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# DEVELOPMENT OF AN INNOVATIVE SHNEKO-HEAT-SINK BORING SHELL FOR DRILLING OF SHURFO-WELLS IN THE CONDITIONS OF A KRIOLITOZONA

*The concept of productivity and safety while also cost reduction for the exploration of alluvial deposits of minerals (diamonds, gold, tin, etc.) in the Arctic zone of the North-East of the country with a powerful layer of permafrost are priority areas for geological exploration organizations. Currently in these areas, the exploration of alluvial deposits largely outdated and inefficient technology of drilling exploration holes by drilling and blasting method.*

*Churn-drilling (CD) of large diameter boreholes is the main mechanized prospecting of placer deposits in permafrost. We should assume that this method of drilling has used up all its opportunities in improving technical and economic performance and it is characterized by low productivity and low sampling quality.*

*The dispersion of the objects in large areas, seasonality of mining operations, low level of mechanization of heavy and labor-intensive processes, lack of provision of mining equipment and high cost of drilling works require the search for new methods and technical means for exploration of placer deposits. In this respect the use of the drilling method, the excavation of exploration pits is promising.*

*Developed the worn auger core drilling string with large diameter for drilling boreholes in order to explore the alluvial deposits of minerals allows optimizing the process of construction of the boreholes. It provides interval sampling and increases the representativeness of the exploring object, it helps to obtain a great economic effect and ensure workers' comfortable safety environment.*

***Key words:*** *shurfo-well, drilling of wells, boring shell, screw, rock cutting tool, pointervalny sampling, kriolitozon, loose mestorzhdeniye, diamonds.*

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## Introduction

The search for new methods, technical means and technologies for exploration of placer deposits on the exploration of alluvial mineral deposits in areas of permafrost is an important task of the exploration industry.

The main method of research and exploration of placer mining (diamonds, gold, tin and other) in the Arctic zone of the North-East of the country with high thickness of permafrost is sinking prospection pits of different depths and cross-sections.

Placer deposits in the zone of permafrost have significant differences from the counterparts in areas with a temperate climate and positive temperature rocks, which determine specific requirements for the selection of technique and technology of exploration. Specificity is determined due to their complex interaction and the influence of geological, geotechnical, cryosolic and climatic factors [1, 2, 4, 5, 8, 13].

At present time OJSC "Almazy Anabara" performs significant amounts of exploration and development of placer deposits of diamonds in the Republic of Sakha (Yakutia).

Prospection work is based on the technology of delve sinking work and are carried out mostly by expensive, inefficient, unsafe drilling and blasting method, which is performed only in the winter time in an excavation depth up to 15–20 m, with a great deal of manual labor, which has a lot of human efforts and potential danger of the whole process.

The mentioned circumstances put forward the important scientific and technical challenge in searching fundamentally new methods, tools and technology for exploration of placer mineral deposits in the Arctic conditions of the North-East of Russia, which will improve technical and economic performance.

## Main part

The study of technique and technology of sinking pits and boreholes of large diameter was investigated by a lot number of researchers, but research in the conditions of permafrost is practically not carried out. The continuation of such research is an important issue for exploration organizations and research centers in the North-East of Russia.

The drilling method of exploration for placer deposits makes it possible to mechanize production processes, increases productivity, provides a great economic effect, and provides security and minimal complexity [6, 7, 9].

In these conditions, rotary drilling with the transportation of rotted rock by auger method, due to its high performance and simplicity of the technological process is more efficient [3, 10].

Obtaining reliable data of a specific field largely depends on the number and condition of the extracted during the drilling samples (gross or technological testing), as well as on the accuracy of determining the boundaries of the formations and mineral deposits and their power [4, 12].

In accordance with the basic requirement of the placer deposits sampling methodology *"methods of selecting and retrieving samples from a certain interval of the well should exclude the possibility of its enrichment or dilution by other rock intervals"* [1].

Drilling boreholes with a traditional auger does not fully meet this requirement, when transported rock in open hole partially mashed and mixed with rock falling from the walls of the borehole, reducing the representativity of this interval samples (**Fig. 1 (b)**.

In order to solve this problem we have proposed the perfection of the traditional design of the worn auger and also we have designed a drilling string in which shortened worn

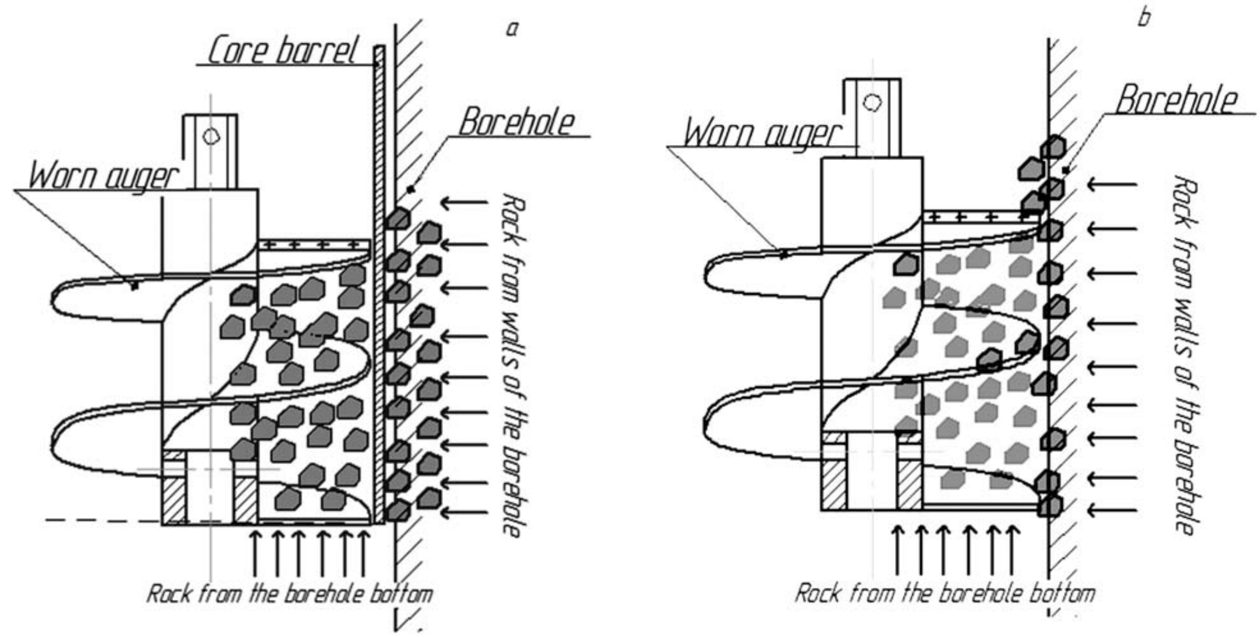


**Fig. 1. Operation of the worn auger conveyer in the borehole: when the location of the worn auger inside the core barrel (*a*); in the open borehole (*b*)**

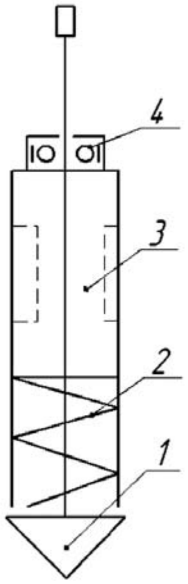


**Fig. 2. Structural-functional kinematic scheme:**
*1* — chisel; *2* — worn auger; *3* — core barrel; *4* — bearing support

auger is located inside the non-rotating core barrel that eliminates the dilution of the destroyed rocks (**Fig. 1 (a)**.

In the process of drilling delve boreholes using this string, the destroyed rock will not be lifted by the worn auger to the surface around the borehole but it is removed after collecting a sample of specific interval within a core barrel of a string (haul cycle method), providing a better representativity of the sample.

The general structural-functional scheme of worn auger core drilling string was composed in accordance with the developed designing method of large diameter drilling string (**Fig. 2**) that can provide interval selection of desintegrated rock.

During full-scale tests, research on the extraction quality samples from the drilling string have been conducted (a prototype of worn auger core drilling string and the standard auger) and the dependence of the sampling chamber volume of the designed drilling string on the sampling assay interval $V_k = f(l_p)$ has been determined **Fig. 3**.

The results obtained according to the volume of the sampling chamber value of the drilling string on the value of the haul cycle (**Fig. 3**) indicate that the volume of the sampling chamber value depends primarily on the design features of the drilling string (diameter of the chisel, the number of revolution of the screw (worn auger) and other parameters), the maximum interval of drilling boreholes by the method of mineral exploration and the coefficient of loosening rocks $K_p = 1,1 \div 1,6$.

We offer to consider the filling ratio $K_н$ for preventing overfilling of the camera and provide the necessary free space in the core barrel at a maximum interval of sinking when calculating the volume of the sampling chamber value $V_к$ of core barrel of the drilling string. ($K_н$ — the degree of core barrel filling with loosened rock, it is determined by the ratio of the volume occupied by a mass of rock $V_{гп}$ to the geometric capacitance of core barrel $V_{кт}$).

The volume of extracted sample is determined by the following expression:

$$V_{пр} = \pi \cdot r^2_{свк} \cdot l_{пр} \cdot K_р, \quad (1)$$

where: $r_{скв}$ — is the well radius, m; $l_{пр}$ — haul cycle penetrating, m; $K_p$ — rock fragmentation index (1,1÷1,6).

In order to calculate the volume of the sampling chamber value of worn auger accumulating core drilling string, we offer the following calculation formula:

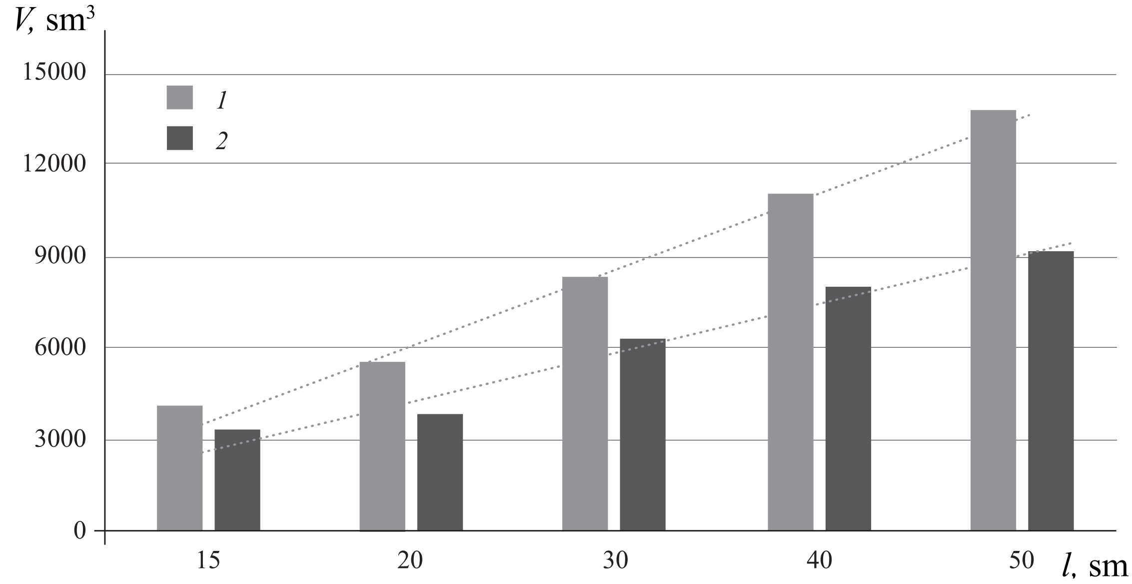


**Fig. 3. The dependence of the extracted sample volume (V) on the value of haul cycle sinking (l):**
*1* — prototype; *2* — standard auger

$$V_k = (V_1 + V_2)\cdot K_н, \quad (2)$$

where: $V_k$ — total volume of the core drilling string chamber, m$^3$; $V_1$ — volume of the sampling chamber, m$^3$; $V_2$ — volume of the screw conveyor, m$^3$; $K_н$ — coefficient of filling.

The volume of sampling chamber $V_1$ is defined by the following expression:

$$V_1 = (\pi\cdot r_{вт}^2\cdot h) - (\pi\cdot r_{шт}^2\cdot h) = \pi\cdot h\cdot(r_{вт}^2 - r_{шт}^2), \quad (3)$$

where: $r_{вт}$ — internal radius of pipe, m; $r_{шт}$— radius of the drill rod, m; $h$ — height of the pipe and rod, m.

Volume of worn auger conveyor of drilling string $V_2$ is calculated by the following formula:

$$V_2 = (\pi\cdot(r_ш^2 - r_{шт}^2)\cdot n_р\cdot l_р) - (\pi\cdot(r_ш^2 - r_{шт}^2)\cdot n_р\cdot h_р) = \\ = \pi\cdot(r_ш^2 - r_{шт}^2)\cdot n_р\cdot(l_р - h_р) \quad (4)$$

where: $r_ш$ — radius of the worn auger, m; is the radius of the drill rod, m; $n_p$ — ribs amount; $l_p$ — step between ribs, m; $h_p$ — rib thickness, m;

Substituting the expressions (3) and (4) in (2), we get the following expression for the determination of the sampling chamber volume of the drilling string:

$$V_k = ((\pi\cdot h\cdot(r_{вт}^2 - r_{шт}^2)) + (\pi\cdot(r_ш^2 - r_{шт}^2)\cdot n_р\cdot(l_р - h_р)))\cdot K_н, \quad (2)$$

According to the proposed formula (2) it is recommended to determine the required sampling chamber value, depending on the diameter and the maximum interval of borehole penetrating in order to define the optimal design parameters of the developed drilling string.

Experimental studies on the volume of extracted samples show that the prototype of drilling string 1.5 times more effective than a standard worn auger. This is because during drilling and lifting the standard auger blades erase the part of the rotted rocks in the walls of the borehole allowing the dilution of selected samples, and after lifting the auger on the surface, some portion of the sample is poured back into the borehole or borehole pad, which reduces the volume and quality of selected samples.

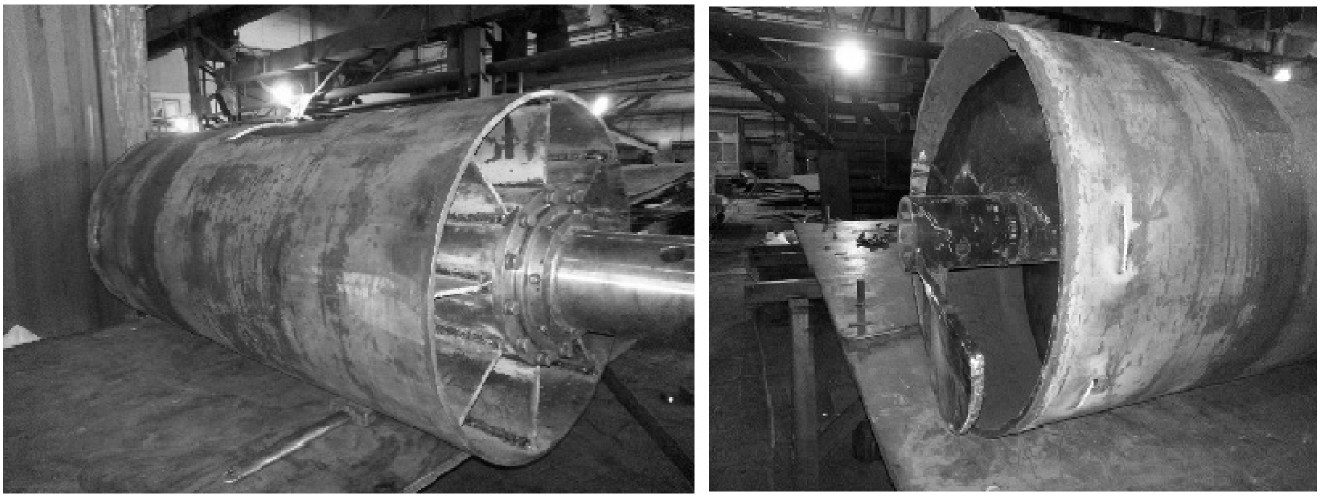

**Fig. 4. Shneko-heat-sink boring shell ∅750 mm**

In the case of our drilling string, due to the location of the shortened worn auger inside the core barrel are retrieved only rocks with drilled interval without dilution and after climbing the rock onto the surface the rock does not get emptied inadvertently from the drilling string, there remains fully recoverable amount of the sample that provides the quality and representativity of the samples from the studied interval of the borehole.

## Conclusion

The developed technique of construction, as well as the results obtained during experimental studies of a prototype of worn auger core drilling string Ø170 mm and the proposed calculation formula (1) has resulted to produce a shneko-heat-sink boring shell with a diameter 750 mm for drilling boreholes (Fig.4) [3,10,11].

Developed worn shneko-heat-sink boring shell of large diameter (Ø750мм) with interval sampling has the following advantages:

- Relatively simplified construction of the drilling string is used (standard drilling tools);
- Auger conveyor is located inside the core barrel, with the rotted rock that is not rubbed off in the walls of the borehole and is provided qualitative sampling in full;
- Limited length of the auger conveyor (2–3 turns) in the core barrel reduces the power consumption of the drive of the drilling rig for rotary drilling;
- Interval (haul cycle) sampling of rotted rock, excluding losses and dilution from adjoining intervals, provides high quality and representativity of the sample in the given time interval;
- transporting complications of frozen rotted rock is reduced, which is typical in a standard worn auger in an open wellbore associated with the process of sticking, freezing icy rotted rock on the flanges of the worn auger and the wall of the borehole by temperature fluctuations on the bottom and in the wellbore;
- Opportunities for optimization of the rational mode of drilling are expanded ($C_o$, $n$): increase frequency of rotation $n$ when limitation and stabilization of the axial load $C_o$,;
- Technological and gross sampling field are possible;

Replacement in delve penetrating work of drilling boreholes by worn auger core drilling string, which we developed, can greatly improve performance, get a large economic effect, ensure a safer and more comfortable working conditions. In this case, the average economic impact of replacing drilling holes and shock-cable-drilling by drilling using worn shneko-heat-sink boring shell Ø750мм., when borehole exploring for placer deposits.

In order to further improve the worn auger core drilling string mode of drilling auger boreholes when exploring for placer mineral deposits in permafrost conditions it is necessary to study the thermal regime of the drilling process, transportation and sampling of the drilling string, as well as the development of technological methods of struggle against the process of thawing and freezing of rotted rock in drilling string.

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