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INNOVATIVE DEVELOPMENTS TO IMPROVE CORE RECOVERY DRILLING EFFICIENCY IN WEAKLY CEMENTED FORMATIONS

Ravshanbek Narimov Anarmetovich
Associate Professor, *Tashkent State Technical University, Tashkent, Uzbekistan,*
Abdurasul Qayumov Shonazarovich
Associate Professor, *Tashkent State Technical University, Tashkent, Uzbekistan,*
Ozoda Akhmedova Baxronovna
Associate Professor, *Tashkent State Technical University, Tashkent, Uzbekistan,*
Abror Akhmedov Sayidmurod o‘g‘li
Senior Lecturer, *Tashkent State Technical University, Tashkent, Uzbekistan,*

Annotation. This study presents innovative core sampling tools and drilling head designs developed to improve core recovery in weakly cemented, fractured, and highly permeable formations. Traditional core barrels used in Uzbekistan often provide only 40–60% core recovery because of tool vibration, frequent lifting from the bottomhole, poor centering, and unsuitable drilling parameters. To address these issues, new cone-type, cylindrical, and PDC drilling heads, as well as a spring-loaded core catcher, were designed and tested under field conditions. Experimental studies were carried out in several oil and gas fields between 2017 and 2023 under different geological and technological conditions. The proposed tools improved core preservation and reduced core loss by minimizing the distance between the cutting head and the core catcher, reducing vibration, and ensuring stable core retention. Field tests showed that average core recovery increased from 73% in 2017–2018 to 84% in 2019–2020 and reached 94–100% after implementation of the improved designs. The developed equipment can replace imported core sampling systems, improve geological information quality, and reduce drilling costs.

Keywords: Core, innovative design, core barrel assembly, cylindrical drill bit, spring-loaded core catcher.

Annotatsiya. Ushbu tadqiqotda zaif sementlangan, singan va yuqori o'tkazuvchan qatlamlarda yadrolarni qayta tiklashni yaxshilash uchun ishlab chiqilgan innovatsion yadro namunalarini olish asboblari va burg'ulash boshlari dizaynlari keltirilgan. O‘zbekistonda qo‘llaniladigan an’anaviy yadro bochkalari ko‘pincha asbobning tebranishi, quduq tubidan tez-tez ko‘tarilishi, markazlashtirishning yomonligi va mos bo‘lmagan burg‘ulash parametrlari tufayli yadrolarni atigi 40–60% tiklaydi. Ushbu muammolarni hal qilish uchun konus tipidagi, silindrsimon va PDC burg'ulash kallaklari, shuningdek, prujinali yadro ushlagichi ishlab chiqilgan va dala sharoitida sinovdan o'tkazilgan. 2017 yildan 2023 yilgacha turli geologik va texnologik sharoitlarda bir nechta neft va gaz konlarida eksperimental tadqiqotlar o'tkazildi. Taklif etilgan asboblar kesish

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boshi va yadro ushlagichi orasidagi masofani minimallashtirish, tebranishlarni kamaytirish va yadrolarni barqaror ushlab turishni ta'minlash orqali yadrolarni saqlashni yaxshiladi va yadro yo'qotilishini kamaytirdi. Dala sinovlari shuni ko'rsatdiki, o'rtacha yadro tiklanishi 2017-2018 yillardagi 73% dan 2019-2020 yillarda 84% gacha oshdi va takomillashtirilgan dizaynlar joriy etilgandan keyin 94-100% ga yetdi. Ishlab chiqilgan uskunalar import qilingan yadro namunalarini olish tizimlarini almashtirishi, geologik axborot sifatini yaxshilashi va burg'ulash xarajatlarini kamaytirishi mumkin.

Kalit so'zlar: yadro, innovatsion dizayn, yadro bochkasini yig'ish, silindrsimon burg'ulash uchi, prujinali yadro ushlagichi.

Аннотация. В этом исследовании представлены инновационные инструменты для отбора керна и конструкции буровых головок, разработанные для улучшения извлечения керна из слабо сцементированных, трещиноватых и высокопроницаемых пластов. Традиционные колонковые барабаны, используемые в Узбекистане, часто обеспечивают извлечение керна лишь на 40-60% из-за вибрации инструмента, частого подъема из забоя скважины, плохого центрирования и неподходящих параметров бурения. Для решения этих проблем были разработаны и испытаны в полевых условиях новые буровые головки конусного, цилиндрического типа и PDC, а также подпружиненный керноуловитель. Экспериментальные исследования были проведены на нескольких нефтяных и газовых месторождениях в период с 2017 по 2023 год в различных геологических и технологических условиях. Предложенные инструменты улучшили сохранность керна и сократили потери керна за счет минимизации расстояния между режущей головкой и керноуловителем, снижения вибрации и обеспечения стабильного удержания керна. Полевые испытания показали, что среднее извлечение керна увеличилось с 73% в 2017-2018 годах до 84% в 2019-2020 годах и достигло 94-100% после внедрения усовершенствованных конструкций. Разработанное оборудование может заменить импортные системы отбора керна, повысить качество геологической информации и снизить затраты на бурение.

Ключевые слова: Керноуловитель, инновационная конструкция, колонковый ствол в сборе, цилиндрическое долото, подпружиненный керноуловитель.

INTRODUCTION.

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Core sampling from prospective oil and gas reservoirs is of great importance during exploration and appraisal drilling because core material provides objective information about hydrocarbon presence and the reservoir properties of the rock, including porosity and permeability [1,2].

Core sampling from deep formations is carried out using a special tool known as a core barrel assembly, which is rotated by the drill string through the rotary drilling system.

Research aimed at developing innovative technologies that improve core recovery remains an important scientific and engineering task [3,4].

MATERIALS AND METHODS.

To provide scientific and technical support for field operations and improve core recovery, the authors developed a new core barrel assembly and drill bit design with several advantages over conventional systems. The internal diameter of the core tube was increased by 2 mm, which facilitates easier extraction of the recovered core sample. In addition, the distance between the collet and the openings of the drill bit, as well as between the collet and the core breaker, was minimized. As a result, the total recovered core length increases during retrieval and core preservation is improved. The proposed design can also operate effectively under the complex geological and mining conditions of oil and gas fields in Uzbekistan (Figures 1 and 2).

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Figure 1. Six-blade conical drill bit of the 6 LBK-MSZ type: 1 – core inlet opening; 2 – drilling fluid channels; 3 – carbide cutters; 4 – drill bit body.

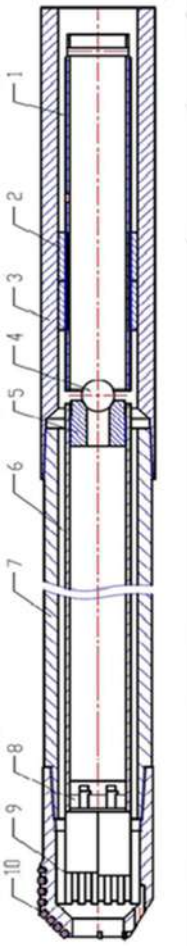


Figure 2. Core barrel assembly ("KOS") with a six-blade conical drill bit: 1 – adjusting screw; 2 – adjusting nut; 3 – upper sub; 4 – ball (Ø 50.8 mm); 5 – ball seat; 6 – core tube; 7 – body; 8 – lever-type core breaker; 9 – collet core holder; 10 – conical drill bit.

To determine the causes of low core recovery, an experimental study was conducted under field conditions. During drilling, a specific drilling mode was established at every 2-meter interval of the formation, and the core recovery results were recorded as the percentage of recovered core relative to the drilled interval. This study was conducted in the following wells:

1. Kokdumalak Field, Well No. 1P, interval 4725–4726 m. A 1 m interval was drilled with coring, and 0.25 m of core was recovered, corresponding to a recovery rate of 25%. The formation consisted of dark gray limestone with a brownish tint.

2. Shortak Field, Well No. 1, interval 2512–2515 m. A 3 m interval was drilled with coring, and 1.5 m of core was recovered, corresponding to a recovery

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rate of 50%. The formation consisted of terrigenous rocks of the XIX horizon belonging to the Lower–Middle Jurassic terrigenous formation.

3. Taldikuduk Field, Well No. 1, interval 2873–2874 m. A 1 m interval was drilled with coring, and 0.70 m of core was recovered, corresponding to a recovery rate of 70%. The formation consisted of dark brown, dense, slightly calcareous, fine-micaceous argillites. The rocks belong to the Lower–Middle Jurassic terrigenous formation.

4. Tuprokkala Field, Well No. 1, interval 1734–1736 m. A 2 m interval was drilled with coring, and 1.5 m of core was recovered, corresponding to a recovery rate of 75%. The formation consisted of brown to dark gray calcareous siltstone sandstones of the XII Cretaceous horizon.

5. Yerkin Field, Well No. 2, interval 1289–1290 m. A 1 m interval was drilled with coring, and 1 m of core was recovered, corresponding to a recovery rate of 100%. The formation consisted of medium- to fine-grained feldspar-quartz sandstone of the XIII Cretaceous horizon.

6. Sovligar Area, Well No. 4, interval 3605–3607 m. A 2 m interval was drilled with coring, and 1 m of core was recovered, corresponding to a recovery rate of 50%. The formation consisted of gray, thin-bedded, nodular limestone of the XV horizon of the Middle–Upper Jurassic carbonate formation.

7. Chakkakum Area, Well No. 4, interval 2190–2192 m. A 2 m interval was drilled with coring, and 1.5 m of core was recovered, corresponding to a recovery rate of 75%. The formation consisted of dark gray, nodular limestone with recrystallized shell detritus. The rocks belong to the XV-2 horizon of the Middle–Upper Jurassic carbonate formation.

8. Murodtepa Field, Well No. 4, interval 2801–2805 m. A 4 m interval was drilled with coring, and 3.5 m of core was recovered, corresponding to a recovery rate of 87.5%. The formation consisted of dark gray clayey siltstone interbedded with sandstone and argillite layers. The rocks belong to the XVIII horizon of the Lower–Middle Jurassic terrigenous formation.

9. Tumaris Field, Well No. 2, interval 1955–1957 m. A 2 m interval was drilled with coring, and 2 m of core was recovered, corresponding to a recovery rate of 100%. The formation consisted of gray to dark gray limestone with a nodular-oolitic, algal, and locally organogenic-detrital structure, containing bituminous material. The rocks belong to the XV-3 horizon of the Middle–Upper Jurassic carbonate formation.

10. Yangi Umid Area, Well No. 2, interval 2731–2732.7 m. A 1.7 m interval was drilled with coring, and 1.7 m of core was recovered, corresponding to a recovery rate of 100%. The formation consisted of black, silty, clayey, micaceous, bituminous limestone of the XV horizon of the Middle–Upper Jurassic carbonate

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formation. The average core recovery rate during 2017–2018 was 73%. A patent for the conical drill bit design was obtained as an industrial design under Patent No. SAP 01552 [5,6,7].

The author developed and manufactured a cylindrical drill bit of the MSZ type in sizes Ø187.3/80 mm and Ø139.7/60 mm (Figures 3 and 4), which was tested during 2019–2020 in the following wells:

1. Isavoy Area, Well No. 2, interval 3627–3628 m. A 1 m interval was drilled with coring, and 0.4 m of core was recovered, corresponding to a recovery rate of 40%. The formation consisted of clay belonging to the Middle Jurassic terrigenous formation.

2. Andakli Field, Well No. 2, interval 2515–2520 m. A 5 m interval was drilled with coring, and 4 m of core was recovered, corresponding to a recovery rate of 80%. The formation consisted of interbedded siltstones, argillites, and sandstones of the XVII horizon belonging to the Lower–Middle Jurassic terrigenous formation.

3. South Kulbeshkak Field, interval 2602–2606 m. A 4 m interval was drilled with coring, and 4 m of core was recovered, corresponding to a recovery rate of 100%. The formation consisted of terrigenous rocks of the XIX horizon belonging to the Lower–Middle Jurassic terrigenous formation.

4. Chordarboza Area, Well No. 3, interval 2861–2862 m. A 1 m interval was drilled with coring, and 1 m of core was recovered, corresponding to a recovery rate of 100%. The formation consisted of medium-grained limestone with interbeds of fine-grained limestone belonging to the Lower–Middle Jurassic terrigenous formation.

5. Dultatapa Area, Well No. 2, interval 1217–1218 m. A 1 m interval was drilled with coring, and 1 m of core was recovered, corresponding to a recovery rate of 100%. The formation consisted of argillite-like clay of the XII Cretaceous horizon.

6. South Kulbeshkak Field, Well No. 4, interval 2080–2083 m. A 3 m interval was drilled with coring, and 2 m of core was recovered, corresponding to a recovery rate of 66.6%. During coring, the following technological parameters were applied: rotor speed – 40 rpm, standpipe pressure – 20 atm, drill bit load – 2 t, and pump output – 10 L/s. The drilling mud parameters were: density – 1.10 g/cm³, Marsh funnel viscosity – 45 s, fluid loss – 6 cm³/30 min, and mud cake thickness – 1 mm. The formation belonged to the XV-3 horizon of the Middle–Upper Jurassic carbonate formation.

7. Sulaimantepa Area, Well No. 1, interval 1661–1666 m. A 5 m interval was drilled with coring, and 4 m of core was recovered, corresponding to a recovery rate of 80%. During coring, the following technological parameters were applied:

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rotor speed – 45 rpm, standpipe pressure – 25 atm, drill bit load – 2 t, and pump output – 12 L/s. The drilling mud parameters were: density – 1.06 g/cm³, Marsh funnel viscosity – 60 s, fluid loss – 6 cm³/30 min, and mud cake thickness – 1 mm. The formation consisted of clayey sandstone of the XV horizon belonging to the Middle–Upper Jurassic carbonate formation.

8. Shorkum Field, Well No. 2, interval 2471–2475 m. A 4 m interval was drilled with coring, and 3.5 m of core was recovered, corresponding to a recovery rate of 87.5%. During coring, the following technological parameters were applied: rotor speed – 50 rpm, standpipe pressure – 20 atm, drill bit load – 3–4 t, and pump output – 7–8 L/s. The drilling mud parameters were: density – 1.12 g/cm³, Marsh funnel viscosity – 41 s, fluid loss – 6 cm³/30 min, and mud cake thickness – 1 mm. The formation consisted of dark gray, platy limestone of the XVII horizon belonging to the Lower–Middle Jurassic terrigenous formation.

9. Sulaimantepa Area, Well No. 1, interval 1772–1777 m. A 5 m interval was drilled with coring, and 4.5 m of core was recovered, corresponding to a recovery rate of 90%. During coring, the following technological parameters were applied: rotor speed – 45 rpm, standpipe pressure – 25 atm, drill bit load – 2.5 t, and pump output – 16 L/s. The drilling mud parameters were: density – 1.06 g/cm³, Marsh funnel viscosity – 60 s, fluid loss – 6 cm³/30 min, and mud cake thickness – 1 mm. The formation consisted of limestone of the XV-1 horizon belonging to the Middle–Upper Jurassic carbonate formation.

10. Tumaris Area, Well No. 6, interval 2061–2065 m. A 5 m interval was drilled with coring, and 4 m of core was recovered, corresponding to a recovery rate of 80%. During coring, the following technological parameters were applied: rotor speed – 50 rpm, standpipe pressure – 20 atm, drill bit load – 3–4 t, and pump output – 16 L/s. The drilling mud parameters were: density – 1.12 g/cm³, Marsh funnel viscosity – 55 s, and fluid loss – 6 cm³/30 min. The formation consisted of gray limestone with dark gray and greenish-gray оттенками, a fine-grained structure, layered texture, and a dense, strong composition containing abundant carbonized black siltstone inclusions. The rocks belong to the Jurassic carbonate formation of the Callovian stage, XVa horizon.

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Figure 3. Cylindrical drill bit: 1 – core inlet opening; 2 – drilling fluid circulation channels; 3 – hard-alloy cutters; 4 – drill bit body.

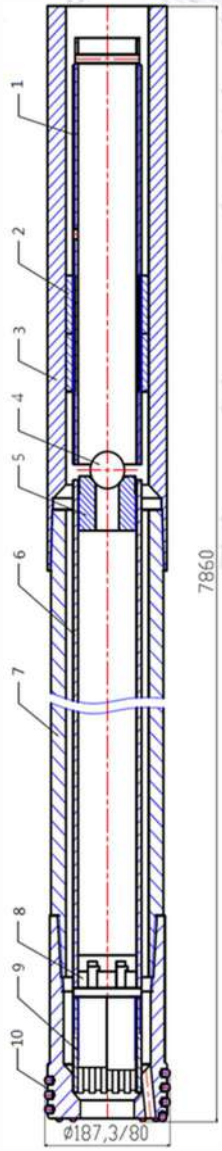


Figure 4. Core barrel assembly ("KOS") with a cylindrical drill bit: 1 – adjusting screw; 2 – adjusting nut; 3 – upper sub; 4 – ball (Ø 50.8 mm); 5 – ball seat; 6 – core tube; 7 – body; 8 – petal-type core catcher; 9 – collet holder; 10 – cylindrical drill bit.

Поддерживался технологический режим бурения, который составил: нагрузка на бурильную головку - 2-3т скорость вращения ротора - 35-50 об/мин, расход промывочный жидкость - 7-16 л/с. Средний вынос керна в 2019-2020 года составил 84% [8]. The teeth inserted into the cylindrical drill bit have a prismatic shape and are made of tungsten carbide alloy [9]. Core sampling assemblies and component parts were developed as import-substituting equipment

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for core recovery operations at oil and gas fields. To ensure more complete core recovery, we proposed an improved cylindrical drill bit and a spring-loaded core holder installed in combination with a collet-type core catcher.

Field tests demonstrated that the combined use of the core catcher and the spring-loaded core holder increased the core recovery rate (Figures 5 and 6).

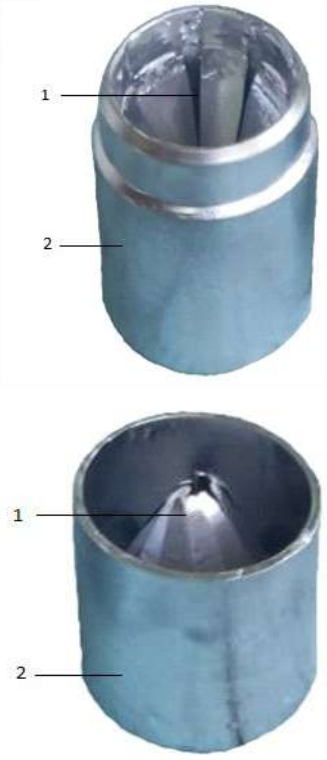


Figure 5. Spring-loaded core holder: 1 – spring-loaded core holder; 2 – body.

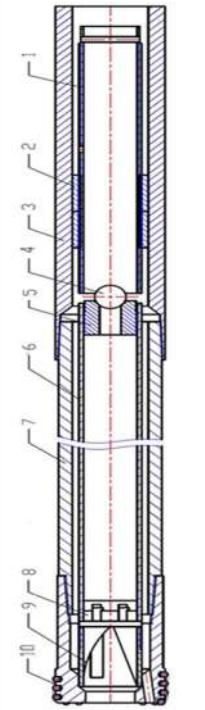


Figure 6. Core barrel assembly ("KOS") with an improved cylindrical drill bit and a spring-loaded core holder: 1 – adjusting screw; 2 – adjusting nut; 3 – upper sub; 4 – ball (Ø 50.8 mm); 5 – ball seat; 6 – core tube; 7 – body; 8 – lever-type core catcher; 9 – spring-loaded holder; 10 – cylindrical drill bit.

During coring operations, it is essential to prevent the drill bit from lifting off the bottomhole. Maintaining continuous contact with the formation ensures a high core recovery rate. Failure to comply with the prescribed drilling regime is one of the main causes of poor core recovery. In many cases, the cause is incorrectly attributed to the core barrel assembly, drill bit, or other equipment. Therefore, strict supervision by engineering and technical personnel is required to ensure compliance with the coring instructions [10,11].

1. Andakli Area, Well No. 6, interval 2071–2074 m. A 3 m interval was drilled with coring, and 2.50 m of core was recovered, corresponding to a recovery rate of 83.3%. During coring, the following technological parameters were applied:

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rotor speed – 45 rpm, standpipe pressure – 25 atm, drill bit load – 2–3 t, and pump output – 12 L/s. The drilling mud parameters were: density – 1.10 g/cm³, Marsh funnel viscosity – 60 s, fluid loss – 6 cm³/30 min, and mud cake thickness – 1 mm. The formation consisted of limestone of the XV-1 horizon belonging to the Middle–Upper Jurassic carbonate formation.

2. Kattatepa Area, Well No. 2, interval 2153–2157 m. A 4 m interval was drilled with coring, and 3.5 m of core was recovered, corresponding to a recovery rate of 87.3%. During coring, the following technological parameters were applied: rotor speed – 45 rpm, standpipe pressure – 22 atm, drill bit load – 2–3 t, and pump output – 12 L/s. The drilling mud parameters were: density – 1.08 g/cm³, Marsh funnel viscosity – 55 s, fluid loss – 6 cm³/30 min, and mud cake thickness – 1 mm. The formation belonged to the XV-3 horizon of the Middle–Upper Jurassic carbonate formation.

3. Temirkazgan Area, Well No. 1, interval 2485–2489 m. A 4 m interval was drilled with coring, and 4 m of core was recovered, corresponding to a recovery rate of 100%. During coring, the following technological parameters were applied: rotor speed – 60 rpm, standpipe pressure – 22 atm, drill bit load – 2–5 t, and pump output – 14 L/s. The drilling mud parameters were: density – 1.09 g/cm³, Marsh funnel viscosity – 55 s, fluid loss – 5 cm³/30 min, and mud cake thickness – 1 mm. The formation consisted of gray to dark gray, fine-grained, hard clay of the XVII horizon belonging to the Lower–Middle Jurassic terrigenous formation.

4. Kattatepa Area, Well No. 2, interval 2492–2495 m. A 3 m interval was drilled with coring, and 3 m of core was recovered, corresponding to a recovery rate of 100%. During coring, the following technological parameters were applied: rotor speed – 55 rpm, standpipe pressure – 22 atm, drill bit load – 3.5 t, and pump output – 14 L/s. The drilling mud parameters were: density – 1.08 g/cm³, Marsh funnel viscosity – 55 s, fluid loss – 6 cm³/30 min, and mud cake thickness – 1 mm. The formation belonged to the XVII horizon of the Lower–Middle Jurassic terrigenous formation.

5. Chetkum Area, Well No. 1, interval 2392–2398 m. A 6 m interval was drilled with coring, and 6 m of core was recovered, corresponding to a recovery rate of 100%. During coring, the following technological parameters were applied: rotor speed – 45 rpm, standpipe pressure – 25 atm, drill bit load – 3.5 t, and pump output – 12 L/s. The drilling mud parameters were: density – 1.07 g/cm³, Marsh funnel viscosity – 48 s, fluid loss – 6 cm³/30 min, and mud cake thickness – 1 mm. The formation consisted of gray limestone of the XV-a horizon belonging to the Middle–Upper Jurassic carbonate formation.

The implementation report is attached. The average core recovery rate in 2021 reached 94%.

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The recovery percentage increased significantly, especially in recent years. Following the implementation of the author's proposed design, core recovery improved and reached 80–100%.

The author developed a new core barrel assembly design with the following components: a spring-loaded core holder and PDC drill bits (polycrystalline diamond cutters) in sizes Ø187.3/80 mm, Ø158.7/67 mm, and Ø139.7/60 mm (Figures 7 and 8). Depending on the hardness, abrasiveness, degree of cementation, and looseness of the formations, drill bits of different sizes and with different numbers of blades may be used.

Based on the above, the following conclusions can be drawn:

1. The study identified the main causes of the low core recovery rate from Jurassic carbonate deposits.
2. These causes include both natural and technological factors:

- rock fracturing;
- high rock permeability;
- frequent lifting of the drill bit off the bottomhole to avoid tool sticking;
- non-compliance with the prescribed drilling regime, including excessive rotational speed and hoisting speed of the drill string, as well as uneven tool feed;
- an excessive distance between the core-forming opening of the drill bit and the lower end of the core catcher;
- the absence of a centralizer in the core barrel assembly.

This problem is addressed by a core barrel assembly consisting of a body made of thick-walled pipe, connected by a special tool joint thread to an upper sub. Inside the body, a core tube is installed; at the lower part, a spring-loaded core holder and a core catcher are mounted, both supported by a cylindrical drill bit. The distinguishing feature of this design is that the core holder is made of spring steel, the thickness of which is selected according to the rock hardness within the range of 0.25 to 0.40 mm (Table 1). The core holder is positioned at a height of L = 30 mm from the end face of the drill bit.

The reduced distance between the core holder and the end face of the drill bit ensures more efficient rock capture during coring, since the contact distance between the rock and the core tube is shortened. In addition, the inner part of the core holder is equipped with tongues arranged in the form of a cone or pyramid, operating on the principle of a check valve.

Table 1.

Classification-based correspondence of the spring-loaded core holder to rock types

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Category of coring difficulty	Rock type	Rock properties			Core receiving device with a spring-loaded core holder
		Hardness according to L. Schreiner	Abrasiveness according to L. Schreiner	Continuity according to B. Baidyuk	
	1	2	3	4	5
I.	Monolithic Slightly fractured, not eroded by drilling fluid, non-swelling, and not damaged by vibrations of the core sampling tool.	5.8	4.0	3.6	0.4 mm
		6.2	8.7	3.7	
II.	Medium- and low-porosity, interbedded, slightly eroded by drilling fluid, and only slightly damaged by vibrations of the core sampling tool.	3.1	1.9	3.4	0.30 to 0.35 mm
		4.0	2.5	3.3	
		4.7	3.4	3.1	
		5.8	4.0	2.9	
		7.4	9.0	2.8	
III.	Highly fractured, interbedded, eroded by drilling fluid,	4.4	3.1	1.9	0.25 mm
		5.1	5.2	1.8	

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	and damaged by vibrations of the core sampling tool.				
IV.	Loose, crushed and floating, swelling, highly porous, and soluble in drilling fluid.	1.6	1.9	1.4	0.25 mm

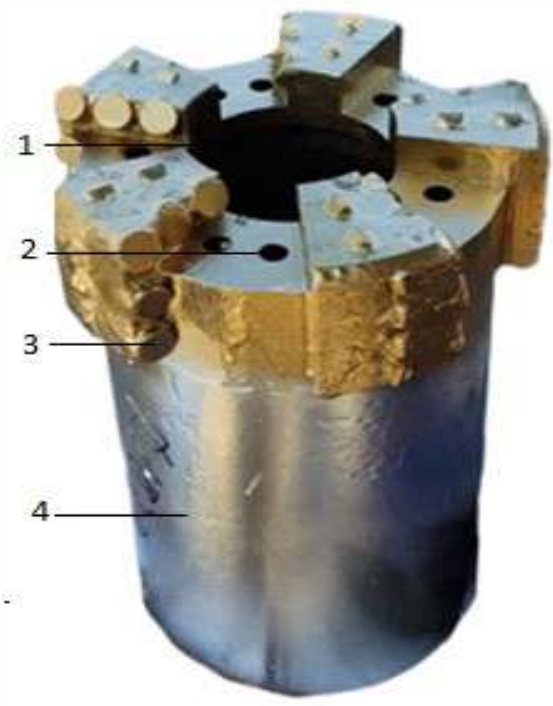


Figure 7. PDC-type drill bit: 1 – core inlet opening; 2 – drilling fluid circulation channels; 3 – polycrystalline diamond cutter; 4 – drill bit body.

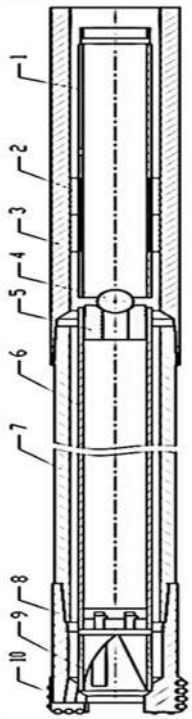


Figure 8. Core barrel assembly ("KOS") with a PDC-type drill bit: 1 – adjusting screw; 2 – adjusting nut; 3 – upper sub; 4 – ball (Ø 50.8 mm); 5 – ball seat; 6 – core tube; 7 – body; 8 – lever-type core catcher; 9 – spring-loaded holder; 10 – PDC-type drill bit.

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The specified core barrel assembly and its component parts were tested and implemented at wells operated by Alat NGRE LLC during 2022–2023 [12,13].

1. Well No. 11R of the Andakli Field, core interval 2367–2371 m. A 5 m interval was drilled, and 4 m of core was recovered, corresponding to a recovery rate of 100%. During coring, the following technological parameters were applied: rotor speed – 50 rpm, standpipe pressure – 20 atm, drill bit load – 4 t, and pump output – 8 L/s. The drilling mud parameters were: density – 1.12 g/cm³, Marsh funnel viscosity – 55 s, fluid loss – 6 cm³/30 min, and mud cake thickness – 1 mm. The formation consisted of limestone.

2. Well No. 11R of the Andakli Field, core interval 2453–2458 m. A 5 m interval was drilled, and 5 m of core was recovered, corresponding to a recovery rate of 100%. During coring, the following technological parameters were applied: rotor speed – 60 rpm, standpipe pressure – 20 atm, drill bit load – 4 t, and pump output – 10 L/s. The drilling mud parameters were: density – 1.12 g/cm³, Marsh funnel viscosity – 55 s, fluid loss – 6 cm³/30 min, and mud cake thickness – 1 mm. The formation consisted of limestone.

3. Well No. 11R of the Andakli Field, core interval 2547–2552 m. A 5 m interval was drilled, and 4 m of core was recovered, corresponding to a recovery rate of 80%. During coring, the following technological parameters were applied: rotor speed – 50 rpm, standpipe pressure – 20 atm, drill bit load – 4 t, and pump output – 8 L/s. The drilling mud parameters were: density – 1.12 g/cm³, Marsh funnel viscosity – 55 s, fluid loss – 6 cm³/30 min, and mud cake thickness – 1 mm. The formation consisted of limestone.

4. Chetkum Field, Well No. 4, core interval 2212–2218 m. A 6 m interval was drilled, and 6 m of core was recovered, corresponding to a recovery rate of 100%. During coring, the following technological parameters were applied: rotor speed – 60 rpm, standpipe pressure – 35 atm, drill bit load – 3 t, and pump output – 11 L/s. The drilling mud parameters were: density – 1.10 g/cm³, Marsh funnel viscosity – 51 s, fluid loss – 5 cm³/30 min, and mud cake thickness – 1.5 mm. The deposits belonged to Jurassic carbonate formations of the Oxfordian–Kimmeridgian stage, XV-2 horizon.

5. Kimmerekum Area, Well No. 1, core interval 2173–2178 m. A 5 m interval was drilled, and 5 m of core was recovered, corresponding to a recovery rate of 100%. During coring, the following technological parameters were applied: rotor speed – 60 rpm, standpipe pressure – 25 atm, drill bit load – 2.5 t, and pump output – 8–9 L/s. The drilling mud parameters were: density – 1.14 g/cm³, Marsh funnel viscosity – 58 s, fluid loss – 6 cm³/30 min, and mud cake thickness – 1.5 mm. The deposits belonged to Jurassic carbonate formations of the Oxfordian–Kimmeridgian stage, XV-2 horizon.

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6. Kimmerekum Area, Well No. 1, core interval 2545–2550 m. A 5 m interval was drilled, and 5 m of core was recovered, corresponding to a recovery rate of 100%. During coring, the following technological parameters were applied: rotor speed – 60 rpm, standpipe pressure – 32 atm, drill bit load – 4 t, and pump output – 11 L/s. The drilling mud parameters were: density – 1.14 g/cm³, Marsh funnel viscosity – 58 s, fluid loss – 6 cm³/30 min, and mud cake thickness – 1.5 mm. The deposits belonged to Jurassic terrigenous formations of the Bajocian–Bathonian stage, XVII horizon.

RESULTS.

Following the implementation of the author's proposed design, core recovery improved significantly and reached 80–100% (the implementation report is attached). In addition, the innovative developments were patented as Utility Model No. FAP 02137.

The application of these developments made it possible to improve both the quality and quantity of core recovery and to save foreign currency previously spent on purchasing imported core barrel assemblies and drill bits. The estimated annual savings amounted to USD 250,000.

There have been no complaints from the customers of the coring operations, namely the oil and gas exploration expeditions, and they are satisfied with the core recovery results achieved by the staff of IGIRNIGM.

The core recovery results for 2017–2023 are presented in graphical form.

Leading specialists of Alat NGRE LLC sent a formal review expressing gratitude to the author for the developed design, which increased core recovery to 90–100% and ensured preservation of the recovered core.

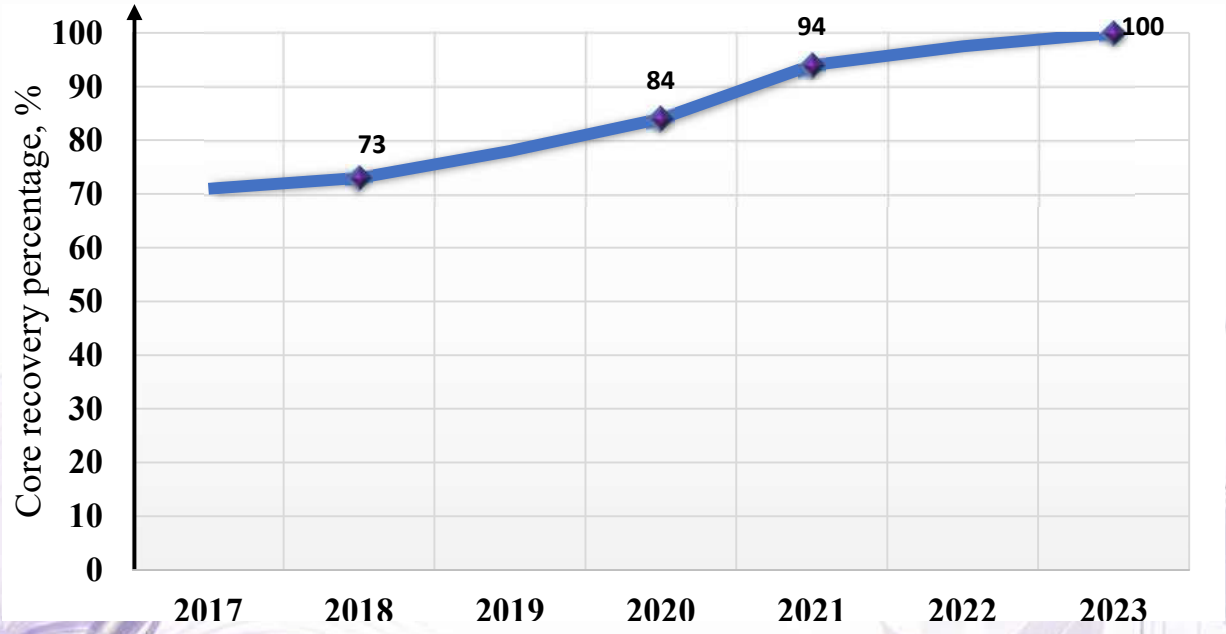


Figure.9. Results of Innovative Technologies Core Recovery Performance at the Fields of JSC "Uzbekneftegaz" in 2017–2023.

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CONCLUSION.

Core recovery and core analysis (rock samples) are of great importance for determining the hydrocarbon potential of oil and gas fields. Core sampling is carried out using a special device known as a core barrel assembly. To date, many types of core barrel assemblies of different designs and sizes have been developed. The performance and design quality of these assemblies are evaluated by the percentage of recovered core length relative to the drilled interval. Unfortunately, the average core recovery rate from wells in Uzbekistan is only 40–60%, which does not provide complete information about the structure of productive formations. Both natural and subjective factors influence this result. Under the geological conditions of Uzbekistan, loose and unconsolidated formations are relatively rare. In most cases, coring is carried out in sandy, clayey, and carbonate formations.

An analysis of coring operations shows that the unsatisfactory performance of core recovery from productive formations is mainly caused by subjective (human) factors. Core barrel assemblies are often not equipped with centralizers, resulting in excessive tool vibration. Due to concerns about tool sticking, the core barrel assembly is frequently lifted off the bottomhole. As a result, part of the core remains at the bottom and is subsequently ground up by the drill bit. In order to increase drilling speed, operators often raise the drill string rotation speed and drilling fluid flow rate beyond the required limits. The author conducted research to establish an optimal drilling regime for coring operations. Compliance with this drilling regime ensures core preservation and a high core recovery percentage. In addition, the author developed a new core barrel assembly with a body made of thick-walled pipes (16–24 mm) equipped with centralizers, which reduce vibration and bending. A spring-loaded core holder installed above the core catcher was also developed, and PDC drill bits equipped with polycrystalline diamond cutter teeth were introduced.

The end of the core tube was moved closer to the core-forming opening to a distance of 30 mm. It is also necessary to strengthen control over compliance with the prescribed drilling regime during coring operations. All of these innovations make it possible to achieve a core recovery rate of 80–100% and save foreign currency by eliminating the need to purchase imported coring equipment.

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