Elaborating of the device for the importation of liquid ameliorants into the soil

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Abstract. Ameliorants (materials which have very high ionic capacity and hold moisture) are applied for long-term improvement of soil's features in production of crops. A device is elaborated for liquid ameliorants' importation into the subsoil space which allows increasing uniformity of an importation and quality of their dispersion in the space under a flat hoe at sweep soil cultivation. This tool contains supply pipe-line with the distributive openings which are evenly located on its length, a material stream divider, the channel of supply of material and the air duct with openings. We have conducted preliminary laboratory researches in which two types of springs were applied: with the equidistant coils and with the decreasing step-by-step distance of coils to an extreme last opening. In the second case the identical rate of flow from openings was observed because the pressure was supported on all length of the pipeline. Thus, as a result of the theoretical analysis and laboratory experiments we established dependence of design data's change of the coil on the created pressure on width of the developed device for the local importation of liquid ameliorants into the soil at sweep soil cultivation.

Major factor of a local importation of liquid soil binders, fertilizers and ameliorants into the subsoil space is the constant discharge of material on all length of the pipeline.

There are various methods of solution of this task. Openings longwise of the pipeline are carried out under a particular diameter which size increases during removal from a source and also other ways considered in work, for example [1].

We have elaborated the device for liquid ameliorants' importation in the subsoil space [2, 3] which allows increasing uniformity of an importation and quality of their dispersion in the space under a flat hoe (figure 1).

The device contains supply pipe-line with the distributive openings which are evenly located on its length, a material stream divider, the channel of supply of material and the air duct with openings. Between the air duct and supply pipe-line freely rotating spring is placed. The spring is set in rotary movement through the plug – a flexible shaft – a cable from a chain wheel which interacts with the bottom of a furrow in the working position [4]. In addition, such device configuration allows increasing quality of dispersion of liquid ameliorants in the space under a cultivator point due to prevention of driving in of outlet openings foreign particulates at sweep soil cultivation.
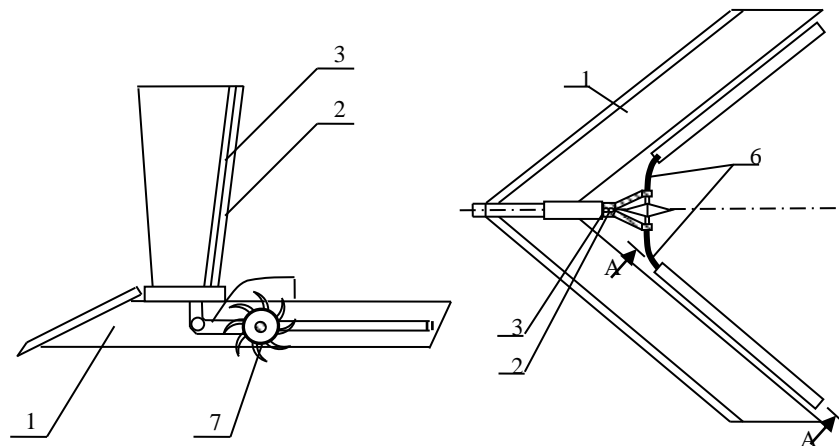
Figure 1. A device for the liquid ameliorants' importation into the soil.

The device for the importation of liquid ameliorants into the soil contains (figure 1) a flat hoe 1, the air duct 2 which is built in in a supply pipe-line 3, the spring 4 which is rigidly connected to the plug 5, a flexible shaft (cable) 6 and the established pivotally chain wheel 7, which interacts with the bottom of a furrow.

The device works as follows. To a flat hoe 1 a supply pipe-line 3 fastens. Behind a cheek of a flat hoe 1 the chain wheel 7 interacting with the bottom of a furrow, bringing a flexible shaft (cable) into rotation and transmitting rotary movement to freely rotating spring 4 through the plug 5 is established.
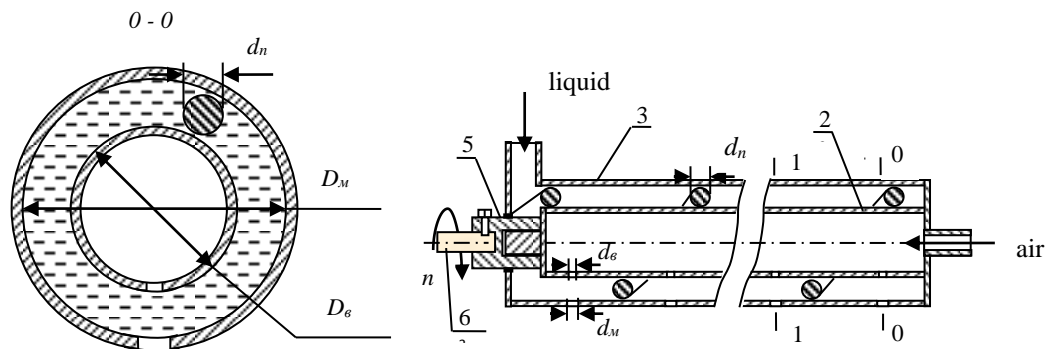
Figure 2. A cross section of the pipeline.

When driving a flat hoe 1 in a supply pipe-line 3 liquid ameliorants enter, and to the air duct 2 air under pressure moves.

Supply pipe-line 3 and the air duct 2 are coaxial and longwise have evenly located openings, at the same time diameters of $d_{\text{в}}$ there is less than diameters of $d_{\text{м}}$ openings and also proportional to them.

Compressed air begins to contact with liquid ameliorants when escaping a cavity, as a result of interaction the gas-liquid environment which is evenly and qualitatively sprayed in the under flat hoe space on capture width is formed.

The uniform of ameliorants distribution on capture width of the device and quality of dispersion is provided due to prevention of driving in of outlet openings of a supply pipe-line 3 with the foreign particulates which are contained in liquid ameliorants, freely rotating spring 4 which is set in rotary movement through the plug 5 and a flexible shaft (cable) 6 from the chain wheel 7 contacting to the bottom of a furrow during working process.

It is necessary to satisfy a condition for establishment of the constant discharge of liquid ameliorants from openings longwise of the pipeline

$$Q_0 = Q_1 = \ldots = Q_i = Q/i = const,\tag{1}$$

where Q – an expense of the entering ameliorants in a supply pipe-line, m^3/s; Q_0, Q_1, Q_i – an expense of liquid ameliorants in the corresponding sections, m^3/s, i – quantity of openings longwise the pipeline.

Let's conditionally divide the device on the leaving openings which there can be i -quantity (figure 1, c) and we will carry out calculation for two extreme sections.

The rate of flow when escaping an opening in section 0-0 according to Figure 1, g will be determined by expression [5]

$$Q_0 = V_0 \omega_0 , \tag{2}$$

where V_0 – traveling speed of liquid in the section of 0-0, m/s; ω_0 – area of a supply pipe-line opening, m^2.

Let's transform the turned-out equation

$$Q_0 = V_0 \frac{\pi d_{_M}^2}{4} , \tag{3}$$

where $d_{_M}$ – diameter of a supply pipe-line opening, m.

In section 1-1 we will have

$$Q_1 = V_1 \omega_1 . \tag{4}$$

where V_1 – traveling speed of liquid in the section of 1-1, m/s; ω_1 – the space occupied by ameliorants in section 1-1, m^2.

Considering the condition (1) we will receive

$$V_0 \frac{\pi d_{_M}^2}{4} = V_1 \omega_1 , \tag{5}$$

$$\omega_1 = \frac{\pi (D_{_M}^2 - D_{_\theta}^2 - d_n^2)}{4} , \tag{6}$$

where $D_{_M}$ – diameter of a supply pipe-line, m; $D_{_\theta}$ – diameter of the air duct, m; d_n – diameter of the spring round, m.

Speed of the stream leaving an opening can be determined as follows [5]

$$V_0 = \varphi \sqrt{2qH} , \tag{7}$$

where φ - speed coefficient; q – acceleration of gravity, m/s^2; H – a pressure, m.

Considering conditions (5), (6) and (7) we will receive the speed of ameliorants arrival for section 1-1 disregarding actions of a spring

$$V_1 = \frac{d_{_M}^2 \varphi \sqrt{2qH}}{D_{_M}^2 - D_{_\theta}^2 - d_n^2} . \tag{8}$$

Further we will consider flow of liquid between pipes in a point O (figure 2). Speed of movement will develop proceeding from traveling speeds of liquid at the expense of a pressure and action of the rotating spring rounds

$$\vec{V} = \vec{V}_{_H} + \vec{V}_n , \tag{9}$$

where $\vec{V}$ – traveling speed of liquid, m/s; $\vec{V}_{_H}$ – traveling speed of liquid under a pressure, m/s; $\vec{V}_n$ – traveling speed of liquid under the influence of spring coils, m/s.
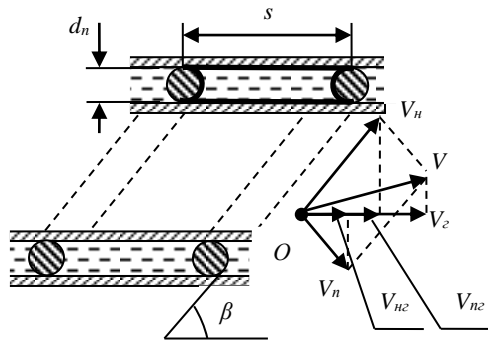
Figure 3. The calculated scheme to definition of traveling speed of liquid between pipes

The horizontal component of traveling speed of liquid ameliorants along the pipeline can be defined as

$$\vec{V}_{\textit{г}} = \vec{V}_{\textit{нг}} + \vec{V}_{\textit{пг}} \ , \tag{10}$$

where $\vec{V}_{\textit{г}}$ – a horizontal component of traveling speed of liquid (along a pipe), m/s; $\vec{V}_{\textit{нг}}$ – a horizontal component of traveling speed of liquid under a pressure, m/s; $\vec{V}_{\textit{пг}}$ – a horizontal component of traveling speed of liquid under the influence of spring coils, m/s.

The horizontal component of traveling speed of liquid at the expense of a pressure can be defined as

$$V_{\textit{нг}} = V_{\textit{н}} \cos \beta \ , \tag{11}$$

where β – a slope angle of spring coils, degree.

Traveling speed of liquid ameliorants under a pressure will depend on their arrive according to design data of the applied spring and supply pipe-line

$$V_{\textit{н}} = \frac{Q}{w} \ , \tag{12}$$

where Q – a consumption of the entering liquid, m³/s; w – a sectional area in the channel formed by a spring, m².

The sectional area of the channel between rounds can be defined proceeding from device design data

$$w = d_n s - \frac{\pi d_n^2}{4} \ , \tag{13}$$

where d_n – diameter of a spring, m; s – step of spring coils, m.

The horizontal component of liquid's traveling speed under the influence of spring coils can be defined as follows

$$V_{\textit{пг}} = \frac{s}{t} = sn \ , \tag{14}$$

where t – time for which the round will pass a path of s, sec; n – springs, sec⁻¹.

Thus, it is possible to calculate the horizontal component of traveling speed of liquid ameliorants, considering the above-stated equations and expression (10)

$$V_{\textit{г}} = sn + \frac{Q}{d_n s - \dfrac{\pi d_n^2}{4}} \cos \beta \ . \tag{15}$$

Equating the equations (8) and (15) we will receive quantity of rounds of a spring for creation of necessary liquid pressure

$$n_i = \left(\frac{d_{\scriptscriptstyle M}^2 \sqrt{2qH}}{D_{\scriptscriptstyle M}^2 - D_{\scriptscriptstyle 6}^2 - d_n^2} - \frac{Q_i}{d_n S - \dfrac{\pi d_{\scriptscriptstyle M}^2}{4}} \cos\beta \right) \cdot S^{-1}. \tag{16}$$

Researches in which two types of springs were applied were conducted in laboratory. The first spring had coils equidistant from each other. The second spring had coils with the decreasing step-by-step coil's distance to an extreme last opening. As a result, the identical rate of liquid from openings was observed in the second case as the pressure was supported on all length of the pipeline due to decrease of the coil's step on the course of the spring's rotation.

Thus, the dependence for determination of the spring's design data was received: quantity and the coils' arrangement under the concrete pressure and respectively the uniform liquid's rate from openings on all width of the developed device's device for an importation of liquid ameliorants at sweep soil cultivation.

References

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