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INNOVATIVE TECHNOLOGY FOR OBTAINING GRANULATED ORGANIC-MINERAL FERTILIZERS

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Abstract

The method of implementing hydrodynamic interaction in the gas–liquid–solid system using the fluidization technique for the production of granulated organic-mineral fertilizers is substantiated. The results of experimental studies, which confirm the effectiveness of the application of inhomogeneous jet-pulsating mode of fluidization with the provision of high intensity of diffusion-controlled systems in the dehydration and granulation of liquid heterogeneous systems are presented.

Keywords: granulation, dehydration, organic-mineral fertilizers, inhomogeneous fluidization, jet-pulsating mode.

Introduction

Even in the conditions of martial law, Ukraine showed its significant contribution to combating the world food crisis, which was deepened by the actions of Russia – the aggressor country.

In modern conditions, the rhythmic functioning of the agro-industrial sector will allow not only to increase the food security of Ukraine, but also contribute to the recovery of other branches of the state's economy.

The fulfillment of these tasks is related to the implementation of complex measures to preserve soil fertility. One of the effective methods of solving this problem is the use of granulated humic-organic-mineral fertilizers of the new generation with a given ratio of nutrients and stimulating substances, which are determined by the agrarian-climatic and ecological conditions of the region of their usage. The main problem is the creation of an energy-efficient technology for the production of a new generation of complex granulated organic-mineral fertilizers of goal direction. In world practice to obtain a granular product from liquid systems in one stage is used the fluidization technique with a heat utilization ratio of more than 50%. An important role in such processes associated with the dehydration of liquid systems containing more than 50% solvent is played by the hydrodynamics of the fluidized bed. This is usually a homogeneous fluidization (gushing mode). However, in both the first and second cases, the problem of intensification of diffusion-controlled processes and effective renewal of the interphase surface of heat and mass exchange in the main zones of the apparatus (irrigation, heating and relaxation) is not solved.

The aim of the work is to substantiate the method of hydrodynamic interaction in the soil–liquid–solid system during the process of granulation of the new generation organic-mineral fertilizers in a fluidized bed granulator.

Results and discussion

The authors [1] proposed a method of dehydration and granulation of heterogeneous liquid systems using inhomogeneous fluidization.

The peculiarity of the method is that the porosity of the fluidized bed is determined relative to the initial volume of the bed (*absrkp*), Fig. 1, by zones *I*, *II* and *III*. It is obvious that at the velocity of the coolant in slits of the gas distributing device (GDD), which practically ensures the absence of stagnant zones on the working surface, the porosity in the zones will be $\varepsilon_{III(\min)} > \varepsilon_{II(\min)} > \varepsilon_I = \varepsilon_0$, which is related to the peculiarities of the formation of gas jets.

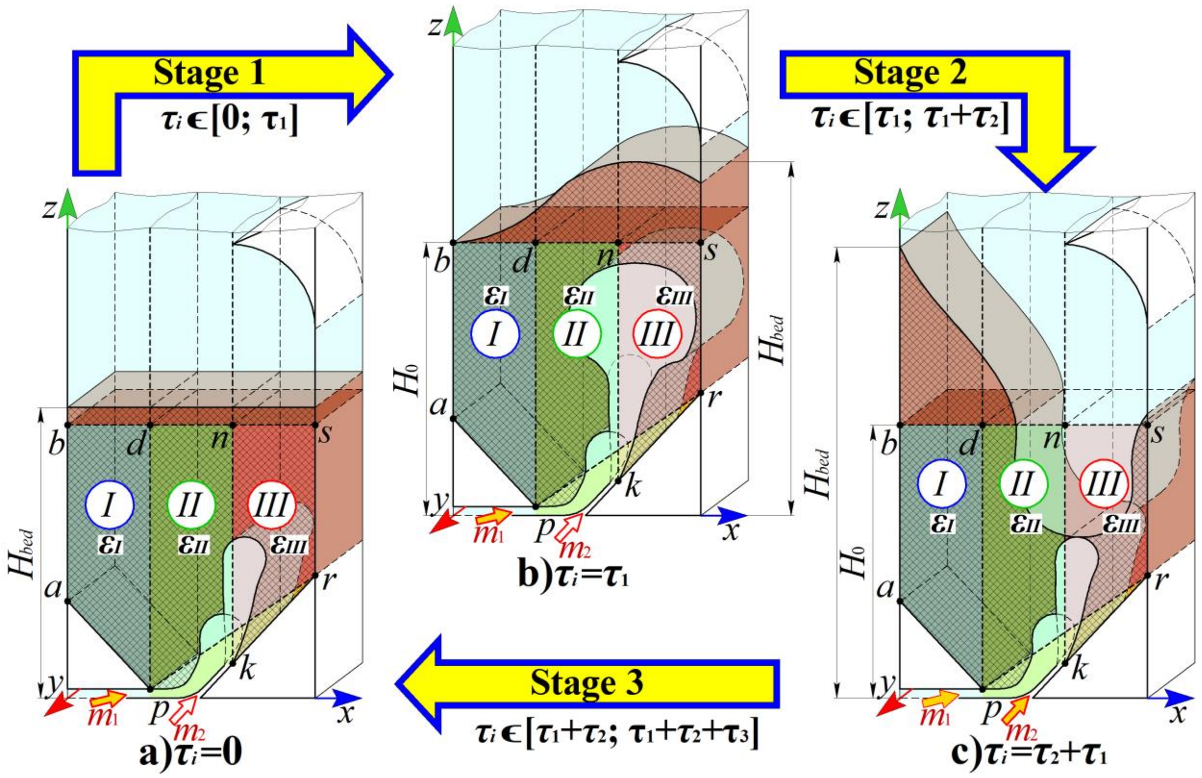

Fig. 1. Physical model of inhomogeneous jet-pulsating fluidization in self-oscillating mode

At the first stage of the cycle (induction period) during time τ_1 at the height $z_f + \Delta$, a gas bubble is formed and reaching its critical size, Fig. 1 b. The second stage (τ_2) is the pulsating ejection of a significant mass of granular material from zones *III* and *II* into the space above the initial bed and its movement to zone *I*, Fig. 1 c, with one or more bubbles, until the residual height of granular material in zone *III* is $H_{residual(III)} \leq z_f + \Delta$. Then there is an intensive movement of the bed of granular material from the space above the bed of zone *I* into the formed voids in zones *II* and *III* and the system returns to the initial state of equilibrium, Fig. 1 a, with countercurrent movement of solid and gas phases (stage 3) – (τ_3). That is, the duration of one cycle of pulsations is, s: $\tau_{cycle} = \tau_1+\tau_2+\tau_3$.

This hydrodynamic mode of fluidization is characterized by a non-linear change in the height of the bed up to $(1.7\div2.0)H_0$ in zone *I* and the inhomogeneity of its porosity (in a fixed volume *absrkp*), which in zone *I* remains constant $\varepsilon_I=\varepsilon_0=0.4$, and in zones *II* and *III* can change cyclically from $\varepsilon_{II(\min)}$ to $\varepsilon_{II(\max)}=1.5\varepsilon_0$ and from $\varepsilon_{III(\min)}$ to $\varepsilon_{III(\max)}=2\varepsilon_0$.

It was experimentally established [2-7] that in the apparatus with a fluidized bed, in which a inhomogeneous jet-pulsating self-oscillating mode with a cyclic impulsive ejection of solids into the space above the initial bed is realized, more than 45% of the mass of the bed with a frequency of f=1.47÷3.3 Hz and its active return to the initial volume.

The use of inhomogeneous jet-pulsating fluidization in self-oscillating mode during the dehydrating of liquid systems containing sunflower ash, ammonium sulfate and humic substances ensures stable kinetics of the process with a granulation coefficient of $\psi \geq 90\%$ and confirms the moisture removal intensity of at least 1.5 times more than in the bubbling mode with simultaneous provision of the absence of melting zones on the gas distributing device surfaces at the temperature of the liquefying agent at the inlet $T_{inlet} = 230^{o}$C.

The obtained granulated organic-mineral fertilizer has a spherical shape and a layered microstructure, thanks to which is achieved a uniform distribution of nutrients throughout the volume of the granule: *K* (21.5%), *N* (9%), *Ca* (3.2%), *S* (13.8%) in the presence of impurities *Mg* (3.2%) and *P* (1.8%) with a given amount of humic substances H.S. (1.5%). The strength of the granules is σ =11÷16 N per granule, which is 1.1÷1.6 times higher than the current standard. The research results can be used to develop the principles of innovative technology for the production of organic-mineral fertilizers of the new generation from domestic raw materials.

Conclusions

Is established that the use of a inhomogeneous jet-pulsating fluidization in the self-oscillating mode during the granulation of organic-mineral fertilizers allows to increase the intensity of diffusion-controlled processes and ensures the production of a granulated product with the desired properties at the granulation coefficient ψ≥90%.

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ІННОВАЦІЙНА ТЕХНОЛОГІЯ ОДЕРЖАННЯ ГРАНУЛЬОВАНИХ ОРГАНО-МІНЕРАЛЬНИХ ГУМІНОВИХ ДОБРИВ

Анотація

Обґрунтовано спосіб реалізації гідродинамічної взаємодії в системі газ–рідина–тверде тіло при застосуванні техніки псевдозрідження для одержання гранульованих органо-мінеральних добрив. Наведено результати експериментальних досліджень, які підтверджують ефективність застосування неоднорідного струменево-пульсаційного псевдозрідження із забезпеченням високої інтенсивності дифузійно-контрольованих систем при зневодненні та грануляції рідких гетерогенних систем.

Ключові слова: грануляція, зневоднення, органо-мінеральні добрива, неоднорідне псевдозрідження, струменево-пульсаційний режим.

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