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Х А Б А Р Л А Р Ы

ИЗВЕСТИЯ

РОО «НАЦИОНАЛЬНОЙ
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ЧФ «Халық»

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В 2016 году для развития и улучшения качества жизни казахстанцев был создан частный Благотворительный фонд «Халык». За годы своей деятельности на реализацию благотворительных проектов в областях образования и науки, социальной защиты, культуры, здравоохранения и спорта, Фонд выделил более 45 миллиардов тенге.

Особое внимание Благотворительный фонд «Халык» уделяет образовательным программам, считая это направление одним из ключевых в своей деятельности. Оказывая поддержку отечественному образованию, Фонд вносит свой посильный вклад в развитие качественного образования в Казахстане. Тем самым способствуя росту числа людей, способных менять жизнь в стране к лучшему – профессионалов в различных сферах, потенциальных лидеров и «великих умов». Одной из значимых инициатив фонда «Халык» в образовательной сфере стал проект Ozgeris powered by Halyk Fund – первый в стране бизнес-инкубатор для учащихся 9-11 классов, который помогает развивать необходимые в современном мире предпринимательские навыки. Так, на содействие малому бизнесу школьников было выделено более 200 грантов. Для поддержки талантливых и мотивированных детей Фонд неоднократно выделял гранты на обучение в Международной школе «Мирас» и в Astana IT University, а также помог казахстанским школьникам принять участие в престижном конкурсе «USTEM Robotics» в США. Авторские работы в рамках проекта «Тәлімгер», которому Фонд оказал поддержку, легли в основу учебной программы, учебников и учебно-методических книг по предмету «Основы предпринимательства и бизнеса», преподаваемого в 10-11 классах казахстанских школ и колледжей.

Помимо помощи школьникам, учащимся колледжей и студентам Фонд считает важным внести свой вклад в повышение квалификации педагогов, совершенствование их знаний и навыков, поскольку именно они являются проводниками знаний будущих поколений казахстанцев. При поддержке Фонда «Халык» в южной столице был организован ежегодный городской конкурс педагогов «Almaty Digital Ustaz.

Важной инициативой стал реализуемый проект по обучению основам финансовой грамотности преподавателей из восьми областей Казахстана, что должно оказать существенное влияние на воспитание финансовой грамотности и предпринимательского мышления у нового поколения граждан страны.

Необходимую помощь Фонд «Халык» оказывает и тем, кто особенно остро в ней нуждается. В рамках социальной защиты населения активно проводится работа по поддержке детей, оставшихся без родителей, детей и взрослых из социально уязвимых слоев населения, людей с ограниченными возможностями, а также обеспечению нуждающихся социальным жильем, строительству социально важных объектов, таких как детские сады, детские площадки и физкультурно-оздоровительные комплексы.

В копилку добрых дел Фонда «Халык» можно добавить оказание помощи детскому спорту, куда относится поддержка в развитии детского футбола и карате в нашей стране. Жизненно важную помощь Благотворительный фонд «Халык» оказал нашим соотечественникам во время недавней пандемии COVID-19. Тогда, в разгар тяжелой борьбы с коронавирусной инфекцией Фонд выделил свыше 11 миллиардов тенге на приобретение необходимого медицинского оборудования и дорогостоящих медицинских препаратов, автомобилей скорой медицинской помощи и средств защиты, адресную материальную помощь социально уязвимым слоям населения и денежные выплаты медицинским работникам.

В 2023 году наряду с другими проектами, нацеленными на повышение благосостояния казахстанских граждан Фонд решил уделить особое внимание науке, поскольку она является частью общественной культуры, а уровень ее развития определяет уровень развития государства.

Поддержка Фондом выпуска журналов Национальной Академии наук Республики Казахстан, которые входят в международные фонды Scopus и Wos и в которых публикуются статьи отечественных ученых, докторантов и магистрантов, а также научных сотрудников высших учебных заведений и научно-исследовательских институтов нашей страны является не менее значимым вкладом Фонда в развитие казахстанского общества.

С уважением, Благотворительный Фонд «Халык»!

NAS RK is pleased to announce that News of NAS RK. Series of geology and technical sciences scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of geology and technical sciences in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of geology and engineering sciences to our community.

Қазақстан Республикасы Ұлттық ғылым академиясы «ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы» ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Webof Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

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EFFICIENCY OF DRILLING WELLS WITH AIR PURGE BASED ON THE USE OF A VORTEX TUBE

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Abstract. The practice of drilling has proven that the use of compressed air as a cleaning agent provides a significant increase in ROP (mechanical drilling speed) and reduces the time spent on eliminating geological complications, which sharply increases the productivity and economy of drilling operations. However, air has a low heat capacity compared to liquid solutions; this affects the operation of the rock cutting tool due to high contact temperatures with irreversible consequences. To prevent these problems, there is a need to develop technical means and technology to effectively ensure the temperature regime of the rock-cutting tool. This article discusses the possibility of normalizing and regulating the temperature regime of the rock-cutting tool due to forced cooling of the cleaning air at the bottom hole to negative temperatures, and a new design of the drilling projectile for drilling with air purging is developed. With a drill string rotation frequency of 69 rpm, the ROP is already 2.76 m/h, and at a rotation frequency of 300 rpm it reaches 7.6 m/h. With an increase in the rotational speed of the drill string, an increase in mechanical speed is observed. Thus, depending on the drilling modes, the penetration rate due to the use of clean air cooled to negative temperatures increases by an average of 6-7%. Reduce the temperature of the rock cutting tool at the bottom by an average of 50–60 °C.

Keywords: air purging, drilling, Rank effect, well, vortex tube, compressor, drill string, flushing fluid, bottom hole, temperature mode

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ГЕОЛОГИЯЛЫҚ БАРЛАУ ОБЪЕКТІЛЕРІНДЕГІ ҚИЫН ЖАҒДАЙЛАРДА ҰҢҒЫМАЛАРДЫ БҰРҒЫЛАУ ПРОЦЕСІНІҢ ТИІМДІЛІГІН АРТТЫРУ

Аннотация. Бұрғылау тәжірибесі сығылған ауаны тазалау құралы ретінде пайдалану бұрғылаудың механикалық жылдамдығын айтарлықтай арттыруды қамтамасыз ететінін және бұрғылау жұмыстарының өнімділігі мен тиімділігін күрт арттыратын геологиялық асқынуларды жоюға кететін уақытты қысқартатынын дәлелдеді. Дегенмен, ауаның шаю ерітінділерімен салыстырғанда жылу сыйымдылығы төмен, бұл матрицаның деформациясы, алмастың бұзылуы, ұнтақтау, алмас қаттылығының төмендеуі және құралдың күйіп қалуы сияқты қайтымсыз салдары бар жоғары жанасу температурасы арқылы тау жыныстарын кесетін құралдың жұмысына әсер етеді. Бұл проблемаларды болдырмау үшін тау жыныстарын кесу құралының температуралық режимін тиімді қамтамасыз ететін техникалық құралдар мен технологияны әзірлеу қажет. Бұл мақалада ұңғыма түбіндегі тазарту ауасын теріс температураға дейін мәжбүрлеп салқындату арқылы тау жыныстарын кесетін аспаптың температуралық режимін қалыпқа келтіру мүмкіндіктері қарастырылады және ауа тазартқышпен бұрғылауға арналған бұрғы тізбегінің жаңа конструкциясы әзірленді. Сондай-ақ бұрғылау құралының әзірленген конструкциясының тәжірибелік зерттеулерінің алдын ала нәтижелері берілген. Бұрғы тізбегінің айналу жылдамдығының жоғарылауымен механикалық жылдамдықтың жоғарылауы байқалады. Бұрғы бағанының айналу жиілігі 69

айн/мин болғанда, механикалық бұрғылау жылдамдығы қазірдің өзінде 2,76 м/сағ, ал 300 айн/мин айналу жиілігінде ол 7,6 м/сағ жетеді. Осылайша, бұрғылау режимдеріне байланысты теріс температураға дейін салқындатылған таза ауаны пайдалану есебінен ену жылдамдығы орта есеппен 6–7 % артады. Өндірістік зерттеулер құйынды салқындатқышы бар бұрғылау құралының әзірленген жаңа конструкциясы үнемді, тиімді екенін көрсетті, оны пайдалану ұңғыма түбіндегі тау жыныстарын кесу құралының температурасын орта есеппен 50–60°C төмендетуге және оны арттыруға мүмкіндік береді.

Түйін сөздер: деформация түзілуі, қалақшалар, гамма-сәулелену, бұрғылау, тау жынысы, деформация, қатты қорытпа, тығыздық

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ЭФФЕКТИВНОСТЬ БУРЕНИЯ СКВАЖИН С ПРОДУВКОЙ ВОЗДУХОМ НА ОСНОВЕ ИСПОЛЬЗОВАНИЯ ВИХРЕВОЙ ТРУБЫ

Аннотация. Практикой бурения доказано, что применение сжатого воздуха как очистного агента обеспечивает значительное повышение механических скоростей бурения и снижает затраты времени на ликвидацию геологических осложнений, благодаря чему резко возрастают производительность и экономичность буровых работ. Однако воздух имеет низкую теплоёмкость по сравнению с промывочными растворами, это сказывается на работе породоразрушающего инструмента через высокие контактные температуры с необратимыми последствиями, такими как деформация матриц, разрушение алмазов, зашлифование, снижение твердости алмазов и прижоги инструмента. Для предотвращения этих проблем, возникает необходимость разработки технических средств и технологии эффективного обеспечения температурного режима породоразрушающего инструмента. В настоящей статье рассмотрены возможности нормализации температурного режима породоразрушающего инструмента за счет принудительного охлаждения очистного воздуха на забое скважине до отрицательных температур, разработана новая конструкция бурового снаряда для бурения с продувкой воздухом. А также приведены предварительные результаты экспериментальных исследований разработанной конструкции бурового снаряда. С увеличением скорости вращения бурильной колонны наблюдается увеличение механической скорости. При частоте вращения бурильной колонны 69 об/мин МСП составляет уже 2,76 м/ч, а при частоте вращения 300 об/мин достигает 7,6 м/ч. Таким образом, в зависимости от режимов бурения скорость проходки за счет использования чистого воздуха, охлажденного до отрицательных температур, увеличивается в среднем на 6–7 %. Производственными исследованиями доказано, что разработанная новая конструкция бурового инструмента с вихревым охладителем является экономичной, эффективной, применение которой позволяет снизить температуру породоразрушающего инструмента на забое в среднем на 50–60°С и повысить механическая скорость проникновения.

Ключевые слова: продувка воздухом, бурение, эффект Ранка, скважина, вихревая труба, компрессор, буровой снаряд, промывочная жидкость, забой, температурный режим

Introduction

Air-assisted drilling is effective in the most unfavorable conditions for the use of drilling fluids: when drilling in areas of significant circulation loss, when there are difficulties with water supply, in high mountainous or difficult terrain, or in areas with a harsh climate (Toshov et al., 2016a: 13). When drilling wells in rocks, the destruction of the rock is accompanied by a significant release of heat, since about 1 % of the mechanical energy supplied to the bottomhole is spent on the actual destruction of the rock, while the rest of the energy is dissipated in the form of heat (Gorshkov, et al., 1992: 173). High temperatures of the drilling tool create emergency situations in the form of burning of diamond bits, the time spent on the elimination of which is 8÷10 % (Kudryashov, 1990a: 263; Muminov et al., 2022a: 5; Kudryashov, 1991a: 295). It is obvious that the increase in efficiency is directly related to ensuring the optimal temperature regime when drilling wells. The conditions for cooling bits in drilling with a purge are significantly worse than when using gas-liquid systems. Therefore, the normalization of the temperature regime of the rock cutting tool during drilling with purge is possible, firstly, due to an increase in mass flow at moderate air speeds with the expansion of passage channels and annular gaps and, secondly, due to forced cooling of the purge air (Merkulov, 2016a: 128; Muminov et al., 2021b: 5; Merkulov, 2013b: 3). The first direction will require an increase in the mass flow rate of the compressor with an increase in its power, which is ineffective. The second method is more acceptable, provided that an efficient cooler is developed. When drilling strong rocks, a high temperature is released, which reduces the microhardness and abrasive properties of the teeth of the rock-breaking tool, as well as increases mechanical deformation. In the process of drilling hard rocks, temperature deformations of the rock-breaking tool prevail, hence the need to normalize temperature regimes taking into account their impact.

Research materials and methods

The presence of complex elements of spherical rock-breaking tools, such as teeth on the ball, ball and roller supports, the paw body, complicates the analytical study of its temperature conditions. At the same time, in the course of the study, it becomes necessary to choose a cross-section of the trunnion of a spherical rock-breaking tool that accurately characterizes its temperature regime:

$$t_{ц} = \left[\left(\frac{h}{\lambda_1 f_{ц}} + \frac{1}{\alpha f_{л}}\right)\frac{k_1 k_2}{m} + \frac{1}{2G_г c_p}\right] N - \frac{\Psi' \Delta W}{2c_p} + t_1, \text{ °C,} \quad (1)$$

where h – is the average thickness of the paw of a spherical rock–destroying tool, m; $f_{ц}, f_{л}$ – the cross–sectional area of the base of the trunnion and the outer surface of the paw, m^2; λ_1 – the thermal conductivity coefficient of the material of the rock-destroying tool, W/h (m*°C); α - the thermal conductivity coefficient, m^2/s; c_p- the specific heat capacity of the cleaning air, J/kg*°C; $G_г$ – purifying air consumption, kg/s; k_1, k_2 – dimensionless coefficients of power loss due to friction in the supports and distribution of heat flows in the bearing; N – downhole power, W; m – number of balls; Ψ` – specific heat of vaporization, J/kg; ΔW is the percentage of humidity.

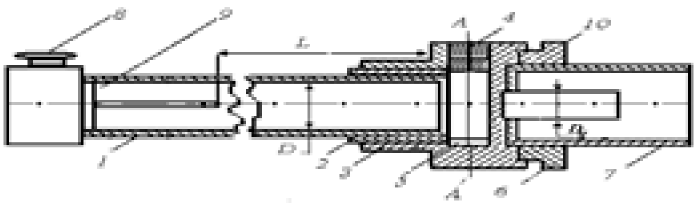
In order to determine the influence of the initial temperature of compressed air and the drilling mode on the temperature regime of the rock-breaking tool, a mathematical model for calculating the temperature regime of the drilling ring crown and a three-pin bit is constructed in the MATHCAD graphical program based on expressions (1). In order to determine the rational drilling regime, i.e., the axial force (Ros) and the bit rotation frequency (n) to normalize the temperature conditions of the rock-destroying tool when drilling wells with air purification, expressions (1) have been improved.

$$t_T = \frac{K_p 2\cdot 10^{-4}\cdot P_{oc}\cdot n\cdot(D_1+D_2)}{\pi\sqrt{\lambda_1(\alpha_1 D_1+\alpha_2 D_2)(D_2^2-D_1^2)}} + \frac{K_p 2\cdot 10^{-4}\cdot P_{oc}\cdot n\cdot(D_1+D_2)}{4G c_p} + t_1, \text{ °C,} \quad (2)$$

Expression (2), which allows you to determine the temperature of a three-ball chisel, will take the following form:

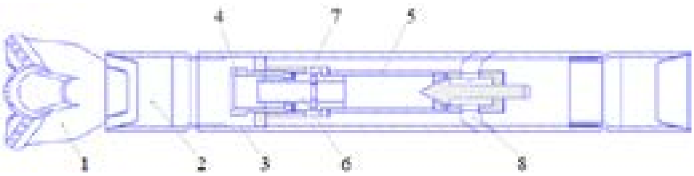
$$t_{ц} = \left[\left(\frac{h}{\lambda_1 f_{ц}} + \frac{1}{\alpha f_{л}}\right)\frac{k_1 k_2}{m} + \frac{1}{2G_г c_p}\right] 10^{-3}\cdot\mu\cdot P_{oc}\cdot n\cdot D - \frac{\Psi' \Delta W}{2c_p} + t_1, \quad \text{°C,} \quad (3)$$

The above expressions (2) and (3) make it possible to determine not only the temperature of the rock-breaking tool when drilling wells with air purification, but also drilling modes that allow normalizing the temperature conditions at the bottom, i.e. choosing rational values of axial force (Rd) and rotational speed (n). The work (Baratov et al., 2021: 4; Kadyrov et al., 2021: 9; Talalay, 2020: 289; Dudak, 2019: 12) presents studies on the use of a vortex tube as an air cooler. The results of the experimental studies made it possible to substantiate the possibility of obtaining negative temperatures of the purge air without the need to increase the compressor power. This allows us to state that the use of vortex tubes in drilling is quite energy efficient. The vortex effect, or Ranque effect, is that if a tangentially swirling gas flow is fed into the pipe, then under certain conditions, thermal separation of the gas will occur in it. A colder flow is formed in the center than at the periphery, and gas will exit through the central hole of one of the ends of the pipe, the temperature of which will be much lower than at the inlet. Peripheral layers of gas having a higher temperature will exit through the orifice from the other end of the pipe (William, 2010: 602; Toshov et al., 2022: 10; Mitchell et al., 2011: 710; Muminov, 2021c: 8). On the basis of the performed calculations, the design of the vortex tube presented in Fig. 1.



1-tube, 2-nut, 3-body, 4-volute, 5-diaphragm, 6-nut, 7-tube, 8-throttle, 9-cross, 10-gasket
Fig. 1 - The design of the vortex tube

In general, the design of the vortex tube (Fig. 1) consists of a housing 3, in the annular cavity of which a tangential rectangular channel with width b and height h is made. A fitting for supplying compressed air is attached to the body from the outer side of the rectangular channel. A beaded tube 1 of a strictly cylindrical shape, with a polished inner surface with a diameter D, is installed in the annular cavity of the body, and then a volute 4, so that its hole (the dimensions of which correspond to the rectangular channel of the body) coincides with the channel, forming a nozzle inlet. A diaphragm 5 with a hole Dg and a sealing gasket 10 with a nut 6 are inserted into the same cavity of the body. A four-bladed crosspiece 9 and a throttle 8 are tightly installed at the opposite end of the tube 1 at a distance L from the volute. The vortex tube is small in size and has no moving parts, which makes it possible to use it as a bottomhole cold generator when drilling wells. Modern mining and geological conditions require the improvement of drilling technology and an increase in drilling performance through the creation of new highly efficient drilling tools for drilling wells in various mining and geological conditions. The introduction of new drilling tools with high durability and increased mechanical drilling speed increases the operational efficiency of drilling rigs. The best results are obtained by using the vortex tube directly at the bottom. In order to increase the efficiency of the rock cutting tool, based on the normalization of temperature conditions during drilling of wells with air cleaning of the bottom hole, a new design of the drill string including a vortex tube was developed (Fig. 2).

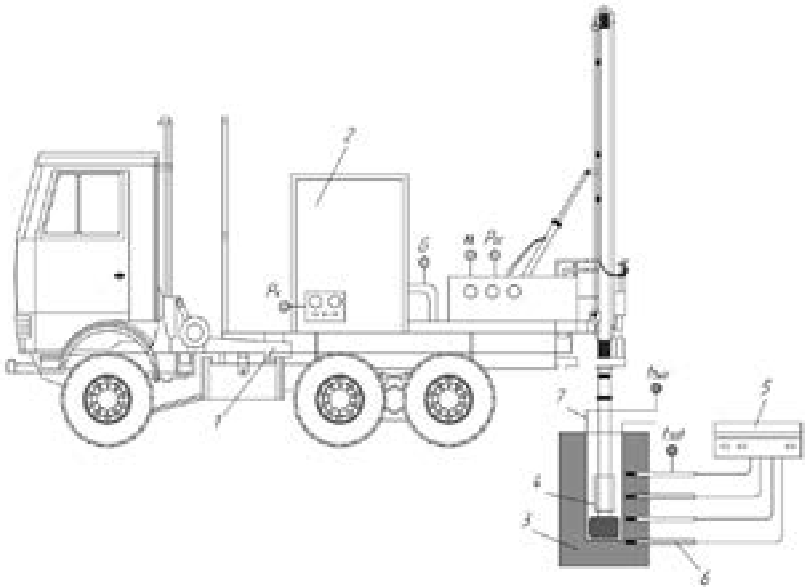


1-cone bits; 2-adapter; 3-outer pipe; 4-nut; 5-vortex tube; 6-cold fraction generator
Fig. 2 - A drill string including a vortex tube for drilling with bottom hole cleaning with air

A drill string with a vortex tube works as follows. When drilling a well, compressed air is supplied through the outer pipe 3 through the inlets 7 to the cold fraction generator 6 of the vortex tube 5 and is twisted in it. The flow of compressed air when passing through the vortex tube is divided into two flows, the flow of cold and hot air. The flow of cold air flows out of the hole of the nut 4 and through the adapter 2 and the drill bit 1 enters the bottom of the well to carry the destruction products into the annulus with simultaneous cooling of the drill bit. The cold fraction generator in this device is made removable, which can be replaced by another type of generator, which allows you to change the cooling mode if necessary when changing drilling modes. Hot air from the vortex tube 5 through the tangential opening for the exit of the hot air flow 8 enters the annulus. Since hole 8 is made tangentially, a vortex motion is created in the annulus annulus, which allows ejection of a cold flow with destruction products. This improves bottomhole cleaning and has a positive effect on bit cooling, as energy costs for repeated regrinding of rock particles are reduced. This design of the drilling tool for drilling with air purge allows you to supply cooled air directly to the bottomhole, normalize the temperature regime and increase the durability of the rock cutting tool (Bridges et al., 2020: 594; Akhmetov et al., 2021a: 9; Caenn et al., 2017: 729; Akhmetov et al., 2021b: 9). The use of cooled purge air significantly reduces the temperature in the well, which creates favorable temperature conditions for the operation of the rock cutting tool, preventing the negative impact of high temperatures on the bottom hole.

Results

In order to evaluate the effectiveness of the developed design of the drilling tool and the effect of low initial temperatures of the cleaning air on the efficiency of the tool, pilot tests were carried out at the Central Exploration Party of the State Geological Survey of the Navoi Mining and Metallurgical Plant. The layout of the experimental setup for testing a drill string with a vortex cooler is shown in fig. 3. Experimental work was carried out as follows: thermocouples 6 were installed on a drilled block 3 of rock with a hardness factor f=7 and connected to a multichannel temperature meter 5. A branch pipe 7 was installed in the upper part of the drilled block to remove cleaning air with sludge. Drilling string with vortex tube 4 was connected to the rotator of drilling rig 1, then compressor 2 was started, then, drilling rig 1, compressed air pressure (Pc) on the compressor, rotation speed (n) and axial load (Pax) were set. After stabilization of the operating mode, the air flow rate (G) at the outlet of the compressor, the temperature at the bottom (tzab) and the temperature (tout) of the cleaning air at the outlet of the well were measured. The duration of experimental drilling (T) for the given parameters in each case was 10 minutes, after which the length of penetration (L) was measured. Experimental work was carried out in several stages with different speeds (n), axial load (Poc), pressure (Pk) and consumption (G) of compressed air. The results of experimental studies of the design of a drilling tool with a vortex tube made it possible to establish the dependence of the temperature change at the bottom of the well (tb) on the temperature of the purge air supplied to the well (tcool), as well as the dependence of the rate of penetration on the temperature of the purge air supplied to the well (tcool).



1-drilling rig, 2-compressor, 3- drillable artificial block, 4-drilling tool containing a vortex tube, 5-multichannel temperature meter, 6-thermocouple K, 7-pipe for removal of clean air with sludge; n - measuring point of the rotational speed of the drill string (rpm), Pos - measuring point of the axial load (kN), Pk - measuring point of the air pressure at the outlet of the compressor (MPa), G - measuring point of the air flow rate at the outlet of the compressor (kg /s), tset – downhole temperature measurement point (°C), tout – cleaning air temperature measurement point at the well outlet (°C)

Fig. 3 - Scheme of the experimental setup for testing a drill string with a vortex cooler

The change in temperature at the bottomhole from the axial load at different temperatures of the cleaning air has a dependence close to linear and is shown in fig. 4.

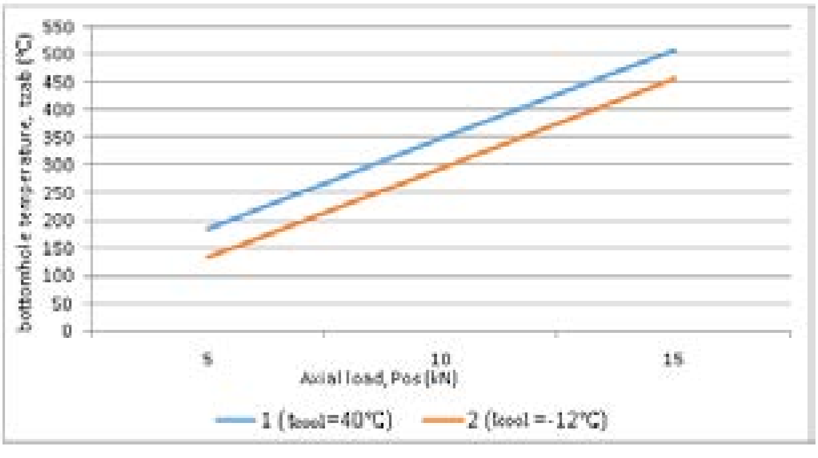


Fig. 4 - Graph of temperature change at the bottomhole (tzab) at a drill string rotation frequency of n=200 rpm on axial load (Poc) with different temperatures of the purge air (tcool)

Drilling with a drill string speed of 200 rpm, with an axial load of 10 kN and an initial cleaning air temperature of 40 °C, the temperature at the bottom hole was 348 °C. Reducing the cleaning air temperature to-12°C with the same drilling parameters resulted in a 54°C decrease in bottom hole temperature. The results of experimental tests confirm the possibility of using chilled air to negative temperatures to reduce the temperature at the bottom of the well. When drilling wells with bottomhole air cleaning, low bottomhole temperatures improve the operation of the rock cutting tool, which leads to faster penetration. The mechanical rate of penetration of a well primarily depends on the regime parameters of drilling, the type and volume of the cleaning agent, but when drilling with air cleaning of the bottomhole, the cooling conditions of the drill string have a significant impact on the rate of penetration. This is confirmed by the results of experimental studies, shown graphically in fig. 5.

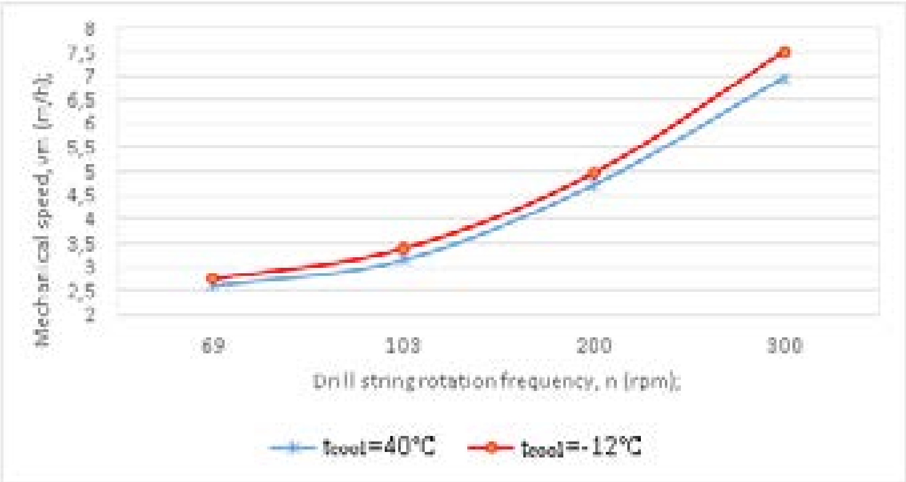


Fig. 5 - Graph of the change in mechanical speed (vm) from the rotational speed of the drill string (n) at an axial load of 10 kN, with different temperatures of the cleaning air (tcool)

Discussion

The dependence of change in ROP on the rotational speed of the drill string shows that at an initial temperature of cleaning air of 40°C, an axial load of 10 kN and a rotational speed of the drill string of 69 rpm, the ROP is 2.6 m/h. With an increase in the rotational speed of the drill string, an increase in mechanical speed is observed. At a rotation speed of 300 rpm, the mechanical drilling speed is 6.8 m/h. The use of-12°C cooled downhole cleaning air under similar drilling conditions results in higher ROP. With a drill string rotation frequency of 69 rpm, the ROP is already 2.76 m/h, and at a rotation frequency of 300 rpm it reaches 7.6 m/h.

Thus, depending on the drilling modes, the penetration rate due to the use of clean air cooled to negative temperatures increases by an average of 6–7 %.

Conclusion

Production studies have proven that the developed new design of the drilling tool with a vortex cooler is efficient, effective, the use of which allows to reduce the temperature of the rock cutting tool at the bottom by an average of 50-60 °C and increase the mechanical speed of penetration. The introduction of the proposed design of a drilling tool with a vortex cooler at the Central Exploration Party of the Geological Survey of the Navoi Mining and Metallurgical Plant ensured low temperatures of the purge air at the bottom of the well, which, in turn, contributed to an increase in drilling efficiency and ROP.

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