OVERVIEW OF MODERN DIAMOND ROCK-BREAKING TOOLS FOR DRILLING HARD ROCKS

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Annotation: This thesis provides an overview of modern diamond rock-breaking tools used for drilling hard rocks in industries such as mining. It explores the types of diamond drill bits, including impregnated, surface-set, and polycrystalline diamond compact (PDC) tools, and examines their performance, advantages, and limitations. The study highlights recent advancements in tool design, coatings, and cooling mechanisms, as well as challenges related to wear resistance and efficiency. The thesis aims to offer insights into optimizing diamond tool selection and performance for hard rock drilling applications.

Diamonds have the highest hardness among natural minerals. The microhardness of diamond grains ranges from 95,000 to 100,000 MPa, which is explained by the special structure of their crystallographic lattice and the presence of a covalent bond between carbon atoms having the densest packing in the planes with which the crystal faces coincide. The compressive strength of diamond crystals is on average 2000 MPa. The coefficient of linear expansion is small— (0.9+1.45) 10*5 degrees"1. The melting point is about 4000 ° C. Due to the high degree of hardness, diamond has very good wear resistance, many times higher than the wear resistance of known abrasive materials — silicon carbide, boron carbide and electrocorundum.

Today, both natural and synthetic diamonds are used for the manufacture of crowns and other drilling tools. Synthetic diamonds are produced using sophisticated technologies, producing diamonds with characteristics and quality similar to natural ones.[1]

Structurally, a diamond rock-breaking tool of any kind consists of three main parts: housings with connecting threads, dies or stacks and cutters. Special channels are made in the matrix and housing for the circulation of the cleaning agent.

The body of a diamond rock-crushing tool can take the form of a standard core ring or a special cylindrical blank with a standard connecting thread. A matrix designed to accommodate and secure diamond cutters (grains) and having a certain geometric shape is attached to the crown ring by soldering or using glue. During drilling (rock destruction at the bottom) The die should provide cooling and exposure of the diamond cutters as they wear out.[2]

It is known that effective destruction of the rock will occur only when diamond cutters are inserted into it to a certain depth. At the same time, there should be some gap between the end of the die and the face plane for the circulation of a cleaning agent that cools the working part of the rock-destroying tool and removes the destruction products. This is ensured by a certain output of diamond cutters from the matrix body, the value of which must remain constant as they wear out. Therefore, the wear resistance of the matrix, depending on its hardness and other factors, should correspond to the nature of the rocks being traversed. Too hard a matrix wears out slowly, diamond grains are exposed little, and therefore the efficiency of rock-crushing tools is reduced. If the matrix is too soft, on the contrary, the grains are intensively exposed and begin to fall out of the matrix body. The work efficiency is also low.

The matrices of diamond rock-crushing tools have different specified hardness and wear resistance. On this basis, they are divided into five types: 1 — the matrix is very soft, having a hardness of 10-15 HRC (according to Rockwell, scale C); 2 — the matrix is soft (15-20 HRC); 3 — normal (20-25 HRC); 4 — hard (30-35 HRC); 5 —very hard (50-55 HRC). They are commercially available with matrices of three types: normal (type 3) for low-abrasive rocks, hard (type 4) for abrasive rocks and very hard (type 5) for very abrasive rocks. It should be noted that the wear resistance does not always correspond to the hardness of the matrix. A sufficiently hard matrix may be less wear-resistant than a softer one.

Natural (A) and synthetic (AC) diamonds or superhard materials (CM) with drilling properties characterized by the cutting or abrasive ability of the grains, their abrasion resistance and strength (hardness) are used as rock-breaking elements (cutters).The criteria for the drilling properties of diamond grains are: the achieved value of the recess per crown, the mechanical drilling speed and the specific consumption of diamonds per 1 m of the drilled well. These properties depend on the shape and size of the grains, their physical condition (presence of cracks, inclusions and chips) and hardness.

Diamond grains and powders are distinguished by size or size. The size of diamond grains is estimated by their number in one carat (1 carat = 200 mg). According to this indicator, rough diamonds are divided into a large number of groups with a diamond grain content from 2-3 to 400-800 pieces/car with an average nominal diameter from 3.65 to 0.72 mm. Diamond powders are divided into groups with a grain size from 800-1200 to 2000-4500 grains per 1 car with an average nominal diameter from 0.57 to 0.36 mm.

Under the influence of dynamic loads, diamonds are destroyed faster than under the action of static ones. The presence of defects in diamond grains — cracks, inclusions — reduces their strength by 1.2—1.9 times. In order to improve the drilling properties of low-grade diamonds, they resort to artificial processing by giving a rounded shape (ovalization), and their strength increases by relieving internal stresses in the crystals, eliminating sharp edges and corners.

Polishing of diamond grains is also used to improve drilling properties. When processing diamonds with a smooth surface in hard rocks, their friction forces against the rock decrease and, accordingly, the degree of heating of diamond grains decreases, which increases their performance or drilling properties. Polishing of diamond grains can be carried out by mechanical, chemical and flame-gas methods.

Special heat treatment helps to increase the strength of diamond grains. In this case, diamonds are heated in special furnaces in a reducing medium to a temperature of 920-940 ° C and then slowly cooled. This process makes it possible to reduce or remove internal stresses in crystals that occur during the formation of diamonds in natural conditions. After heat treatment, the mechanical strength of diamonds increases by 1.5—1.8 times. The same effect occurs during abrupt cooling, for example, in liquid nitrogen, which has a temperature of -190 ° C, or when diamonds are irradiated with small doses of electromagnetic radiation and other physical fields.

The drilling properties of diamonds are also enhanced due to their metallization — coating the surface of crystals with a thin layer of refractory metal that adheres well to diamond. This ensures a stronger bond of diamond grains with the matrix of the rock-crushing tool, and also leads to the “healing” of microcracks in diamonds coming to the surface, which increases their mechanical strength by 15% and durability by 15-25%.

In the manufacture of rock-crushing tools, in certain cases, diamond granulation is resorted to. This process consists in wetting the diamond grains with an adhesive and coating them with a hard alloy powder. As a result, granules are formed in the form of balls, inside of which there are diamond grains. Diamond rock-crushing tools are made from such granules in special molds.[3]

The diamond drilling method differs from the carbide and spherical method in the nature of rock destruction and the significant dependence of the mechanical drilling speed on the physical and mechanical properties and condition of the rocks. The physical and mechanical properties of rocks that affect the drilling process are very diverse. They are determined by the mineral composition, structure, texture, the nature of the connection of the rock grains with each other, the composition of cement, etc.

To a large extent, the drillability of rocks when drilling wells with diamond crowns is influenced by fracturing, granularity, intermittency, the ability to "cover up" the crown, etc. The properties, as well as the composition of the rock, mainly determine the choice of the type of diamond crown corresponding to these drilling conditions. The mechanical drilling speed and other performance indicators of the diamond crown largely depend on the correct choice. Therefore, when determining the drillability of rocks during diamond drilling, in addition to the mechanical speed, it is necessary to take into account the amount of penetration before wear of the diamond crown (m) and the specific consumption of diamonds per 1 m of drilling (carat / m).

Proper operation of a diamond rock-crushing tool can significantly increase its efficiency, reduce diamond consumption, cause an increase in the average penetration per crown and, ultimately, contributes to a significant reduction in the cost of drilling operations.

Conclusion:
This thesis provides a detailed analysis of modern diamond rock-breaking tools used for drilling hard rocks, focusing on the materials, design, and performance of diamond drill bits. It highlights the unique properties of diamonds, including their extreme hardness and wear resistance, which make them ideal for high-efficiency rock drilling. The study explores various types of diamond tools, including impregnated, surface-set, and PDC drill bits, and their optimal use for different rock formations. Additionally, advancements in diamond tool technologies, such as coating, heat treatment, and polishing, are discussed, along with the challenges and solutions related to tool wear and efficiency. The proper selection and maintenance of diamond rock-breaking tools are crucial for maximizing drilling performance and minimizing costs in hard rock drilling operations.

Used literature;

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