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PRINCIPLES OF INNOVATIVE SEED PELLETING TECHNOLOGY

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ABSTRACT. *The methods of crop seed treatment and their apparatus design are analyzed in order to ensure high yields, specified consumer characteristics and resistance to unfavorable agro-climatic conditions. Existing methods are characterized by a high risk of agglomerate formation, mechanical seed injury, and low heat utilization. To eliminate these disadvantages, the principles of innovative seed treatment technology using an apparatus with a heterogeneous jet-pulsation mode of fluidization are scientifically substantiated.*

KEY WORDS: PELLETIZING, HETEROGENEOUS FLUIDIZATION, JET-PULSATION MODE.

ЗАСАДИ ІННОВАЦІЙНОЇ ТЕХНОЛОГІЇ ДРАЖУВАННЯ НАСІННЯ

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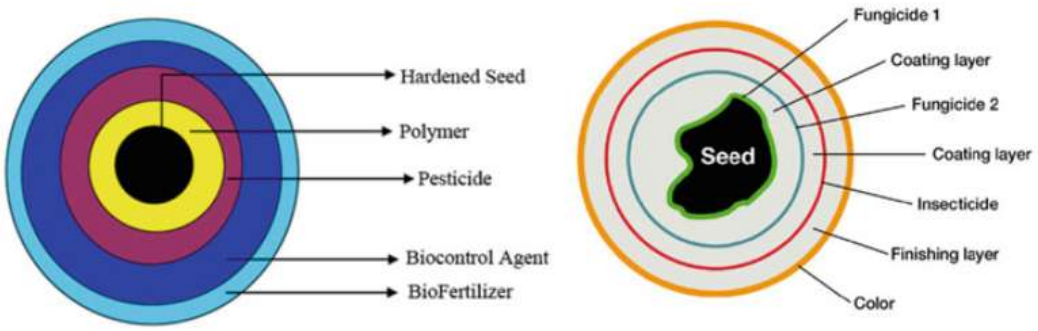
АНОТАЦІЯ. *Проаналізовані методи обробки насіння сільськогосподарських культур і їх апаратурне оформлення з метою забезпечення високої врожайності, заданих споживчих характеристик та стійкості до несприятливих агро-кліматичних умов. Існуючі методи характеризуються високим ризиком утворення агломератів, механічного травмування насіння та низьким коефіцієнтом використання теплоти. Для усунення цих недоліків науково обґрунтовано засади інноваційної технологій обробки насіння з використанням апарата з неоднорідним струменево-пульсаційним режимом псевдозрідження.*

КЛЮЧОВІ СЛОВА: ДРАЖУВАННЯ, НЕОДНОРІДНЕ ПСЕВДОЗРІДЖЕННЯ, СТУРМЕНЕВО-ПУЛЬСАЦІЙНИЙ РЕЖИМ.

Pre-sowing chemical treatments are essential for increasing agricultural production efficiency and ensuring food security. Seed pelletizing is an innovative method of pre-sowing treatment that improves seed properties, protects them from pests and diseases, and provides them with the necessary nutrients at the early stages of growth.

The use of fluidization techniques for dehydration and granulation during pelletizing ensures mass crystallization with intensive solvent removal, and in the presence of suspended components in the working solution, the formation of composite materials with different morphologies.

In the case of seed pelleting, the most appropriate mechanism for the formation of pelletized seeds is the layer-by-layer mechanism (Figure 1), which will ensure the formation of pellet layers with the specified physical and mechanical properties.



a) – Agritech company b) – Legro company

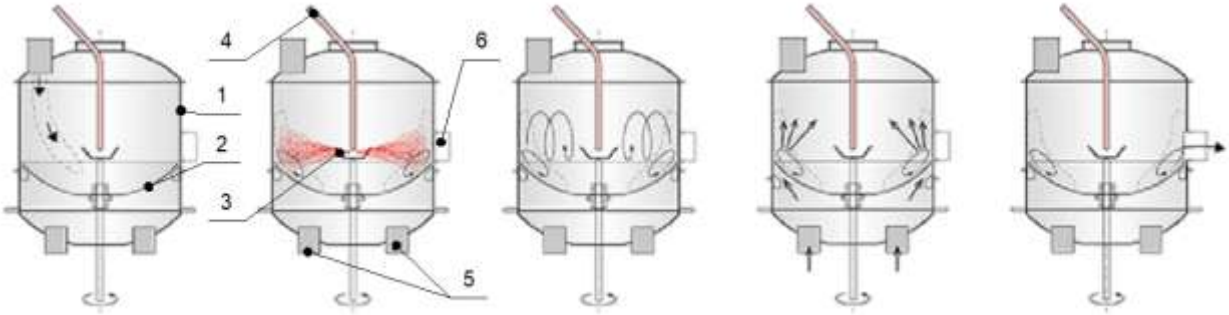
Figure 1 – Mechanisms of seed formation [1, 2]

The most common equipment for all types of pre-sowing processes is a stirrer machine in various modifications, in which the liquid and dust phases are sprayed using a mechanical disk-type disperser. In this case, due to the impact of mechanical blades on the seeds, both the surface layer and the seeds themselves can be damaged. In addition, there is a high risk of agglomerate formation. To dry the resulting product, a drum machine is usually installed, or the process is carried out in a bowl

granulator with subsequent drying of the material. Sometimes the pelletizing process is carried out in a cascade of drum machines. The main disadvantage of such equipment is the multi-stage technology and low heat utilization.

Figure 2 – Pelletizing system DPP [3]

The company Petkus/Roeber [4] proposed a new multi-coater, Figure 3.



a) filling; b) spraying; c) mixing; d) drying; e) unloading of finished products;

1 – cylindrical body; 2 – rotating bottom; 3 – mechanical disperser; 4 – liquid phase supply pipe;

5 – diffusers for air supply; 6 – nozzle for unloading the finished product

Figure 3 – The principle of Petkus/Roeber multi-coater functioning [4]

The obvious complexity of the design and the high cost of the manufacturing technology do not reduce the risk of seed injury in the gap between the edges of the rotating bottom and the walls of the cylindrical body. In addition, insufficient mixing does not ensure effective contact of the coolant with individual particles, which

significantly reduces the mass and heat transfer coefficients. As a result, the specified coating uniformity is not ensured, the granular material is not dried sufficiently, and agglomerates spontaneously form during the pelletizing process.

The peculiarity of the pelletizing process is the formation of a multilayer cluster on the surface of the grain, which is 5 or more times its initial weight. At the same time, pelletized seeds are a biological object with a specific genetic code and, when applied to the soil, must be active and have the resource to counteract negative factors of organic, chemical and climatic origin.

Technologically, the pelletizing process involves the cyclical application of a liquid phase containing a solvent, mineral and organic nutrients, and growth stimulants to the seed surface, followed by evaporation of the solvent (water). As a result, a composite solid phase with a micro-layer structure is formed on the seed surface. To achieve this, it is necessary to ensure effective circulation of the granular material between the irrigation and drying zones without mechanical damage to the seeds. But the main feature is that the process can only take place at a temperature of 40^0C, and the heat supply for the evaporation of the solvent from the liquid formed on the grain surface can only be due to convection from the heated coolant.

Given that the heat transfer coefficient α from the gas coolant has a limited value, an increase in the amount of heat supplied can be achieved by increasing the total contact surface of the phases F, i.e., the product αF tends to max. Given that the liquid phase is continuously dispersed into the fluidized bed, to ensure stable kinetics of the process with a layer-by-layer granulation mechanism, it is necessary to actively renew the working surface of the phases in the irrigation and drying zones at a high driving force for mass transfer. This will increase the coefficient of utilization of the supplied heat with the heated coolant.

All of these requirements are met by a fluidized bed apparatus in which a continuous gas medium is used as a liquefying agent, coolant, and moisture receiving phase. It is known that the coefficient of utilization of the supplied heat of such an

apparatus can reach 50% or more, and in the case of heterogeneous fluidization, the coefficients of heat and mass transfer increase by 1.5–2 times [5]. The high efficiency of the transfer processes in the fluidized bed apparatus is achieved through the use of a heterogeneous jet-pulsation hydrodynamic regime, the physical model of which is shown in stages in Figure 4 [6].

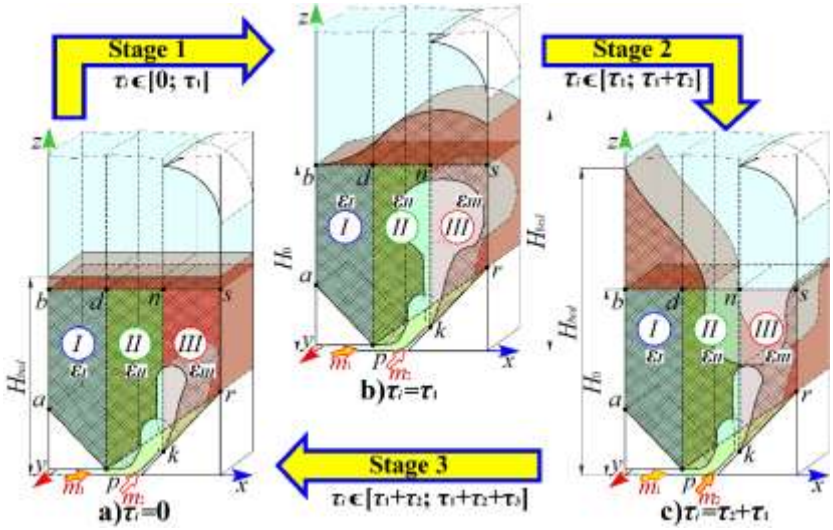
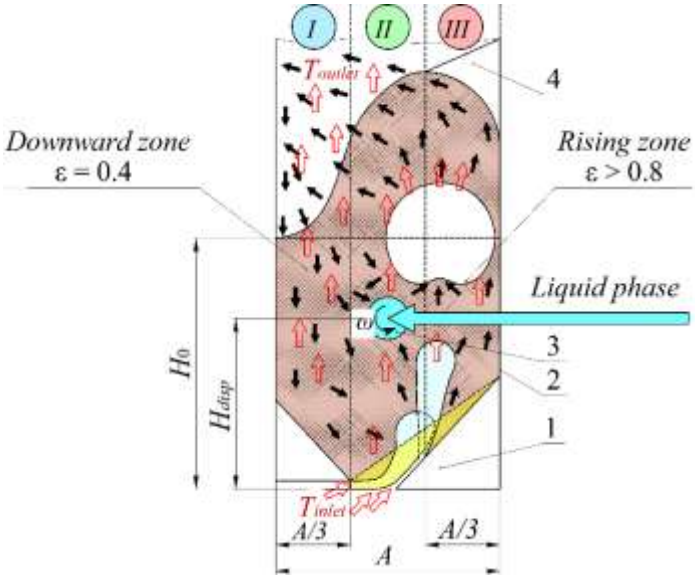


Figure 4 – Stages of evolution of heterogeneous jet-pulsation fluidization [6]

The essence of the process of the proposed technology is that seeds are loaded into the chamber of the granulator 2, which has the shape of a parallelepiped equipped with a slotted gas distributor 1 (GDP) in the lower part. The heated coolant is introduced into the apparatus asymmetrically through the slotting device to create a pulsating fluidization. The liquid phase is sprayed by a mechanical disperser 3 located inside zone II, through which the mass of granular material moves bilaterally (Figure 5).

Testing of this technology in the dehydration and granulation of heterogeneous liquid systems containing almost the same amount of bone meal 29% (organic matter) and ammonium sulfate 27% (mineral component), 2% each of potassium chloride and humate, made it possible to obtain organic-mineral fertilizers of stimulating action of spherical shape with a layered structure, Figure 6–7 [7].



1 – gas distribution device, 2 – granulator chamber, 3 – mechanical disperser, 4 – directing distributor;

Figure 5 – Scheme of the apparatus for carrying out the process of pelleting and granulation under geterogeneous fluidization

Figure 6 – General view of humic-phosphorus-calcium-nitrogen-potassium-sulfur-containing fertilizers with a stimulating effect of the composition: $\Gamma : P : Ca : N : K : S$ = 1 : 10 : 19 : 11 : 2 : : 12.5

1 – initial center of granulation, 2 – layered structure;

Figure 7 – Cross-section of the pellet (increased by a factor of 10)

At the same time, the granulation coefficient is $\Psi \geq 88$ % (dust removal is less than 12 %) at a specific moisture load of the layer surface a_f = 0,5 kg/(m^2·h), which is

2 times higher than this figure compared to the process when implementing homogeneous fluidization [7].

In conclusion, the innovative technology of pelletizing using heterogeneous jet-pulsation fluidization has been successfully tested in the production of granular organic-mineral fertilizers during the dehydration of composite fertilizers containing nutrients of mineral and organic origin and stimulating macro-impurities. The weight of the final granular product increased by 18 times compared to the initial one without deterioration of physical, mechanical, and chemical properties, which indicates the high adaptability of the proposed technology. The fundamental difference from existing technologies is the possibility of obtaining a layered structure on the surface of seeds according to an individual recipe, which is determined by the agro-climatic and environmental conditions of the region of application. This technology is also characterized by high thermal efficiency (over 50 %), which helps to reduce the carbon footprint and improve the environmental safety of production. In addition, the proposed approach is fully suitable for the efficient implementation of drying, seed dressing, encrustation and even calibration processes.

Further research will be aimed at determining the characteristics of hydrodynamics for each type of seed, taking into account their aerodynamic properties and the conditions of the pelleting process, which ensure the preservation of high biological activity of the treated seeds.

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