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OPTIMIZATION OF PRESS-GRANULATOR WORK IN SMART TECHNOLOGIES SYSTEM

Abstract

It has been repeatedly tested and proven that granulated feed and granulated semolina have a number of advantages over loose feed, since there is no self-sorting of components, losses during transportation and loss of nutrients during storage is reduced. The effective effect of such compound feeds is higher than that of loose feeds by 10-15% due to an increase in the level of sanitary quality and an increase in the digestibility of nutrients. In addition, up to 3...4% of liquid components can be introduced into the compound feed during granulation, compared to 1...2% for loose compound feed. At present, there is a tendency towards an increase in the share of production of granulated feed. The technology of granulating feed allows you to ensure stable uniformity, improve sanitary and hygienic indicators, increase nutritional value, increase shelf life, and minimize losses during its transportation and distribution. All this affects both the consumption of compound feed and the performance of animal and poultry rearing. At the same time, the main equipment for the production of mixed feed pellets is a pellet press. The task of controlling the press granulator as part of SMART technologies is to determine and implement such a ratio of steam consumption and the initial product, in which the indicators of the granulation process such as productivity, specific consumption of steam and electricity, as well as the quality properties of the granules would correspond to the required values. According to the most important practical recommendation for conducting the technological process of granulation, it is to provide the required conditions for conditioning with steam, liquid components in accordance with the properties of the initial processed product. At the same time, the hydrothermal treatment of compound feed affects, practically, all indicators of the granulation process and the quality of its final product. An analysis of the dependence of productivity on steam consumption obtained for various compound feed recipes allows us to conclude that it is possible and expedient to search for the optimal position of the regulating body for supplying steam to the pellet press mixer. At the same time, it is necessary that the productivity of the press tend to the maximum depending on the position of the regulating body for supplying steam to the press, and the magnitude of the current load of the main drive motor, which mainly determines the energy intensity of the process, was limited in a given range of values at zeroing of the corresponding compound feed recipe: The increment in the filling time of the cooling column between the cycles of the unloading device, which characterizes the performance of the pellet press, can be used to indirectly evaluate it and be used as an output indicator in the control system for the granulation process. The search algorithm for the optimal granulation mode consists of two parts: the stepwise start algorithm (bringing the system into the search zone) and the search algorithm for the optimal granulation mode. It is proposed to use the SMART-INDIVIDUAL system, which is equipped with a module with a regulation for monitoring parameters of equipment according to passport characteristics. At the same time, the system maintains an archive and controls the timing of maintenance.

Keywords: press granulator, performance, stabilization, optimization, search algorithm, SMART technology

Introduction

It has been repeatedly tested and proven that granulated feed and granulated semolina have a number of advantages over loose feed, since there is no self-sorting of components, losses during transportation and loss of nutrients during storage is reduced. The effective effect of such compound feeds is higher than that of loose feeds by 10-15% due to an increase in the level of sanitary quality and an increase in the digestibility of nutrients. In addition, up to 3...4% of liquid components can be introduced into the compound feed during granulation, compared to 1...2% for loose compound feed. At present, there is a trend towards an increase in the share of production of granulated feed [1, 2].

Purpose and objectives of the study

One of the main directions of intensification of the technological process of granulation is the introduction of automated control systems, the highest form of which, at present, is the use of SMART technologies. Automatic control of the granulation process should be aimed at maintaining such a ratio of steam consumption and the initial product, which provides the nominal value of the stator current of the main drive electric motor of the press at a given output and the required quality of finished granules. However, it is far from always possible to establish the optimal value of this ratio in each specific case, since its value is not constant and depends on the physical and mechanical properties of the initial product, steam parameters. This circumstance leads to the need to apply methods for searching for regime parameters of granulation. Existing control systems for the granulation process do not implement search control methods, limiting themselves to stabilizing one or more parameters.

The purpose of this work is the implementation of search methods (on a model or directly on an object) that requires the use of a set of technical means of SMART technologies.

Equipment and research methods

Mixed feed granulation technology allows ensure stable uniformity, improve sanitary and hygienic indicators, increase nutritional value, increase shelf life, as well as minimize losses during its transportation and distribution. All this affects both the consumption of compound feed and the performance of animal and poultry rearing. At the same time, the main equipment for the production of mixed feed pellets is a pellet press [1]. The granulator press is rather specific, technological equipment, the design of which has several varieties [3]. The granules leaving the press are cooled in a cooling column to a temperature not exceeding the ambient temperature by more than 10°C, sieved to isolate the product required by its physical and mechanical properties, which is then weighed by portion scales and with the help of transport mechanisms is placed in the warehouse of finished products. The fine fraction (crumb) obtained by sieving the granules is returned for re-granulation. Figure 1 shows the principle of operation of the press-granulator.

Structurally, press-granulators consist of the following main units: feeder, mixer, pressing section, communications for supplying steam and liquid components.

Loose mixed fodder (initial product) in the process of production enters the auger-feeder I, designed for uniform feeding and dosing of the initial product into the press mixer. The rotation speed of the auger is changed using a V-belt variation 2. Under the feeder there is a mixer 3 designed for hydrothermal processing (conditioning) of loose feed with steam or water, as well as enrichment with liquid components (molasses, hydrol, fats, etc.).

The conditioned product is fed into the pressing section 4, where it is pressed through the holes of the rotating annular die 5 with the help of corrugated rolls 6. The pressed product is cut off at the exit from the die by knives fixed on the press casing.

The most widely used in domestic and foreign practice is the "dry" method of granulation, implemented on roller-type presses with a vertically rotating matrix. At the same time, the task of controlling the granulator press as part of SMART technologies is to determine and implement such a ratio of steam and initial product consumption, in which the indicators of the granulation process such as productivity, specific consumption of steam and electricity, as well as the quality properties of the granules would correspond to required values. However, the optimal value of the indicated ratio, for each specific case, differs from each other and cannot be determined a priori, due to the instability of the composition and quality of raw materials, the peculiarities of the technology for preparing loose feed intended for subsequent granulation, a large number of options feed recipes.

According to the most important practical recommendation for conducting the technological process of granulation, it is to provide the required conditions for conditioning with steam, liquid components in accordance with the properties of the initial processed product. At the same time, the hydrothermal treatment of compound feed affects, practically, all indicators of the granulation process and the quality of its final product.

Results and discussion

Considering the press - granulator as a control object in the form of a "black box", it is advisable to highlight the main parameters that affect the granulation process [3]. The input parameters are: the flow rate of the initial product G and the flow rate of steam Q for conditioning. The outputs parameters are taken as - load

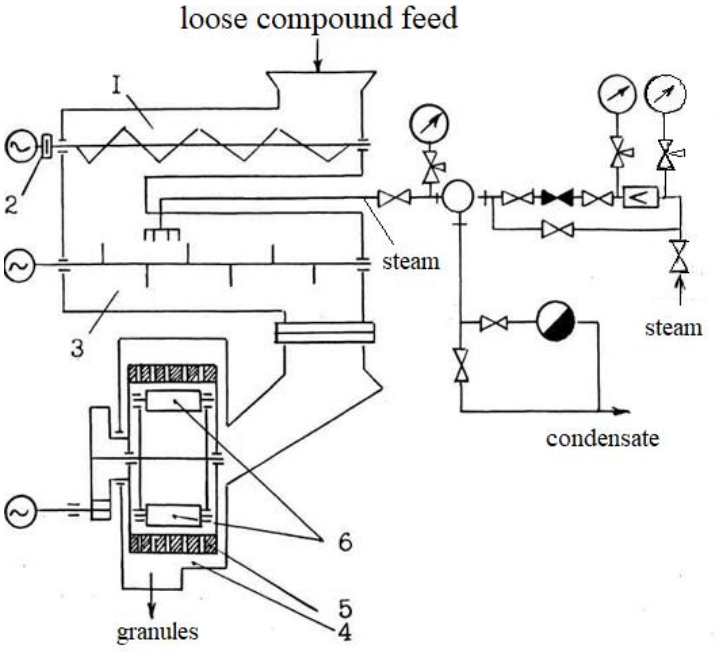

Fig. 1. Schematic diagram of the technological process of granulation of feed:
1 - screw feeder; 2 – feeder rotation speed variation;
3 - mixer; 4 - pressing section: 5 - rotating matrix;
6 - corrugated rolls.

current - Jm of the main drive motor of the press and temperature $\theta_{к-к}$of the conditioned product at the outlet of the press mixer. Disturbing influences that cause changes in the current load of the main drive electric motor of the press are determined by the variability of the physical and mechanical properties of the original product, and disturbances that affect both the conditioning temperature and the current load of the main drive of the press are due to a change in the steam meters of steam, fluctuations in temperature and quality of the original product.

As a result of the experimental studies carried out in production conditions, it was revealed that the analysis of the dependence Pri = f (Q) obtained for various compound feed recipes allows us to conclude that it is possible and expedient to search for the optimal position of the regulating body for supplying steam to the mixer of the granulator press . At the same time, it is necessary that the productivity of the press tend to the maximum depending on the position of the regulating body for supplying steam to the press, and the magnitude of the current load of the main drive motor, which mainly determines the energy intensity of the process, was limited in a given range of values at zeroing of the corresponding compound feed recipe:

$$P_{ri}=f(Q) \qquad \max$$
$$\text{при } J_{1i} < J_i < J_{2i}$$

where: Pri-productivity of the press granulator at development1st compound feed recipe, kg / s;

J_i –`is the value of the current load of the main drive electric motor, which varies in a certain range of values of $J_{1i} < J_i < J_{2i}$ during the development of the i-th compound feed recipe, A;

Q - position of the regulator of steam supply to the press,% r.b.s.

The task of implementing the search for the optimal granulation mode required the solution of two issues: the development of a method for measuring the performance of a granulator press and the choice (development) of an automatic search algorithm.

The formulation of the problem of automatic search for the optimal granulation regime is determined by the presence of factors that ensure the possibility and necessity of this search.

It is known [2] that in order to be able to implement the search, there must be an extreme static dependence between the output parameter of the object and the corrective action; As the results of the research showed, there is such a dependence. We are talking about the dependence of the press productivity on steam consumption at a stabilized current load of the stator of the main drive electric motor of the press.

On the other hand, the need for an automatic search for the optimal granulation mode is confirmed by the fact that this dependence is characterized by an extremum drift, which occurs not only when changing the recipe, but also when developing the same feed recipe.

When considering the issue of measuring the productivity of a press, it should be noted that there are known methods for directly determining the productivity of technological equipment using flow meters. However, the attempts of researchers to use these tools to measure the instantaneous value of the press performance turned out to be unsuccessful, since the low noise immunity did not allow estimating and taking into account the measurement error.

The productivity of the press- granulator can be estimated from the rotational speed G of the feeder. However, when stabilizing the current load J of the main drive electric motor of the press through the channel G - J, it is difficult to obtain reliable performance values under the conditions of existing disturbances.

With automatic control of the granulation process, the performance of the press can be determined by the number of weights (per unit time) of portion scales installed after the granule sifter in the production line. This method has certain advantages, since it allows you to indirectly assess the quality of the produced granules, since only a high-quality product without a fine fraction is sent for weighing, which is returned for re-granulation. However, the technological scheme of the granulation process can be built in such a way that the weighing of the finished product is carried out by one common scale installed for a group of presses. At the same time, the problem arises of determining the productivity of the press in other ways, for example, by the time of filling T_n of the cooling column between the cycles of the unloading device.

The task of the study is to confirm the assumption made about the possibility of measuring the productivity of the press in terms of time Tn, which is spent on filling the working chamber of the cooling column between the next cycles of the unloading device.

A positive solution to this problem depends on the degree of correlation between Tn and the rotational speed G of the press feeder, for which it is necessary to determine the correlation coefficient between these parameters. On the other hand, it is necessary to estimate the relative error in determining the productivity by filling time Tn to obtain the probabilistic characteristics (expectation, dispersion) of this process.

The proposed method for measuring productivity can be used in the development of a control system for the granulation process, the relative error does not exceed 10%. However, the practical application of this method is hampered by the need to determine the current value of the bulk density of granulated feed. In addition, when changing the unloading time of the cooling column (the cycle of operation of the unloading device), which is associated with technological features, it can become significantly more complicated, which will lead to difficulties or impossibility of determining it. In this case, it is proposed to determine the productivity by the number of cycles of operation of the unloading device of the cooling column for a certain fixed operating time of the press.

Conclusion

Thus, based on the foregoing, the following conclusion was drawn - the increment ΔTn of the cooling column filling time between the cycles of the unloading device, which characterizes the performance of the

granulator press, can be used to indirectly evaluate it and be used as an output indicator in the granulation process control system.

The search algorithm for the optimal granulation mode consists of two parts:

- step-by-step start algorithm (system output to the search area);

- search algorithm for the optimal granulation mode,

A feature of this algorithm is the fact that after the control system enters the search zone (regulated zone), after a time equal to the period of the switch, a trial step is made (the search begins). At the same time, it is not known exactly at what point of the static characteristic the system is located. After the end of the trial step, a time delay is provided corresponding to the time of the transient process in the object, and the values of Tn (memorized and steady) are compared. The analysis of the obtained increment ΔTn in this case allows you to determine the need for further execution of a trial step, if the increment value is greater than the value of the dead zone value, or to carry out a working step, i.e. change the position of the steam supply regulator in the direction of increase. Trial steps of the value set for each compound feed recipe are made by changing the position of the steam supply regulator only to decrease, working steps – only to increase. Taking into account the studies carried out, as well as on the basis of the SMART-INDIVIDUAL system, created using SMART technology by specialists of the Scientific and Production Complex "Elevator Equipment Plant" (ZEO), together with employees of the Department of Technological Equipment of Grain Production of the Odessa National Academy of Food Technologies ", it seems it is possible to apply the developed system to control the granulation lines of feed mills.

SMART self-control and reporting technology is an effective technology for setting and formulating goals is inextricably linked with the SCADA system [4] of supervisory control and data collection, which is designed to monitor and supervise a large number of remote objects or one geographically distributed object.

The tasks of SCADA systems include:

- automatic optimization of the operation of technological and transport equipment, including press granulators

- data exchange with USO (devices for communication with the object), that is, with industrial controllers and input - output boards) in real time through drivers;

- processing of information in real time;

- displaying information on the monitor screen in a form understandable to humans;

- maintenance of a real-time database with technological information.

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ОПТИМІЗАЦІЯ РОБОТИ ПРЕСА-ГРАНУЛЯТОРА В СИСТЕМІ SMART ТЕХНОЛОГІЙ

Анотація

Неодноразово перевірено і доведено, що гранульований комбікорм і гранульована манна крупа мають ряд переваг перед сипучими комбікормами, оскільки не відбувається самосортування компонентів, зменшуються втрати при транспортуванні та втрати поживних речовин при зберіганні. Ефективна дія таких комбікормів вища від сипучих кормів на 10-15 % за рахунок підвищення рівня санітарної якості та підвищення засвоюваності поживних речовин. Крім того, при грануляції в комбікорм можна вводити до 3...4% рідких компонентів проти 1...2% для сипучих комбікормів. В даний час спостерігається тенденція до збільшення частки виробництва гранульованих кормів. Технологія гранулювання корму дозволяє забезпечити стабільну однорідність, покращити санітарно-гігієнічні показники, підвищити харчову цінність, збільшити термін зберігання, мінімізувати втрати при його транспортуванні та розподілі. Все це впливає як на споживання комбікорму, так і на продуктивність вирощування тварин і птиці. При цьому основним обладнанням для виробництва гранул для комбікормів є пелетний прес. Завданням управління прес-гранулятором у складі технологій SMART є визначення та впровадження такого співвідношення витрати пари та вихідного продукту, при якому враховуються такі показники процесу гранулювання, як продуктивність, питома витрата пари та електроенергії, а також якісні властивості гранул відповідали б необхідним значенням. Згідно з найважливішою практичною рекомендацією щодо проведення технологічного процесу гранулювання, це забезпечення необхідних умов для кондиціонування парою, рідкими компонентами відповідно до властивостей вихідного продукту обробки. Водночас гідротермічна обробка комбікорму впливає практично на всі показники процесу гранулювання та якість його кінцевого продукту. Аналіз залежності продуктивності від витрати пари, отриманий для

різних рецептур комбікормів, дозволяє зробити висновок про можливість і доцільність пошуку оптимального положення регулюючого органу для подачі пари до змішувача прес-пеллет. При цьому необхідно, щоб продуктивність преса прагнула до максимуму в залежності від положення регулюючого органу подачі пари на прес, а також величини поточного навантаження двигуна головного приводу, що в основному визначає енергоємність процесу, була обмежена в заданому діапазоні значень при обнулінні відповідної рецептури комбікорму: Приріст часу заповнення колони охолодження між циклами розвантажувального пристрою, що характеризує продуктивність преса - гранулятора, може бути використаний для опосередкованої його оцінки та використаний як вихідний показник у системі керування процесом гранулювання. Алгоритм пошуку оптимального режиму грануляції складається з двох частин: алгоритму покрокового запуску (переведення системи в зону пошуку) та алгоритму пошуку оптимального режиму грануляції. Запропоновано використовувати систему SMART-INDIVIDUAL, яка оснащена модулем з регулюванням моніторингу параметрів обладнання за паспортними характеристиками. При цьому система веде архів і контролює терміни обслуговування.

Ключові слова: прес-гранулятор, продуктивність, стабілізація, оптимізація, алгоритм пошуку, технологія SMART.

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FORECASTING GRAIN CARGO HANDLING AT PORT ELEVATORS SOUTH-EASTERN REGION OF UKRAINE

Abstract

The results of a study of the state and possibilities of increasing the capacity of grain transshipment in the ports of Ukraine and substantiation based on the developed trend models of forecast volumes of grain cargo transshipment in Berdyansk and Mariupol seaports of the South-Eastern region of Ukraine until 2025 are presented. The studies established the characteristics of grain cargo flows in the seaports of Ukraine, the SWOT analysis revealed the strengths and weaknesses, advantages and threats of the Mariupol Sea Trade Port, developed trend forecast models for grain transshipment volumes in the ports of the South-Eastern region of Ukraine and substantiated the forecast volumes of transshipment grain cargo until 2025. A rather uneven loading of the Mariupol port during the year is shown. August and all summer months are especially critical, when both industrial and agricultural goods