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ANALYTICAL AND APPLIED MODEL OF ABSORPTION IN THE SEED GRAIN DRESSER AND PELLETIZER SYSTEM

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Summary. *The article deals with the model of analytical and applied estimation of complex functional and technological processes of dressing the seed crops both grain and liguminous. Special attention is paid to the pelletizing process of sugar-beet seeds, soybeans, peas, corn seeds and other globulus seed grains. Basic mathematical model has been formed due to the kinematic principles, mobile agricultural technical equipment in particular. The type and contact influence for seed grain flow being subjected to moisty medium (spraying agents) exposure are important factors for dressing and pelletizing processes. Certain assumptions and simplifications have been made for describing these complex hydro-accumulative processes.*

Key words: *dressing, pelletizing, seed grains, technological process, parameters, absorption, concentration, aerosol.*

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Statement of the problem. The development of analytical methods for dressing and pelletizing of seed grains, description of the seed mass flow subjected to the spraying agents medium and the efficiency of its covering the seeds in particular have always been and still are of difficulty for both engineers – designers and technologists. The mathematic logarithm of the seed flow contact with the spraying agent, which is batched appropriately, is rather effective in such cases. The procedure depends on the seeds flow movement speed, hydraulic pressure of the spraying liquid and geometric parameters of the operating unit structure of the working system. Besides, in the paper the prevailing factor (the speed of the seed flow) has been investigated while making canonical equations of these processes.

Analysis of the latest investigations and publications. The advantage of the proposed mathematic model in comparison with that conventional is, that while taking into account the effect factors, such as the aerosol concentration on all area of cross – section of the seed flow mixer filler with the spraying liquid which were not taken into account earlier for the description of this process. In the papers [1, 2] experimental investigations taking advantage of the cut – and – try method and the random values mathematic statistics method have been carried out, which need more sufficient description using analytical dependencies.

The Objective of the article. To develop analytical – applied model of dressing and pelletizing of grains and leguminous sowing materials taking into account the characteristics of soil and climatic conditions of their sowing or planting. The work will contribute to the improvement of the construction system of dressing and pelletizing devices, which consist of the tank, transformers, mixers and kinematic mechanisms, which are very dependable and benefit to the optimization and development of the exact solution of these tasks resulting in their practical application. The calculation of parameters with the design – technological solution is carried out as well.

Statement of the task. To calculate geometric and design parameters of the operating part of dressing and pelletizing devices, to create the analytical model of their efficient performance of the processes in question for the grain or liguminous flow in the aerosol or other physical – chemical liquid state of the spraying agent.

The result of investigations. Chemical protection in plant – growing, sowing materials

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in particular, performed by the system of technical means like dressing and pelletizing devices, is of special importance in agriculture.

The main contribution to the efficient crop is the seed dressing performed according to the agricultural requirements. Dressing itself must be very relevant, because even small unproper procedure can contaminate or damage the seed and it can result in the failure of the plant – growing protection procedure [3, 4].

Nowadays a wide range of different technical means, including stationary and movable dressing devices of the chamber, screw or rotation type (Fig. 1) is being applied for the chemical treatment of the sowing material of the agricultural crops. The most popular are such dressing devices: PK – 20 Super „Lvivagromashproect“ Ukraine (Fig. 1a), Mobitox – Super „Farmgep“, Hungary (Fig. 1b) for the loading of the dressed seeds into the seeding – machine tank; screw dressing devices of the PNSh – 5 type (Fig. 1c) and PNSh – 3 „Lvivagromashproect“ or Gramax – V („Farmgep“) for the loading of seeds into the sacks (Fig. 1c).

a) b) c)

Figure 1. Seed dressing devices

In Fig. 2 the scheme of the calculation model is presented and geometric and functional parameters of the typical dressing and pelletizing devices fillers are shown.

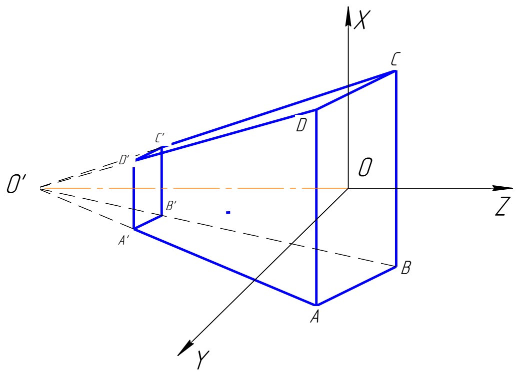

Figure 2. Calculation model of geometric and functional parameters of aerosols spraing (O – the peak of the pyramid, ABCDA'B'C'D' – trancated pyramid, OO' = h – the pyramid height)

The aerosol occupies the area G in the space and is sprayed in it with the density $\rho(x,y,z)$. The vector field of the aerosol speeds $\vec{V}(x,y,z)$ is known. The solid body of M_0 mass, that can absorb the aerosol substance, gets into the point $\vec{V}_0$ in the area G with the known speed $\vec{V}_0(x,y,z)$. The movement of the body is subjected to the weight force and the impulse change force as the result of collision with the aerosol particles. The collision of the body with the aerosol particles can be accompanied by the absorption of particles by the body, relative number of particles being $\eta (0 < \eta < 1)$, which are absorbed, depends on the absorption process and is considered to be known. While absorbing the aerosol particles the mass of the body is increased correspondingly. Under collision without absorption the aerosol speed is equal to that of the body with the corresponding impulse transmission and without the change of the body movement.

Having analysed the real procedure, let us mark the aerosols concentration ρ_0 on all square of the filler cross – section and assume, that $\rho_0 = const$, that is, it does not depend on the changeable coordinates *x* and *y*. But the aerosol concentration in the filler semi – space at $z > 0$ is the function from x, y, z , that is, $\rho = \rho(x, y, z)$, thus $\rho(x, y, z) = \rho_0$.

Points *K* belong to the filler semi – space $K \epsilon (ABCD)$, where *KM* – the aerosol particle trajectory, points *K* and *M* coordinates: $K(x_0, y_0, z_0)$; $M(x, y, z)$.

Besides, while creating the analytical model we assume that:

1. The section from the filler semi – space square (*ABCD*) (Fig. 2) to the elementary particle *M* is a streight line *KM* (as the aerosol particles settlement is much more slow than their movement under pressure).

2. The speed of the aerosol particles in the nozzle filler cross – section *(ABCD)* is constant according to the module, that is, $\left|\vec{V}(x,y,z)\right| = V_0$.

3. The aerosol particles move along the streight line $O^{/}K$ (Fig. 2, 3) being subject to the medium pressure, which is in proportion to the particle squred speed.

The task deals with:

1) finding the aerosol concentration in the elementary particle (cloud) of the flow (area G);

2) finding the field of the aerosol particles speed in the flow (cloud) as the function $\vec{V} = \vec{V}(x,y,z)$, at $z > 0$, where $(x, y, z) \in G$.

Aerosol concentration occurs at the *G* threshold, that is, in the semi – space, as *ρ(x,y,z)=const*.

$$\rho = (M) = \rho_0 = \left(\frac{O^{/}K}{O^{/}M}\right)^2. \tag{1}$$

To find the aerosol concentration in the point *M, ρ(M), M(x,y,z), Z > 0* , let us find at first the corresponding point in the nozzle filler $K(x_0, y_0, z_0)$, when $O'K$ and $O'M$ – are collinear vectors. Let b – is the way of the particle from the point *K* to the point *M*. Then $(x - x_0)^2 + (y - y_0)^2 + z^2 = b^2$, $\frac{x}{x_0} = \frac{y}{y_0} = \frac{z+h}{h}$.

That is why $x_0 = \frac{h}{z+h} \cdot x$; $y_0 = y \cdot \frac{h}{z+h}$, $(|x_0| \le a,\ |y_0| \le b)$.

$$b = \sqrt{\left(1 - \frac{h}{z+h}\right)^2 x^2 + \left(1 - \frac{h}{z+h}\right)^2 y^2 + z^2}\ . \tag{2}$$

Let us find the field of speeds. The movement of particle, under the inertia caused by the resistance forces is in proportion to the squared speeds

$$F_{an} = KV^2, \tag{3}$$

where k – coefficient, $[k]=\frac{K_2}{M}$.

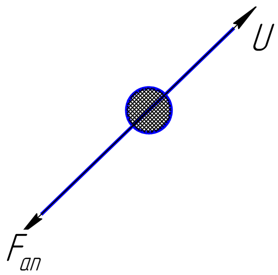

Figure 4. Trajectory scheme of the drop

The particle mass – $\begin{cases} m\frac{dV}{dt}, m; \\ V(0)=U_0. \end{cases}$, speed $\frac{dV}{V^2}=-\frac{k}{m}dt \Rightarrow -\frac{1}{V}+C=-\frac{k}{m}t,$

$U(0)=U_0 \Rightarrow C=\frac{1}{U_0}$.

$$\frac{1}{U}=\frac{m+k\cdot V_0\cdot t}{V_0 m} \Rightarrow V=V_0\frac{m}{m+k\cdot V\cdot t}. \quad (4)$$

Let us mark the time, in which the particle is in the point M in t_0. Then

$$b=\int_0^{t_0} Vdt = V_0 m\int_0^{t_0}\frac{dt}{m+k\cdot V_0\cdot t}=\frac{m}{k}\ln\frac{m+k\cdot V_0\cdot t_0}{m}. \quad (5)$$

From the dependence (5) we will obtain the time, in which the particle gets into the point *M (x,y,z)*:

$$t_0=\frac{m}{k\cdot V_0}(\exp\frac{k\cdot b}{m}-1), \quad (6)$$

or taking into account the dependence (2)

$$t_0=\frac{m}{k\cdot V_0}\left(\exp\frac{k}{m}\sqrt{\left(1-\frac{h}{z+h}\right)^2 x^2+\left(1-\frac{h}{z+h}\right)^2 y^2 z^2-1}\right). \quad (7)$$

The absolute value of the speed in the point M is found due to the formula (4), in which t is changed into t_0.

Now let us find the speed direction in the point M. As according to the assumption the particles move along the streight line OK, the unit vector of the speed direction $\frac{\vec{V}}{|\vec{V}|}=\frac{\vec{OM}}{|\vec{OM}|}$, that is why

$$\vec{V} = \left|\vec{V}\right| \frac{x_i + y_j + (z+h)_k}{\sqrt{x^2 + y^2 + (z+h)^2}}. \tag{8}$$

Finally, the vector field of the aerosol particles speed is provided by the formula (8), in which $\left|\vec{V}\right|$ is found due to the formula (5), in which in its turn *t* is changed into t_0. Coordinates of the point *M(x,y,z)* must satisfy the conditions presented above.

From the presented formulas it is easy to find the equation of the aerosol cloud shape for any moment of the time t_0:

$$\frac{m}{k} \ln \frac{m + k \cdot V_0 \cdot t_0}{m} = \left(\sqrt{\left(1 - \frac{h}{z+h}\right)^2 x^2 + \left(1 - \frac{h}{z+h}\right)^2 y^2 z^2} \right). \tag{9}$$

In the direction of the symmetry axis the aerosol clouds are spreaded in the distance $\frac{m}{k} \ln \frac{m + k \cdot V_0 \cdot t_0}{m}$.

Conclusions. The analysis of the construction schemes of the technical means for dressing and pelletizing of seeds has been carried out, basing on which the mathematic model of the seeding crop dressing, which includes the analytical dependencies for the finding of the aerosol cloud shape for any moment and its concentration as well as the vector field of the aerosol particle speeds, have been proposed. The advantages of the proposed analytical applied model have been interpreted.

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АНАЛІТИЧНО-ПРИКЛАДНА МОДЕЛЬ ПРОЦЕСУ АБСОРБЦІЇ В СИСТЕМІ ПРОТРУЮВАЧІВ ТА ДРАЖИРАТОРІВ ПОСІВНИХ МАТЕРІАЛІВ

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Резюме. *Викладено модель аналітично-прикладного оцінювання складних функціонально-технологічних процесів протруювання насіннєвих зернових та зернобобових культур. Значну увагу приділено розгляду дражування, зокрема насіння цукрових буряків, сої, гороху, кукурудзи та інших кулько-виражених насіннєвих зернин. Базову математичну модель сформовано, виходячи з кінематичних принципів, а саме мобільних сільськогосподарських технічних засобів. Для протруювачів та дражираторів посівного матеріалу дуже важливо охарактеризувати процес проходження та контакту насіннєвого потоку в зволоженому середовищі відповідного препарату, тобто аерозолі. Певні припущення та окремі спрощення зроблено при описуванні цих складних гідроакумулятивних процесів.*

Ключові слова: *протруювання, дражування, посівний матеріал, технологічний процес, параметри, абсорбція, модель, концентрація, аерозоль.*

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