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# IMPROVING OF MANUFACTURING METHOD OF THREE-CONE ROCK BITS



**Запропоновано критерії побудови оптимального технологічного маршруту виготовлення бурового тришарошкового долота, які встановлюють логічний об'єднуючий зв'язок між показниками якості деталей долота та технологічними операціями. Особливістю вдосконалення технології виготовлення є розроблений підхід до декомпозиції бурового долота, на основі якої встановлюються множини показників якості, що висуваються до технологічних операцій.**

**The construction criteria of optimal technological route of three-cone rock bits manufacturing are offered. These criteria define the logical connection between the quality factors of rock bit parts and production operations. The developed approach to rock bit decomposition is one of the main features of improving of manufacturing process. On its base the sets of quality factors placed to production operations are defined.**

**Introduction.** Three-cone rock bits are often used for multifunctional well drilling. It is the main reason for our domestic manufactures to solve the difficult complex problem connected with such rock bits planning and manufacturing. In spite of the wide usage of_integrated computer-aided information systems and technologies, the rock bits manufacturing meets the problem of improving of approaches either to preparation for production or to technological processes.

**Analysis of the latest researches and publications.** Such companies as "Halliburton International, Inc", "Baker-Hughes International, Inc", "Shlumberger", "Smith International", "National Oilwell Inc", "Security DBS", "Varel International", "Lilin Industrial Park", "Reed Tool" and other take the first place in manufacturing of three-cone rock bits of modern design. These companies have flexible system of designing, engineering and mobile preparation for production. It creates conditions for continuous development of specialized production of various designs and standard sizes of rock bits. Such system allows to fill rock bit consumers' fast-changing needs for short period.

As known, the creating of technological precision reserves (reserves of quality) is the main element in the process of products quality improving. The technological precision reserves are the positive difference between tolerance value and scattering field of any parameters of components (bit assembly units). Thus, with the same engineering standards the quality of bits will be higher with large reserves of technological precision. At the plants which produce rock bits the available tolerances are known to be much the same. But the working indices of rock bits are different. It is worth to note that rock bits made by "Hughes" and "Smith" have the best working indices among the competitors in the world market of rock bits. It is determined that the parts of three-cone rock bits made by these enterprises have high quality of physical mechanical material properties (purity of chemical composition and criteria of strength and ductility) and also high accuracy of surfaces design indices which show the least departure from standardized documents. The same can be said about the stock of machine tools, special equipment, tools, technological processes, level of informatization and computerization, automation and other that directly or indirectly helps to get given standard of accuracy. To get high quality of rock bits means to choose objectively technological processes and define the most optimal route. That is why much attention is paid to the problem of improvement of three-cone rock bits technology [1-4]. Besides, general mathematical models for designing of three-cone rock bits are worked out and also theoretical foundation of organization of rock bits manufacturing is laid in [1]. It is worth to mention "Volgaburmash" open joint-stock company's experience of three-cone rock bits designing and manufacturing. The works [2, 3] are devoted to solving problems connected with assembly operations of the technological process of three-cone rock bits manufacturing. The principle of selective approach to organizing of such process that

increases qualitative working indices of rock bits is motivated in these works. Developed and well-founded complex approach to improving of manufacturing method of three-cone rock bits on the basis of "Drohobych pit drill works" open joint-stock company and LLC "UniBurTech" is described in [3-5]. In particular, the problem of speeding-up of preparation for three-cone rock bits production by using of computer-aided design of rock bit components and getting of control programs for CNC lathes is solved. It is also determined that the using of CALS-technologies and uniting of complex production operations of machining into one computer-aided process give sudden increase of production flexibility and provide mobile reset and mastering of new designs and standard sizes of rock bits. However, analyzing current technology it is found poorly studied reserves of its improvement.

**Purpose.** The aim of the research is to developed applied recommendations to improvement of three-cone rock bits current manufacturing process. With this purpose it is necessary to improve the engineering technique of construction of technological route described in [6] by developing the optional system of quality criteria.

**Main part.** It is known that the estimation of three-cone rock bits manufacturing process should be studied simultaneously with technological route [4]. For example, if the level of production concentration is not taken to the consideration, it can cause the increase of working and detail operations number (poor concentration) on the one hand, and complication and reduction of technological subsystem reliability (excess concentration) on the other hand.

Each operation of technological route has its set of qualitative factors. It includes sets of design (allowed values of roughness, deviation of dimensions, etc.), technological (invariability and precision of given design parameters getting, value of physical-mechanical indices of machined parts materials, level of automatic control and production concentration, etc.), functionally-operating (rock bits working indices, value and character of wear resistance curve for machined rock bit parts, contact endurance, crack resistance, etc.), and economic (possible energy expenditure, materials consumption, output, product cost, etc.) quality factors.

Першим етапом у структурі єдиної інформаційної системи реалізації процесу проектування, конструювання, підготовки виробництва і виготовлення тришарошкових бурових доліт є декомпозиція деталей долота [7].

There are three decompositions of three-cone rock bit: design, materials expertise and technological. Taking into account [8], it predicts systemic approach to formulation and solving of such design and technological problems as support of technologically oriented planning either structure of rock bit parts (arm, cone) or assembled rock bit; support of concurrent technological preparation of production, including technological aids; support of realization of design and technological decisions in the technological process of rock bit making.

Motivated placing of requirements set for the arm and cone and their components is the important phase in the process of the problems formulation before planning. For that it is necessary to analyze the components of rock bit structure, taking into account the experience of manufacturing and usage. For this purpose, at first 3-D models of main parts (three cones: the first, second, third and arm) and then those of the assembled rock bits are constructed in the environment of Cimatron E. After that all the components get the set of requirements. For example, figure 1 shows the main of such requirements. Besides, the requirements for guarantee of qualitative hardening (propitious distribution of carbon concentration and hardness) are placed on either all components of the bearing structure or the surface of rock bit cone. Such requirements form principle problems connected with the choice of suitable materials, determining of parts components most optimal design parameters, and using of effective technological operations for their manufacturing and assembling.

Two systems are taken into account in the process of technological routes modeling. They include equipment, tooling, machine tools and other objects that support technological and detail operations and also system of production processes results. Both systems are logically connected. The process of rock bits and their parts making is modeled in the form of ordered sequence of technological events. As the result the form and indices of blank material are qualitatively changed [6]:

$$\iota_i = \left(\iota_1,\ \iota_2,\ \iota_3,\ \ldots\ \iota_{k-1},\ \iota_k,\ \ldots,\ \iota_n\right).$$

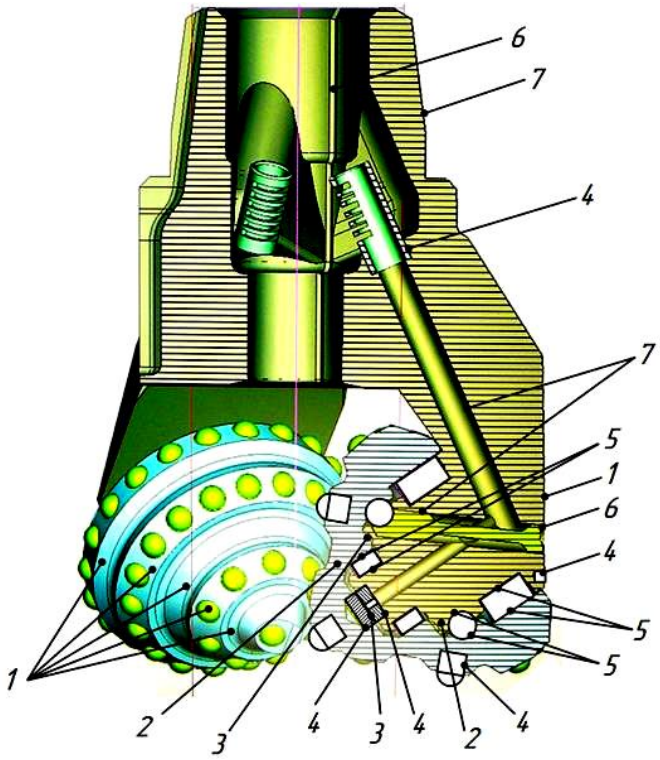


*Figure 1. Structure of three-cone rock bit with inserted hard-alloyed rock-destruction and protecting equipment, in which the chief components are marked. For these components such functionally-operating and technological requirements are placed as:*
*1 – wear resistance under conditions of hydro-abrasive and percussion-abrasive influences;*
*2 – resistance to plastic deformation and fracture failure; 3 – wear resistance under conditions of sliding friction and high contact temperatures; 4 – security of connection; 5 – contact endurance and wear resistance under conditions of rolling friction; 6 – high welding ability; 7 – high machining ability*

Each of model operators fits with performance of concrete operation. Operators admit some variants of getting of construction given parameters, physical-mechanical and working indices. Afterwards, the conditions for generation of alternative variants of operations performance are created. The model of technological processes is diagrammatically presented in the form of oriented graphs, where the units are operators $\iota_k$. Each graph contour is constructed according to parametric condition of $\theta_j(\iota_k)=1$.

The minimum graph tree path is the criterion of optimal version of technological process. The least path is the minimally possible set of operators, which support qualitative performance of technological process:

$$H_{min}=\{i:\iota_i=1\}.$$

$H_{min}$ is the least path under condition of $\theta(\iota)=1$ and $\theta(t)=0$ for optional $t\le\iota$ but not identically equal to $\iota$. Such path length depends on the number of operators which belong to this path. Each of such paths of $H_{min\ j}$, where $j=1,\ 2,\ldots,r$, has binary logical function of

$$\alpha_j(\iota)=\prod_{i\in H_{min\ j}}\tau_i\ ,$$

which takes value of logic unit if operators of the least path satisfy quality conditions. Such quality conditions are placed because of reasons described in [3, 5, 6]. And their numerical or parametric values are set on the basis of experimental tests data and data of rock bit usage.

Maximum guarantee of quality factors under the condition of the least path is the second criteria of optimality of technological process version.

Such modeling discovers key operations of generalized technological route that define the efficiency of one or another route version.

**Conclusion.** The construction criteria of optimal technological route of three-cone rock bit manufacturing, which logically connect rock bit parts quality factors and production operations are offered. The peculiarity of manufacturing technology improvement is the developed approach to rock bit decomposition. On its basis the sets of quality factors required by production operations are set up. Improvement of rock bit bearings assembling processes and technology of assembled rock bit machining (shaping of nipple part) is still current.


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