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Spiral Method of Concretion Mining from the Bottom Waters

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Summary. These features occurrence and distribution of deep-sea nodules. A development of the bottom of fossil spiral manner. Scheme is shown floating and complex trajectory carriage bottom of the unit. The basic technological calculation unit that moves around the base module and given recommendations on its use.

Key words: floating complex, iron-manganese minerals, spiral method of extraction, trajectory of motion, hose-cable.

INTRODUCTION

The researchers conducted by oceanologists and marine geologists in the past decade have revealed patterns of occurrence of nodules based on landforms, direction of flow, sediment character, hydro chemical conditions and other factors [15, 17]. Usually deposits are elongated shape with compact placement areas where the concentration of nodules in 2...3 times the average [7, 10, 11]. Nodule deposits are characterized in terms of patchy structure with discrete zones of high placement concentrations [2, 3]. The above makes it necessary to justify the methods of ocean exploration, technology testing, research and industrial mining exploitation [9, 16].

PURPOSE OF WORK

In order to save of resources need to set up a floating complex in such a way that the original data obtained in the pilot mining exploration mining complex would be representative for complex industrial exploitation.

ANALYSIS METHODS OF EXTRACTION

The main element of the exploration mining complex for concretion mining, given the significant depth of development (4...6 km), is a system of concretions raising [1, 4]. Based on the results of tests in natural conditions, conducted by leading foreign companies, to be implemented in the first phase accepted as the most simple pipeline system recovery or airlift pump type [5]. Known technical solution patented by "Lockheed" (USA), which includes craft; descent gear unit pipeline; bottom platform located on its lower end; hose-cable flexible communication and data collection unit [6].

In such a system is extremely difficult to manage the orderly systematic treatment of a loose plot, given the significant difference in the length of the pipeline (6 km) and the width of the working body of the unit fee (a few meters), the masses craft (several hundred thousand tons) and aggregate collection (several tens of tons), the power of influence of natural factors (wind, flow rates of up to 2 m/s) on the pipeline during its movement by floating means (the pressure is several dozens, hundreds of tons) and the aggregate fee (perturbation effects turbid bottom flows on submarine slopes inhibitory effect of flexible communications and ground soil) [8, 13, 14].

Deprived of such deficiencies on short-term fixation of the lower end of the pipe when lowering the bottom of the bottom platform – bottom base module interacting with flexible communication with the bottom end of the pipeline and shvydkoruhomoyu carriage carrying the tool "carrier" absorption (analog – cleaner containing unit and dust extraction head, interconnected corrugated hose).

SPIRAL WAY NATURE

The proposed technical solution is shown in a design setup is shown in Fig. 1. Bottom

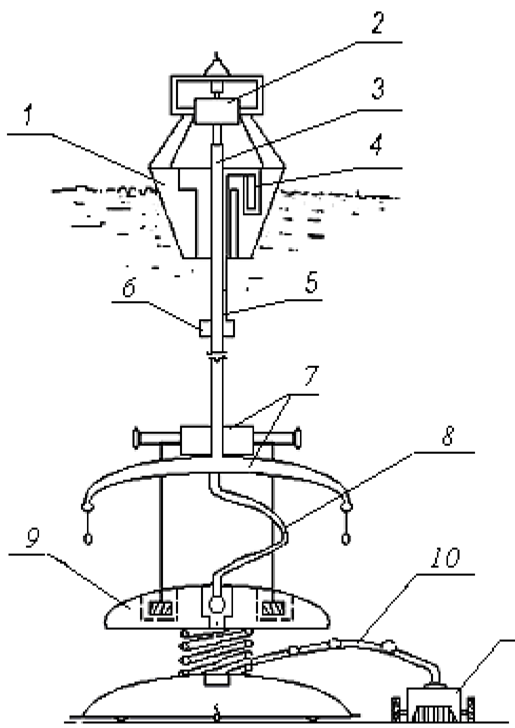

Fig. 1. Scheme complex floating:
1 – craft, *2* – descent gear unit, *3* – pipeline transport artery, *4* – compressor Station (airlift system recovery (ESR) or diesel generator – with pumping system recovery (PSR)), *5* – piping for compressed air at ESR or cable at PSR, *6* – mixer (ESR), submersible pumps (PSR), *7* – bottom base module; *8* – flexible pipe, *9* – donna coil, *10* – hose-cable, *11* – drive carriage

base module, which fixes the lower end of the pipeline to the processing area deposits (unit) includes a guided coil connected through hose cable Actuated of carriage, the latter performs a circular motion around the spiral path by bottom base module (Fig. 2).

Efficiency of up moving in spiral trajectories with respect to the bottom of the coil is determined as follows (Fig. 3). Carriage with free automatic hose-cable rewinder hose cableya coil describes involute circle, defined by equations in polar coordinates in the parametric form:

$$\rho = R_0\left[1+(\varphi + l_0/R_0)^2\right]^{1/2},$$
$$\alpha = \varphi - \mathrm{arctg}(\varphi + l_0/R_0),$$

where: ρ – polar radius of the point of attachment to the carriage hose-cable; α – polar angle (phase) point of attachment; R_0 – radius of the coil; l_0 – length of the initial segment hose-cable, pulled coil; φ – phase separation of the coil hose cable.

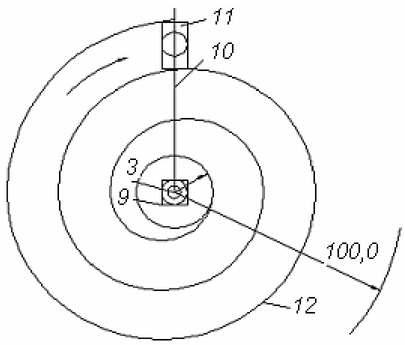

Fig. 2. Trajectory of motion of carriage: denotation *1 – 11* as on Fig. 1, *12* – carriage way

It is assumed that the value l_0 depends on the size of the foundations of the bottom coil, which prevents the carriage freely maneuver close to the coil; apparently, $l_0 \geq R_0$. It is also assumed that the width of the carriage is connected with coil radius ratio $b = 2\pi R_0$ to ensure complete overlap of the treated area between the two coils.

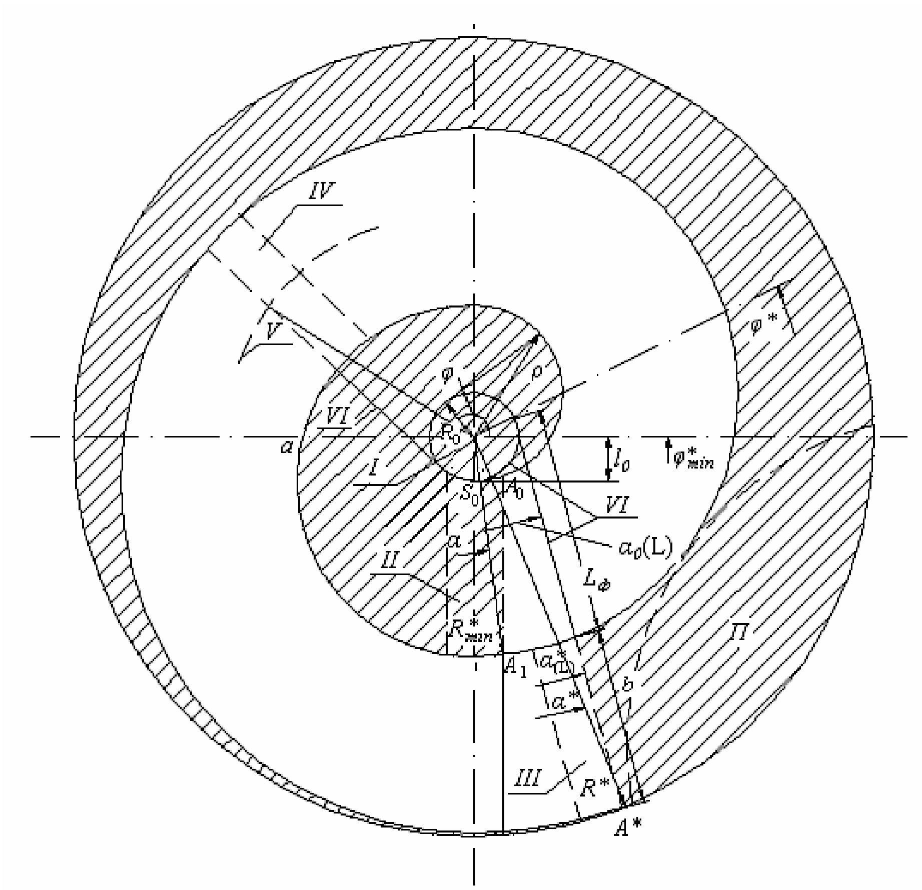

Fig. 3. Diagram spiral trajectory of up bound hose cable coil:
I – coil, *II* ... *IV* – caret position (*II* – original, *III* – end, *IV* – intermediate), *V* – trajectory of the carriage, *VI* – hose-cable, *П* – overlay zone adjacent blocks

Square shape A_0aA_1 (uncultivated space inside the helix) S_0 consists of the area covered by the polar radius ρ from the point A_0 to point A_1 when deploying hose-cable ($S_0A_0aA_1$), and the area of a triangle ($S_0A_0A_1$):

$$S_0 = S_0A_0aA_1 + S_0A_0A_1,$$

where:

$$S_0A_0aA_1 = \frac{1}{2}\int_{\alpha_0}^{\alpha_1}\rho^2 a\alpha = \frac{1}{2}\int_0^{2\pi}\rho^2\alpha^1 a\varphi = \frac{1}{2}R_0^2\int_0^{2\pi}\left(\tau+\frac{l_0}{R_0}\right)^2\alpha\tau = \frac{1}{6}\left(\tau+\frac{l_0}{R_0}\right)^3\Bigg|_0^2.$$

Denoting:

$$S(\varphi) = \frac{1}{6}R_0^2\ (\varphi + l_0/R_0)^3,$$

we obtain:

$$S_0A_0aA_1 = SR_0{}^2 = S(\Delta),$$
$$S_0A_0aA_1 = S(2\pi - S_{(0)}),$$
$$S_0 = S[2\pi - S_0 + S(\Delta)].$$

Let processed space is limited circle of radius R^*, associated with the maximum length hose-cable $L_Ф$, by ratio:

$$R^* = R_0\left[(L_Ф/R_0 + 2\pi)^2 + 1\right]^{1/2}.$$

Limit setting R^* will be determined from the expression:

$$\varphi^* = (L_Ф - l_0)/R_0 + 2\pi.$$

Note: $\varphi^*{}_{\min} = 2\pi$, corresponding $R^*{}_{\min}$. Therefore, the number of complete rotations a carriage:

$$K^* = \lfloor \varphi^* / 2\pi - 1 \rfloor .$$

The area that is maintained carriage, in which case:

$$S = \frac{1}{2} \int_{\tau^*-2\pi}^{\tau} \rho^2 \alpha^1 a\tau + S_\Delta - S_0 =$$

$$= S(\tau^*) - S(\tau^* - 2\pi) - S(2\pi) + S_{(0)} .$$

The area of a circle of radius R^*:

$$S^* = \pi R^{*2} .$$

Percentage of area processed,

$$E = \left(S / S^* \right) \cdot 100\,\% .$$

Trajectory, which makes the center of the carriage (see Fig. 2), is described by the equations:

$$\rho = R_0 \left[1 + \left(\varphi + (l_0 / R_0) + \pi^2 \right) \right]^{1/2} ,$$

$$\alpha = \varphi - \operatorname{arctg}\left(\varphi + (l_0 / R_0) + \pi \right).$$

The path of movement of the carriage:

$$L = \frac{1}{2} \int_{\alpha_0(L)}^{\alpha_L^*} \rho^2 a_X = \int_0^{\varphi^*-2\pi} \rho \ \alpha^1 a\varphi =$$

$$\int_0^{\tau^*-2\pi} \frac{\left(\varphi + \frac{l_0}{R_0} + \pi \right)^2}{\sqrt{1 + \left(\varphi + \frac{l_0}{R_0} + \pi^2 \right)}} \alpha\varphi .$$

Denoting:

$$z = \varphi + (l_0 / R_0) + \pi ,$$

we obtain:

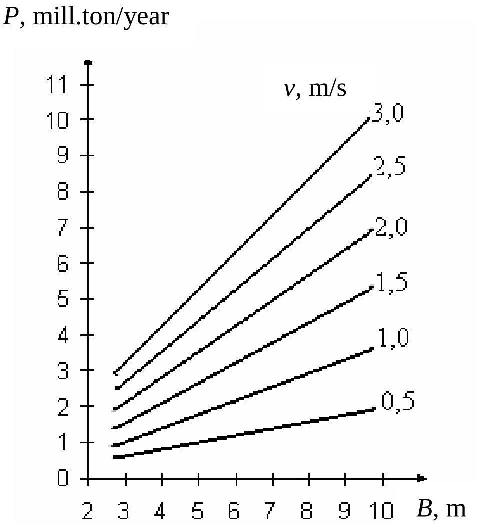

Fig. 4. Graph of the performance of the enterprise P from the width B and speed v of pickup

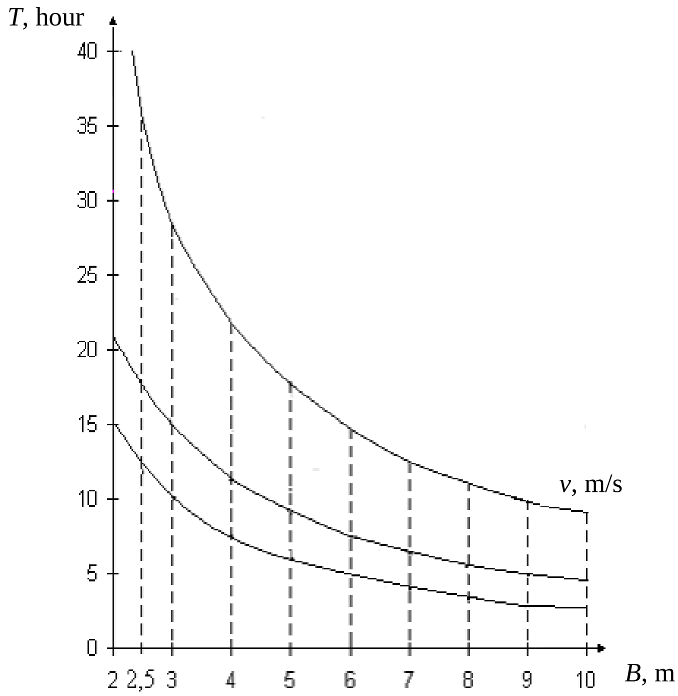

Fig. 5. Dependence term treatment areas T from the width B and speed v of pickup

$$L = R_0 \int_{\frac{l_0}{R_0}+\pi}^{\tau^* + \frac{l_0}{R_0} - \pi} \frac{Z^2}{\sqrt{1+Z^2}} aZ =$$

$$= \frac{1}{2} R_0 \left[Z\sqrt{Z^2+1} - \lg\left(Z + \sqrt{Z^2-1} \right) \right].$$

Then:

$$L = L\left(\varphi^* + \left(l_0/R_0\right) - \pi\right) - L\left(l_0/R_0\right) + \pi .$$

Specific treatment area, id the area that is treated as a unit path traversed by carriage:

$$D = S/L .$$

Using the computer program calculated the values R^*, φ^*, K^*, S , S^*, E, L, D for different lengths of hose-cable ($L_Ф$ = 100...200 м) and radiuses of the coil (R_0 = 0,2...1 м) for a given width of the working body (B = 2,0...10 м) and the length of the initial segment of hose-cable, pulled by coil (l_0 = 1...5 м). According to our calculations, built feasibility dependency mining company (Fig. 4 and 5).

GUIDELINES FOR POOL DEVELOPMENT

Move the bottom platform – bottom base module in the next section area (block) is at a distance equal to twice the length hose cable. Thus, the deposits are processed by successive overlap of circular blocks in circuits where excavation is performed spiral (Fig. 6). The variant of the carriage passes through it forward and in reverse on the inside back-spiral.

To improve the efficiency of nodules slot scheme can be used with the trajectory of the carriage for reciprocal trajectories with a fixed rotation angle (210, 240, 270 ° etc.) by operation of reversing switches or program laid down in the onboard memory computer bottom base module. Thus skate chassis up (caret) must be reversed at a small angle (~ 7 °) at the outer side of the coil to create a constant tension in hose-cable that has neutral or slightly positive buoyancy.

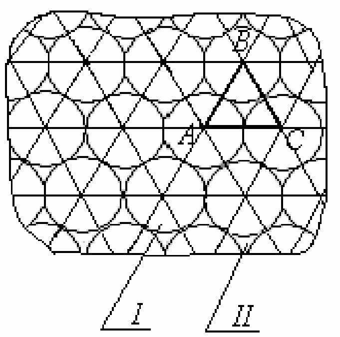

Fig. 6. Scheme working in field plots spiral circular trajectory carriage:
I – processed, *II* – uncultivated land

Moving the complex area of the new unit should be carried out by the pendulum movement of the lower end of the pipe at elevated above the bottom of the base module at a time when the craft is in the distance between the centers of adjacent range blocks (when included with the drivers, taxiing). More economic office hours – at moving of floating means taking into account influence of superficial flows and wind without including of main propulsion engines.

Lowering the bottom of the module should be performed at the time of stay of the craft center of a new unit (including the effects Angle undercurrents in trubop-rovid). Control mode switching engines, taxiing, carried out by the display location of the bottom base module based on signals received from the bottom sonar beacons.

As can be seen from the graph in Fig. 4 and productivity of industrial enterprises 1...3 million tons of nodules per year can be achieved with acceptable parameters of the speed range up to v = 1...2 m/s and the width of the working body B = 2,5…3 м. And working land area 0,2 $км^2$ depending on these parameters extended from a few hours to 1,5 days (see Fig. 5). Losses in between a block areas can be substantially reduced by overlapping the blocks in slot pitch contours, for example in the area of "*II*" (see Fig. 3).

CONCLUSIONS

1. A block diagram of practicing deep deposits of ferromanganese nodules sedentary set of fixed at the bottom of the base module and quickly by a movable collector. The latter has a coordinating communication via hose cable with a drive carriage and performs a circular motion around the base module on a spiral trajectory.

2. Productive area of minerals in circular overlapping blocks, where excavation occurs spiral steps. Moving to the next set of traffic control unit and a collector carried by the installed program automatically includes data from sonar beacons.

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СПИРАЛЬНЫЙ СПОСОБ ДОБЫЧИ КОНКРЕЦИЙ СО ДНА АКВАТОРИЙ

Аннотация. Отмечены особенности залегания и распространения глубоководных конкреций. Предложена разработка донных ископаемых спиральным способом. Показана схема плавучего комплекса и траектория движения каретки донного агрегата. Приведены основные технологические расчеты агрегата, движущегося вокруг базового модуля, а также даны рекомендации относительно его применения.

Ключевые слова: плавучий комплекс, железомарганцевые конкреции, спиральный способ добычи, траектория движения, шлангокабель.