Литература

1. Александров М. М. Определение сил сопротивления при бурении скважин. –М.: недра.–1965.–176 с
2. Александров М. М. Силы сопротивления при движении труб в скважине. – М.: Недра.–1978.–209 с
3. Махмудов Д. М. Методика определения коэффициента сопротивления в бурящейся наклонной скважине// АНХ.–№5.–1965.–с.14-15
4. Сеид-Рза М. К., Муфидзаде Р. Г. К вопросу о силах сопротивления при движении труб в скважине // АНХ.–1988.–№3.–с. 27–29
5. Определение коэффициента трения при движении труб в наклонной скважине / Гулизаде М. П., Шахбазбеков К. Б., Иорданов Д. С., Халимбеков Б. М.–Нефть и газ.–1965.–№5.–с. 23.
6. Həsənov İ. Z. Maili quyuların əyriliyinin idarə edilməsi. Baki, Şırvannəşr.–2006.– 135 c

Поступила 09.06.10

УДК 622.243

Zhang Xiaoxi, **Yang Kaihua**, professors, **Zhang Hui**

China University of Geosciences, Wuhan, 430074

CHINESE SCIENTIFIC DRILLING №1 WELL DIAMONDS CORING BIT TECHNOLOGY (ТЕХНИКА БУРЕНИЯ СКВАЖИНЫ № 1 В КНР АЛМАЗНОЙ КОРОНКОЙ)

Показана комплексная буровая технология с применением винтового двигателя, гидроударника и колонкового бурения алмазной импрегнированной коронкой, при бурении высоковольтных метаморфизованных пород скважины № 1 глубиной 5000 м в КНР. Разработаны оптимальные конструкции коронок и матрицы для предотвращения влияния ударной силы на алмазную коронку. Бурение в твердых породах с использованием разработаной технологии дало позитивные результаты.

Summary [1]

China Continental Scientific Drilling Project is an important Scientific Research programs of China's "Ninth Five-Year Plan". Its main goal is to obtain and research on whole well coring and fluid sampling, and in situ well logging and long-term experiments observations in the region of Donghai, Lianyungang City, northern Jiangsu Province with two boreholes with depth of 2000 m and 5000 m. One of the important jobs of the diamond coring drill bit is to continuously obtain big sized core while drilling in dense and hard, compact, grinding strong, and anisotropy prominent crystal rock.

The challenges of diamond bit in Scientific Drilling №1 well includes:

1. Rock is hard and has great abrasive resistance. The bit has problems cut the rock. The efficiency of drilling is low. Matrix wears out quickly. The lifetime of the bit is too short.
2. Endures impact load of hydro-hammer, matrix of the bit must has high strength. The quality of the diamond must be excellent. The matrix has great holding force toward the diamond.
3. The wall thickness of the bits must be as thin as possible. The diamond bit in the drill has the following basic dimensions: OD of 157 mm, ID of 96 mm, and height of 240 mm.
4. The diameter of the bit is too large and the old manufacturing techniques only support smaller diameters (φ 95 mm or lower). Thus we must completely change the design and the manu-

facturing techniques to meet the requirements of Scientific Drilling №1.large diameter oil bits can only be used for the softer sedimentary rocks, so we need newly designed bit design and corresponding manufacturing techniques.

5. Scientific drilling №1 drill through rocks with over 50% of gneiss that easy to lead drilling trajectory deviation beyond the design, thus the bit needs better stability and deviation control performance.

Physical mechanical property and drillability of Scientific Drilling №1's main formations

China Continental Scientific Drilling Engineering Center entrusted BJIEE to test the physical and mechanical properties of four types of rocks typically drilled, including Felsic gneiss, Biotite amphibolite, Rutile-rich eclogite, and Biotite plagioclase gneiss. Testing details include: indentation hardness, ball pendulum hardness, uniaxial compressive strength, abrasive resistance and erodibility which can sufficiently reflect the overall characteristics of the rocks and help the design of the bit and also design the drilling parameters. Through the testing, the drill ability of the rock formation is detected (table, data for bit designing).

CCSD formation rock drill ability test report

№	Rock type	Rock sample		Testing Data				Drillability level
		Sampling Location	Sampling Depth (m)	Hardness (kg/mm^2)	ball pendulum hardness		uniaxial compressive strength (kg/cm^2)	
					(Number of times)	(angle)		
1	Felsic gneiss	Dong Hai	1485.18	365	68	78	1718	VIII
2	Rutile-rich eclogite	Dong Hai	536.40	502	85	80	1860	IX
3	Biotite plagioclase gneiss	Dong Hai	916.20	315	66	76	1408	VII
4	Biotite amphibolite	Dong Hai	1143.50	175	60	70	1078	V-VI

The Basis of Scientific Drilling №1 Well Diamond Coring Bit's selection and basic design [2]

3.1. Diamond Coring Bit's selection

Eleven bit factories has bid for diamond coring bits that manufactured by different methods such as sintering process of hot pressing, infiltration process of vibration, infiltration process of cold pressing, electroplating and insert natural diamond bit. After repeated experiments, the data shows that: insert natural diamond bits overall drilling performance is not satisfactory, and the ROP is not good enough. Especially after drilling for a period of time, the rate decrease rapidly, and after trip out we noticed that the diamond is partially broken, and mostly blunt (figure 1). The lifetime of bit is not long enough, with highest being 38.65 m, lowest 1.1m, and average 13.16 m, average ROP 0.72 m/h, lowest ROP 0.35 m/h, and the average trip interval is less than 2m. Cost is high.

The data from experiments demonstrated that the impregnated diamond bit drills better in rotary drilling with impacting action as it can drill through hard rocks of all abrasive and integrity, and can sustain the impact load and not break (figure 2). Most impregnated diamond bit use artificial diamond, lowering the cost.

Thus, China Continental Scientific Drilling project eliminated surface-insert type diamond coring bit, instead we decided to use impregnated diamond core bit.

Fig.1. Wear situation of surface-insert type diamond bit

Fig.2. The edge situation of diamond under impacting action by hydro-hammer

3.2. design and selection of impregnated diamond bits

Scientific Drilling №1 Well uses the combination of hydraulic hammer, plus Mud motor with diamond drill bit and conventional coring technology. Based on the requirements of the coring bit used to drill the rock formation and also the characteristics of the down hole motor used for the BHA, we suggest the bit to have medium hardness and high abrasive resistance, ensuring high ROP and longer bit life.

Fig.3. The collapse of the bit crown

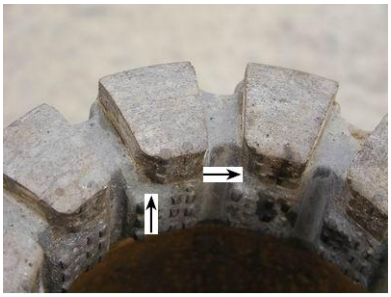

Fig.4. Bit waterway has been eroded

Since scientific drilling well requires drilling in great diameter and depth, and also requires big pump rate and high pump pressure. And the cutting has high hardness and abrasive, meaning that Scientific Drilling №1's cuttings has great erodibility, negatively impacting the diamond bit. see figure 4.

Apparently, the requirements for scientific drilling bit differs from normal rotation drill bit, in which it requires higher matrix hardness, wear capacity, impact toughness and erodibility.

Scientific Drilling №1 Well Diamond Coring Bit Manufacturing Techniques

4.1. Mosaic Matrix Block Type Diamond Bit Manufacturing Techniques

Manufacturing of two step formed bit needs many new technique, including pressing the manufacture of floor mosaic matrix block method, non-pressure impregnation manufacturing gage regulation and medium temperature brazing welding mosaic block on method to the bit. meanwhile, to improve welding fastness, we used hot press and non-pressure impregnation to manufacture welding layer matrix.

4.1.1. Manufacturing of mosaic matrix block

The process of sintering, including the adjust and maintaining of temperature and pressures and shutting down, is controlled by computers, requiring no manual input. Maintaining the temperature of sintering is crucial, maintaining the strength and structure of diamond, so the diamond would not fracture or wear out in the process of cut hard rock formation, improving ROP and bit life.

4.1.2. The manufacture of the bit body

Use the method of hot press and non-pressure impregnation, in the sintering furnace with automatic temperature controlling. The body of the drill bit has high strength, good abrasive resistance and ability of anti-erosion, and also the welding ability is good. The position of mosaic matrix block within the body of the drill bit must be very accurately predefined. And also the best width of weld joint has to be kept to maximize the strength of the weld of the bit.

4.1.3. Weld of the mosaic matrix block on bit

First to clean the pre-manufactured mosaic matrix block, then put it into the body of the drill bit. Mount the model for control the position of the mosaic block. Finally, use medium temperature two steps brazing to weld the bit together. Followed the bit will be cooled down within the air (Fig. 5).

4.2. Electroplating Diamond bit by two-step forming manufacture technology

Based on the combination of design of electroplating technology and non-pressure impregnated method, there are three steps to manufacture the drill bit:

- The manufacture of the steel bit body and also the model of the bit;
- Eon-pressure impregnated method to crate the gauge part of the drill bit;
- Electroplating the main part of the diamond drill bit and also its outer and inner gauge part (Fig. 6).

Fig.5. Mosaic Matrix Block Type Diamond Bit

Fig.6. Electroplating Diamond bit by two-step forming manufacture technology

5 The new creation of bit design

5.1. Two-step hot-press mosaic matrix block formed bits

5.1.1. Use Drill Bit Expert computer system to help on the design of matrix properties

The decision was made by the Drill Bit Expert System to use high abrasive resistance, high erosive resistance, plus high density of diamond. So the abrasive resistance is $0.25ML\times10^{-5}$, erodibility is 28 $1/cm^3$, density of diamond is 80~85%.

Based on the cuttings erodibility and matrix wear out while drill, the bit erosive resistance was designed by the Drill Bit Expert System. The bit design is chosen to have erosive resistance between 25 to 22 $1/cm^3$, the inner and out gauge erosive resistance is 28 $1/cm^3$. See figure 7.

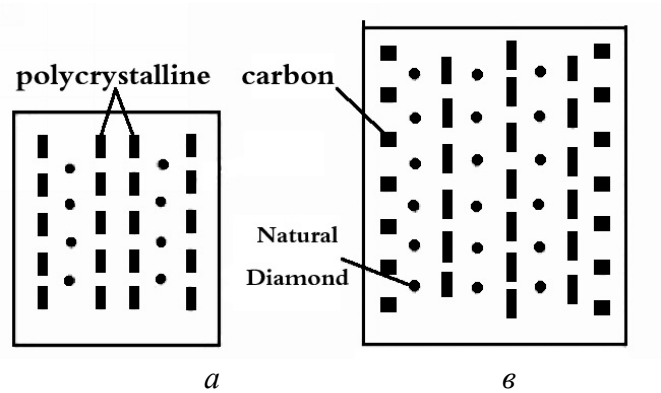

Fig. 7. Inner and Outer Gauge (A) gauge protection of ID, (B) gauge protection of OD

5.1.2. Diamond

It is recommended to us SDA100+ artificial diamond. Because this kind of artificial diamond has the ability to has micro fracture when it is worn to certain amount. This micro fracture will keep the diamond sharp and will keep the ROP high, as well as to keep the

bit life longer. The size of the diamond mainly would be 40/4. Use the combination of 2 to 3 different sizes of diamond together to keep the ROP higher and also maintain the bit life.

5.1.3. The usage of ultra-fine pre-alloyed powder

With specially designed ultra-fine pre-alloyed powder, we can decrease the temperature of matrix sintering and increase the strength and holding force of matrix. And this will be the future of Powder Metallurgy Industry.

5.2. Once Formed Hot-Press Diamond Bit

5.2.1. Structural Design of the Bit

Bit manufactured by Guilin Diamond Industrial Co, Ltd. has crown shaped as flat. The ID and OD edge chamfering of the bit crown is about R5 mm to preventing the matrix of the bits be broken while drilling.

This drill bit has the creative new structure of figure 8. There are 3 layers of gauge keeping structure from the bottom of the bit upwards (right side of the figure).

The working area of the bit cuter can be divided into 3 different function area as showed in Figure 8 (left side of the figure). Inner and outer areas (A and B), in between is another area (C).A and B are added strength area with higher hardness of matrix, higher density of diamond. And also has PDC acting as gauge and to increase the ability of impacting action resistance and abrasive resistance. Keep the bottom of the drill bit from eccentric of wear, bit worn out. It will keep the bottom of the drill bit flat, enabling the outer/middle/inner part wear out equally. Increase the bit life, and drilling performance.

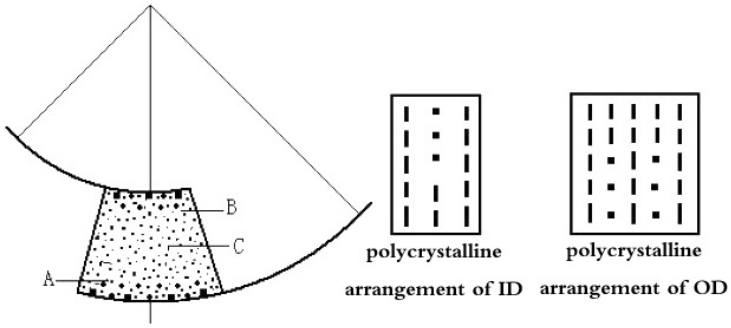

Fig. 8. Diamond bit structure

5.3. Two-step formed electroplate diamond bit

This is the combination of the bit manufacture method of non-pressure impregnated and electroplate methods. This new creative drill bit manufacture method keep the high performance of gauge of non-pressure impregnated, and also the high ROP of electroplate diamond coring bit

5.3.1. Drill bit gauge structure

Electroplate diamond coring bit has the high performance, but gauge ability is not very good. In using the experience of making petroleum drill bit with PDC and nature diamond, a "combination" method is used to manufacture this diamond coring drill bit as show in figure of 9. The normal electroplate is used to manufacture the bottom cuter part of the drill bit with high strength diamond set aside as gauge keeper.

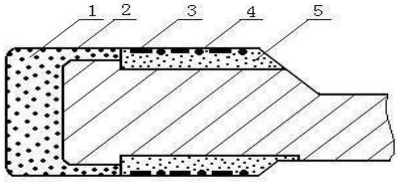

Fig. 9. The gauge structure formed by two step method: 1–cutting layer; 2–high strength single crystal; 3–polycrystalline;4–natural diamond; 5–gauge protection

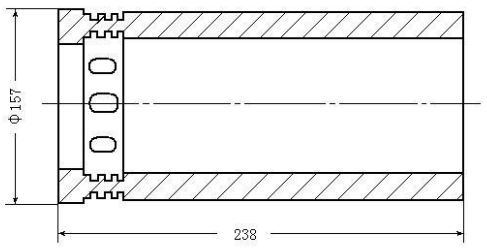

Fig. 10. The body formed by two step method

The gauge part length is also increased to 43 mm. This both increase the stability of the drill bit, as well as increase the gauge ability of the bit.

5.3.2. The property of matrix

The PDC drill bit manufactured by CDIET with a very special matrix recipe totally different from other vendors. It is using the method of control the amount of addictives and also the different combination of the addictives to control the property of the drill bit. The advance of this drill bit is its higher hardness of the matrix, as well as the combination of this hardness and the brittleness. Although the brittleness lower the abrasive resistance of the bit, but it increases the edge condition of the diamond. So there is association of increased ROP, combined with more rock formation fit ability.

Conclusion

The drill bits used within this well were all have the following characteristics:

1. The TFA is bigger than normal design. The flow area is 25-30% of the total drill bit area. The inner and outer waterways are deeper than the normal design as well. These combinations are better for clean the cuttings, and cool the drill bit, minimized the erosive caused by using high pump rate and high pump pressure.
2. The contact area of bottom hole rocks with the diamond matrix is less than normal bit design, providing higher bit pressure and to increase ROP. So the required weight on bit is smaller than normal.
3. The inner and out gauge is longer than normal. The outer gauge is 35 mm, and the inner gauge is 25 mm. This not only to increase the gauge quality, but also to increase the stability of the BHA, minimizes the vibration of the BHA.
4. By using the high quality diamond and increase the height of the working layer of the diamond matrix, the life time of the diamond drill bit is increased.

References

1. The Drilling Technology of CCSD// Wang Da, etc. Sc. Press.–2006.– P.258-282.
2. Liu Guangzhi, Geng Junfeng. Diamond Drilling Handbook//Geological Publishing House. –1992.–P.217-261.

Received 11.06.10