. The carbide-tipped tool bits have high hardness, thus is effectively used for drilling soft and medium hard rocks. As well as using hydro and air-powered percussive drills for drilling hard and strong rocks. At the same, Hard Alloy has a poor toughness against impact.

The properties mentioned above sound good, but in fact, equipment are vulnerable for fracture. There are a lot of factors which influence on fracture appearance. Pressure, temperature and friction take a big role in fracture appearance. Even though engineers take care of equipment, they compensate high temperature and friction with drilling fluid. Drilling fluid cools bits and decreases temperature and friction. This action is inevitable procedure in drilling. Unfortunately, it does not give us 100 percent guarantee safety of equipment [1-3].

Methodology analysis of the work of carbide drill. Let's consider the influence of this index on the integrity of carbide bit in the formation of kerf in monolithic and the carbide-tipped tool bits (see *Figure 1*).

In monolithic rocks (see *Figure 1a*), the rotation of bit by kerf is equally.

Cutter deepens into the kerf to the depth t by the influence of axial load, which corresponds to a volumetric nature of destruction.

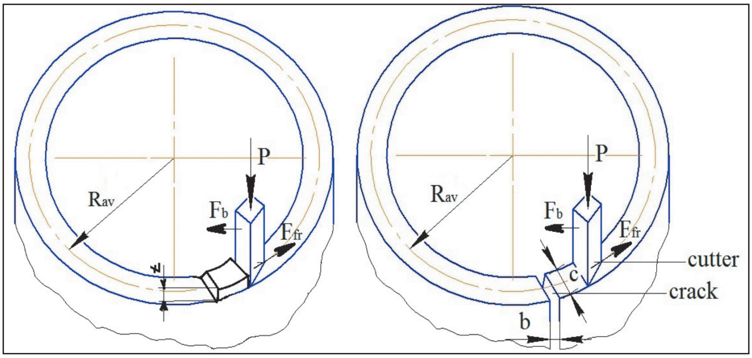

Figure 1 – **Rotation of bit in the formation of kerf**
a – drilling of monolithic array; b – array crosses the crack

In time of rotation of bit annexes thereto rotational force FB must overcome the force of friction $F_{fr}= fP$ and the force, which is required to the section of rocks in front of the bits face:

$$F_B = fP + \delta_{sec} S \tag{1}$$

where: f – the coefficient of friction to the contact; P – axial load to bit; δ_{sec} – tensile strength of rock to the section; S – area of the bit faces which contacts with rock.

Bit wear occurs under the influence of the friction force is abrasive in nature and reduces to increasing of the contact area of bit with kerf. It leads to necessity of increasing the load on the bit to keep the surround mode of destruction. However, increasing of axial load on the bit results in a proportional increase of the frictional force, and thus to accelerate the abrasion, which is converted into the avalanche [3-5].

At this stage, the process of volumetric destruction is not possible to realize due to restrictions that are imposed to increase of axial load, for example due to the technical capabilities of the drilling rig.

The drilling process has features, some of which were discussed earlier in our paper. Let me briefly describe the main essence. At a meeting crack bit under the influence of the gravitational acceleration is moved into the cracks space, in addition to the rotation under the force F_B (see *Figure 1 b*). The speed of bit υ_n by this direction is equal to:

$$\upsilon_n = g_0 t_n \tag{1}$$

where: g_0– acceleration of gravity; t_n– the fall time of bit to its encounter with the edge crack.

Linear speed υ_{lin} of bit during the rotation at an angular velocity ω the radius of gyration R_{av} has to be:

$$t_m = \mathrm{W} R_{av} \tag{2}$$

The crossing time by bit cracked up to its encounter with the side n_k (see *Figure 2*) is equal to:

$$t_m = {}^{b}/_{\upsilon_{lin}} = \frac{b}{\omega R_{av}} \quad (3)$$

In this case, the bit will deepen in the fissure space at a distance h, which is equal to:

$$h = \frac{g_o t_n^2}{2} \quad (4)$$

Since the time of bit movement in the fracture t_n and time tm intersection of cracked are the same, (including 3) could be possible to record next:

$$t_n = t_m; \sqrt{\frac{2h}{g_0}} = \frac{b}{\omega R_{av}} \quad (5)$$

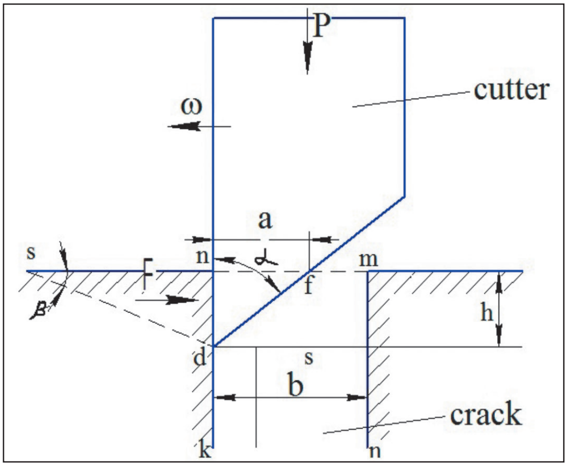

Figure 2 – **Position of the rotary bit at a meeting fracture**

From (4) deepening h of bit into the fracture (see *Figure 2*) will be:

$$h = \frac{b^2 g_0}{\omega^2 R_{av}^2} \quad (6)$$

During ongoing rotation of the bit there is a hit the wall n_k of the fracture (see *Figure 2*). Parameters of torque shock are related to the well-known relation:

$$M = I_p \varepsilon \quad (7)$$

where: M – torque applied to the bit, N×м; I_p – moment of bits inertia, kg×м^2; ε – deceleration of the bits angular velocity, sec^{-2}.

$$I_p = m_p R_{av}^2 \quad (8)$$

where: m_p– weight of bit, kg [4-7].

The slowing of bit happens in time of hit T_y, which according to various estimates ranges from 10^{-3} to 10^{-4} c. During this time, the angular velocity ω over time hit T_y drops to zero.

Assuming a linear law of falling of the angular velocity ω during the time of hit, can be written:

$$\varepsilon = \frac{\omega}{T_y} \quad (9)$$

Including (8) and (7), the dependence (6) will be written as:

$$M = mR_{av}^2 \frac{w}{T_y}, \text{N×m} \quad (10)$$

Wall reaction n_k (see *Figure 2*) upon the bits hitting, let's denote it as F_R. By considering well-known Newton's law, can be written next:

$$M = F_R R_{av} = I_p \frac{w}{T_y} \quad (11)$$

The force F_R by taking into account (10) is equal to:

$$F_R = \frac{m_p R_{av} \omega}{T_y}. \quad (12)$$

The strength of bit is determined by the formula:

$$\sigma_p = \frac{F_R}{S}, N/_{m^2} \quad (13)$$

where: S – the section of bit, m^2.

Figure 1,2 shows:

$$S = nc = htga \times c \quad (14)$$

By using of (10) and (14), the condition of destruction (separation of the prism n^{td}) of the bit (see *Figure 2*) will have the next form:

$$\sigma_{av} = mR_{av}^2 w /_{T_{y \times chtga}} > \sigma_{av}^0 \quad (15)$$

where: σ – the wedge angle bit;

σ_{av}^0 – the strength of the bit [9].

Figure 3 shows the operation of the drill bit burrow which intersects one fracture. It is not difficult to calculate that the number of hits per revolution bits on the edge of the fracture will be y = 2 (x – number of hits). Furthermore, it is likely a double hit to the fracture diametrically opposite cutters simultaneously. In this case, the formula (10) turns to [7-10]:

$$M_k = 2I_0 \frac{w}{T_y} = 2m_k R_{avk}^2 \frac{w}{T_y} \quad (16)$$

where: I_0 – the moment of inertia of the core set (crown, core barrel, adapter);

w, T_y – explanation is the same as before;

m_k – the weight if core set, kg.

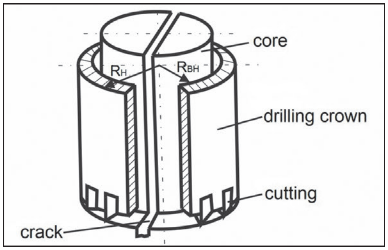

Figure 3 – **Formation of bottom hole by drilling of crumbling rocks**

For thin-walled cylinder, as the coring kit (crown core barrel) is, the last the moment of inertia equal to:

$$I_0 = m_k R_{av}^2 = p_{cs} \pi (R_{\text{Н}}^2 - R_{\text{ВН}}^2) \times L_k \times R_{av}^2 \tag{17}$$

where: p_{cs} – material density of core set;

R_h, R_{Bh} – inner and outer radius of the core barrel;

$R_{av} = \frac{R_H + R_{BH}}{2}$ - medium radius of the core set.

L_k – The length of the of core set.

On the other hand, double hit of diametrically opposite bits, got in fracture will cause torque M_k, equal to $M = 2Fr_{av}$.

Further consideration of the process leading to the validity of formulas (13-15) provided a replacement of the bit mass m on the weight of the core set of m_k.

However, the most dangerous in the drilling process is a violation of the strength of carbide bits because of low toughness [10-12].

The energy of the rotating core set is:

$$U_k = J_0 \frac{w^2}{2} = m_k R_{avk}^2 \frac{w^2}{2} \tag{18}$$

where: I_k – the moment of inertia of core set, kg×м^2.

$I_k = m_k R_{avk}^2$ (m_k – weight of core set);

R_{avk}^2 – middle radius of core set.

While crossing the fracture by bits there is toughness of the needs to be less than the critical value of this parameter σ_{cr}, wherein the bit breaks:

$$\sigma_n = \frac{U_k}{s} = \frac{m_k R_{avk}^2 w^2}{2s} \leq \sigma_{cr} \tag{19}$$

Parameter σ_{cr} and more than ten times less than steel (article 3), component $6 \cdot 10^5 \div 12 \cdot 10^5$ J/m^2, i.e. for hard alloy it lies the in the range $0{,}5 \cdot 10^5 \div 1 \cdot 10^5$ J/m^2. As a result there is chipped and violation of the integrity of carbide bits.

However, the increase of cobalt content from 3% to 20% in the solid alloy causes an increase of toughness and flexural strength is more than 2 times [13-15].

Conclusions.

1. For core drilling crumbling rocks there is a phenomenon due to the hit of participation of bits crossing fractions in the movement in two directions:

– rotate for the formation a ring round curf;

– the falling of bits into the fraction space while crossing by them fractions.

2. The strength, which can lead to breakage bits, depends on the mass of the rotating body (of core set), the radius of the angular velocity of rotation.

3. Most often frequent fracture of carbide-tipped bits occurs because of their low toughness.

4. It is recommended whenever possible to reduce the diameter of the drill the weight of core set and reduce the speed of the destroying of the crumbling rocks and to use equipment to drill carbide bits with high toughness, such as the VC-20. [15-18]

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