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RESEARCH OF OPERATING MODE OF RHOMBIC GRAVITATIONAL PNEUMATIC CLASSIFIER

В роботі розглядається технологія отримання органічних і органо-мінеральних гранул пролонгованої дії. З'ясовано, що гранульований товарний продукт повинен відповідати певним вимогам за розміром частинок. Отже, блок сепарації (класифікації) в розробленій технологічній схемі грає дуже важливу роль в процесі отримання товарних гранул. Об'єктом дослідження є процес класифікації гранульованих органічних добрив в гравітаційному пневмокласифікаторі ромбічної форми. Дослідження було спрямоване на встановлення оптимальних режимно-технологічних параметрів роботи «ромбічного» пневмокласифікатора. Для цього була вивчена фізична модель процесу пневмокласифікації дисперсних частинок (гранул) в апараті ромбічної форми, яка пояснює умови поділу полідисперсної суміші на більш вузькі фракції, формування зваженого шару матеріалу. А також циклічний механізм дозавантаження і розвантаження зваженого шару. Крім забезпечення чистоти продукту апарат також повинен мати низький гідравлічний опір і малу енергоємність. Для фізичного моделювання використовувався лабораторний стенд гравітаційного пневмокласифікатора ромбічної форми, на якому було поставлено ряд дослідів щодо підбору оптимального режиму поділу і чистоти продукту. Раціональне використання робочого простору і ефективних способів впливу на потік матеріалу дозволяють в рамках одного корпусу отримати необхідні параметри поділу. Проведення процесу класифікації в «ромбічному» пневмокласифікаторі дозволяє ефективно видаляти з гранульованого продукту до 99 % частинок розміром менше 2 мм. На виході з апарату отримуємо товарний продукт з розміром частинок 2–4 мм в кількості 99 %, що відповідає стандартним вимогам щодо якісного гранулометричного складу. Таке ефективне розділення в даному апараті здійснюється за рахунок його форми (оптимальних кутів розкриття і закриття «ромба» корпусу), яка сприяє обертанню потоку матеріалу і призводить до додаткового пересіву. Відсутність же всередині апарату контактних елементів значно знижує його гідравлічний опір і зменшує енергоємність.

Ключові слова: *процес пневмокласифікації дисперсних частинок, ромбічна форма, гранулометричний склад, гідравлічний опір, гранульований продукт.*

1. Introduction

The work [1] presents the technology of producing granulated fertilizers on an organic basis. Standard requirements for granular fertilizers include a fraction of 1–4 mm of at least 85–90 %, and a fraction of less than 1 mm of no more than 3–5 %. The considered method of granulation by spraying a suspension into a fluidized bed of particles is characterized by a different residence time of both growing granules and the return of small particles of retur [2, 3]. This causes an uneven coating of the surface of the particles with a suspension, with the result that the product after the granulator turns out to be non-uniform in terms of particle size distribution. Due to the presence of heated small particles less than 1 mm in size, the use of mechanical screens is impractical because of the clogging of the grid cells, which leads to frequent stopping of equipment for repair [4]. Thus, the developed production line for the production of organic and organo-mineral granules [1, 5] should be equipped with a pneumatic classifier for screening out fine fractions from a polydisperse mixture of a granulated product. Since the classifier plays a very important role in the process of obtaining commodity granules, then its efficiency must meet the requirements imposed on it [6–8]. After analyzing the known designs of separators [9–11], it can be concluded that none of the structures provide the desired purity of the product within the framework of the proposed technological scheme. In addition to ensuring the purity of the product, the apparatus should also have a low hydraulic resistance and low power consumption. This causes the relevance of the study.

Therefore, *the object of research* is the process of classification of granular organic fertilizers in a rhombic gravitational pneumatic classifier. And *the aim of research* is studying the classification process of granular organic fertilizers in a rhombic gravitational pneumatic classifier and the establishment of optimal operating and technological parameters of the equipment.

2. Methods of research

The methods of physical modeling of the processes of pneumatic classification of gas-dispersed systems are used. In conducting experimental studies, multivariate experiment planning methods are used. To summarize the experimental data obtained, differential methods of mathematical analysis and integral calculus are applied, which were performed using computer hardware and an application software package, namely: MathCAD, MS Office Excel.

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3. Research results and discussion

For research, a laboratory stand of the «rhombic» pneumatic classifier was used, on which a number of experiments were performed on the selection of the optimal separation mode and product purity.

Rational use of the working space and the use of effective methods of influencing the flow of material make it possible to obtain the required separation parameters within one case. The absence in the case of contact elements significantly reduces the hydraulic resistance of the device, and significantly reduces its power consumption.

Fig. 1 shows that the case 1 of the rhombic form can be divided into two zones: the lower part (separation zone) is designed to rotate the material, and the upper part – to disperse and remove the granules from the apparatus to regrow. The hopper 2 is used to uniformly dispense the pellets entering the apparatus, and the unloading devices 3 and 4 serve to drain the pellets out of the apparatus.

The principle of operation of pneumatic classifier is as follows. The gas blower forms a steady air flow. Granules are fed continuously to the middle part of the apparatus. Under the action of gravity, the granules fall into the separation zone of the apparatus (Fig. 1), where, with the help of an air flow, a rotating layer of them is formed, which is pressed from wall to wall. In this case, a small fraction is blown out of the layer, which is accelerated in the upper part of the body and sent to the fluidized bed apparatus for re-growth. And large granules (more than 2 mm in size), wake up through a rotating layer, and are discharged into the collection in the form of a commercial fraction.

The research results are presented in Fig. 2 and in Table 1.

As can be seen from the graph (Fig. 2), the purity of the commodity fraction is 96–98 %, and 2–4 % are losses. This means that the efficiency of this unit is very high and the degree of separation meets the requirements that apply to this type of equipment.

The part of the material that is not divided continues to rotate. Further in the case of the device new granules arrive. Conditions are created in the housing that allows the material layer to rotate from wall to wall.

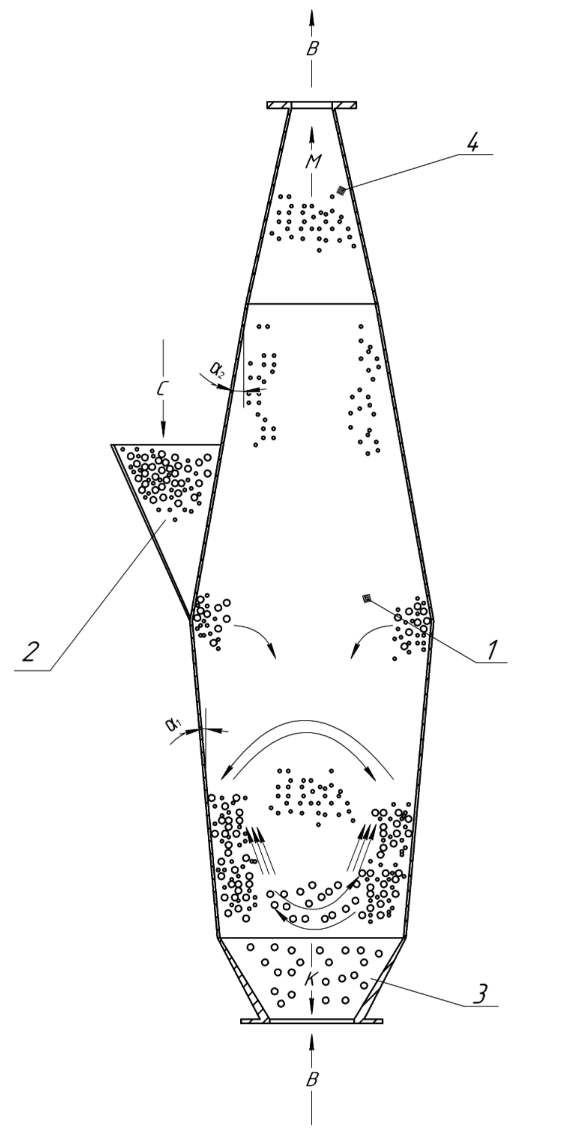

Fig. 1. The principle of the «rhombic» pneumatic classification: 1 – case; 2 – loading hopper; 3 – lower loading device; 4 – upper loading device; α_1 – the angle of the rhomb opening; α_2 – angle of rhomb closure; B – air flow; K – large fraction; M – small fraction; C – initial mixture of granules

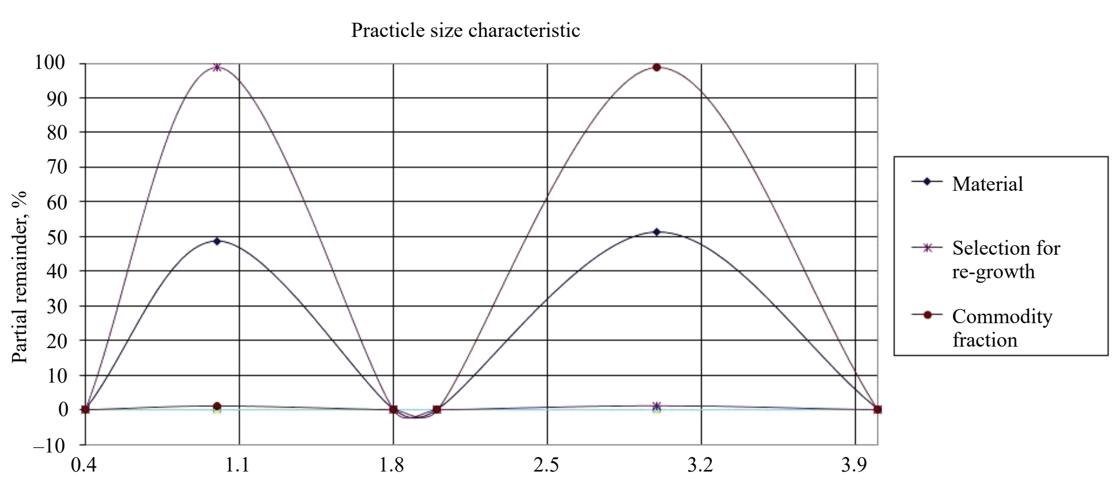

Fig. 2. Screening curves for fractions

Table 1

The results of the experiment on a binary mixture (commodity fraction 2–4 mm and undeveloped fraction 0.4–2 mm)

Sample	Weight, g	Fraction 0.4–2 mm, g	Fraction 2–4 mm, g
Raw material	3129.2	1524.6	1604.6
%	100.0	48.7	51.3
Yield of the granules to re-growth	1559.6	1507.3	52.3
%	100.0	98.8	1.2
Yield of product fractions	1569.6	17.3	1552.3
%	100.0	1.1	98.9

4. Conclusions

The paper shows that carrying out the pneumatic classification process in the «rhombic» pneumatic classifier allows to effectively remove particles less than 2 mm in size from the granulated product. At the exit of the apparatus, let's obtain a marketable product with a particle size of 2–4 mm, which meets the standard requirements for a qualitative particle size distribution. Effective separation in this apparatus is due to its rhombic shape, which contributes to the rotation of the material flow and leads to an additional reseeding. Cyclic loading of the material into the apparatus also affects the nature of the motion of the particles and prevents them from collecting into agglomerates.

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