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Ways to Improve Structures Gear Pelleting Presses

Natalia Boltyanska

Tavria State Agrotechnological University.
E-mail: bolt.n74@gmail.com

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Summary. In order to develop the design of a press granulator for processing biomass for pressed biofertilizer and fuel pellets, a scheme for separating gear pellet presses by the main features is presented, the main works of scientists devoted to the investigation of the operation of gear presses-granulators are analyzed, ways of increasing the productivity and reliability of press granulators with a ring matrix, reducing the energy intensity of the granulation process and labor-consuming maintenance of working bodies, controlling quality obtained pellets revealed a complex constructive and technological drawbacks and solved certain problems by improving the synthesis of the structural designs pellet presses. The requirements imposed on the construction of the restraining rings in the development of a press granulator with an end stop of the wedge-shaped space are formulated.

Key words: gear press granulator, construction, granulation, increased productivity, increased reliability, advantages, disadvantages.

INTRODUCTION

Now actively developing existing and developing new industrial areas, where the technology used pre-press granulation of powdered materials in pellet presses extrusion-type cylindrical working bodies. Experts reasonable opportunity granulation over 5000 various raw materials [1, 2].

In the field of agribusiness in pelleting presses perform processing ahrosyrovyny in the manufacture of granular animal feed and their individual components in the production of pellets of APC (such as straw, husks) and to obtain granular intermediate products to improve further process (such as granulation cake for crushers) [2, 3].

Pellet-presses are widely used as a tool for farmers to prepare feed and waste of agriculture. The main field of application – the production of granulated combined fodder. Animals, birds and fish eat well pelleted feed and gain weight faster than the conventional food system. By balancing the diet each granule contains the entire set of nutrients, vitamins and additives provided and laid in the bunker granulator. The exact proportions of ingredients control ensures maximum balanced diet, improve feeding and reduce the cost of animal feed consumption per unit of weight gain. Using pellet farmers are able to effectively use industrial waste through recycling and fertilizer on compressed pellets (pellets).

THE ANALYSIS OF RECENT RESEARCHES AND PUBLICATIONS

The widespread use for the production of fuel pellets industry are foreign press granulators. The main disadvantage of the design SKJ pellet production Zhangqiu Yulong Machine performance is low (up to 0.8 tonnes / hour) and the presence of two-step manual adjustment granulation unit. Largely devoid of these shortcomings granulator OGM 1.5 design that has single-system management and higher performance (up to 3 tons / hour). Construction AMANDUS pellet production KAHL Group has an automatic control system position of the roller relative to the matrix and productivity to 5 tons / hour. However, the said design requires a source of compressed fluid to the hydraulic drive control system, additional measurement and power tools, resulting in increased cost granulator almost 5 times against the OGM 1.5. In the modern classification of extruding mechanisms squeezing press release type presses with cylinder working bodies, which excludes slippage. This press presses Gear with internal toothing wheel-matrix and extruding wheel [5-8].

The study of gear pelleting presses devoted to scientific work [9-21] and other researchers. According to them the prospects of substantial interest and represent Gear pellet feed. However, despite the accumulated experience, the task of creating competitive structures for pelleting biomass to bio-compressed pellets and is still not resolved and requires further investigation.

OBJECTIVE

The aim of this work an analysis of gear pelleting presses to develop design pelleting presses for processing biomass and bio-compressed pellets.

THE MAIN RESULTS OF THE RESEARCH

Pellets have significant advantages over traditional fuels. So for their production consumes about 3% energy with oil during the production of these energy costs are

about 10% and electricity production - 60%, their calorific value varies from 4.5 to 5.0 kW / kg, 1.5 times more than conventional wood and coal. The combustion of 2000 kg of fuel pellets released as much heat energy as during combustion: 3200 kg of wood, 957 m3 of gas, 1,000 liters of diesel fuel, 1,370 liters of oil. Burning of wood pellets in the furnace boiler is more effective - the number of residues (ash) does not exceed the limits of 0.5 to 1.0% of the total fuel used. When burning pellets do not affect on the environment [8, 13].

However, the pressing granulation - is energy-intensive process, and improve its relevance is high enough. One of the feasible ways to improve the process of press granulation is to develop new and optimize existing structures pellet presses.

In Ukraine and abroad the most common matrix roller-press granulators with an active matrix and passive circular extruding rollers. However, over the last two decades the construction of extruding mechanisms while and reached a high technical level, but the structural characteristics have changed slightly. Gear presses marked separately, as they combine a continuous process of batch granulation material. The most detailed scheme of separation gear pelleting presses on the main characteristics is given in known works [9]. They proposed division presses:

- the method of forming granules - those that form and those squeezed,

- about the method of working - the press wheels that combine the functions of granulation material and the transfer of torque, and the press with separate wheels rotation function of parallel transmission,

- by way of meshing gears into two types - internal and external gears.

- the type of impact tooth wheels granulating the material - the press plunger and blade types. Gears of blade impact on food upresovuyut it bokovoyu zyba surface, and with a plunger - head zyba.

- extruding wheels on location - at the press of a vertical or horizontal layout of the job.

Gear processing presses perform a wide variety of raw materials, while many of them no opportunity to regulate pressing channel through which energy in such devices is too high.

In the briquetting plant materials YA Simakin [10] first used toothed kolesa. Simultaneously pressing toothed wheels transmit torque media (Fig. 1).

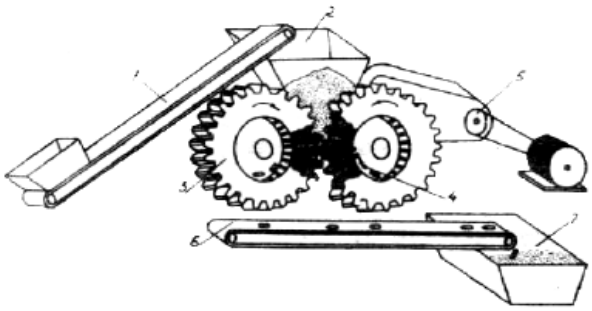

Fig. 1. Scheme of laboratory and industrial settings: 1 and 6 - the loading and unloading conveyor belt, 2 - hopper, 3 - pressing gears, 4 - than oblamuvalnyy, 5 - drive press, 7 - capacity drive.

They obtained density dependence material extruded from the extruding wheel turning angle that is:

$$\rho = \gamma \frac{r_e^2\left(\frac{\pi}{2z} + \sin\alpha_e - inv\alpha\right) - \frac{r_0^2}{3}(\alpha_e + inv\alpha_e) - r_0^2\left[\begin{matrix}\frac{\pi}{z}\varphi^2 - \frac{2\pi}{z}\left(\mathrm{tg}\,\alpha - \frac{\pi}{z}\right)\varphi + \\ + \frac{\pi}{z}\left(1 + 2tg^2\alpha - \frac{2\pi}{z}\mathrm{tg}\,\alpha + \frac{4\pi^2}{3z^2}\right) - \frac{1}{3}tg^3\alpha_e\end{matrix}\right] - r_з^2\left(\frac{\pi}{2z} - inv\alpha\right)}{-r_e^2\left(\frac{\pi}{2z} + inv\alpha - inv\alpha_e\right) - z_з^2\left(\frac{\pi}{2z} - inv\alpha\right)}$$

where: γ - bulk weight of feed, kg / m^3,

Re, r0, Rz- the radii of circles under the upper teeth, the main event and teeth Depression wheels, m,

z - the number of teeth wheels,

a - angle gearing gears, rad,

α - the angle of the radius vector of a top involute tooth wheels, boards,

φ - angle gears, rad.

Efforts compression varies according to his data space changes cavities between teeth:

$$q_{см} = \gamma \frac{k_0 \gamma S_b}{\rho_k\left(S_{зп} - \frac{\gamma}{\rho_к} S_b\right)}$$

where Sb and Szp - the original and current cross-sectional area depressions m^2.

Throughput of the toothed granulator offered them determined by the formula:

$$\varphi = \mathrm{Bz}\omega\gamma K_з K_б \frac{1}{\pi}\left[r_e^2\left(\frac{\pi}{2z} + inv\,\alpha_e - inv\alpha\right) - \frac{r_0^2}{3}(\alpha_e - inv\alpha_e)^2 - r_0^2\left(\frac{\pi}{2z} - inv\alpha\right)\right]$$

where B - width, m,

ω - angular speed gears, s^{-1},

KZ - filling factor basins,

KB - briquetting ratio (the proportion of the finished granules of mass submitted feed).

It is also known expression for determining the length of the pressing holes:

$$L_0 = \frac{S_b}{Uf\delta}$$

where S_0 - cross-sectional area, m^2,

U - perimeter section, m,

f - coefficient of friction,

δ - coefficient of lateral pressure.

Studies Y.A. Simakina new layout used in the hollows filyer - strictly radial elongated opening round, which increases the living section. Scalloped crown extruding wheel was standard involute, displacement profile rails had been made. At the press of equal gears used. Defined pattern of change of specific energy granulator feed extruding the speed of rotation of the wheels, gearing module and number of teeth. According to the research Y.A. Simakina use of such media reduces power consumption pressing alfalfa by 30%.

Some interest in the analysis of presses and work represents [12] devoted to the same gear granulator. It considered the production of feed pellets from a mixture of drugs and crushed grain. For the first time [12] identified the pressing stage: linear compression compression teeth and feed in mizhzubovomu space matrices. The author

noted the phenomenon of expansion squeeze portions of the material in the channel extrusion at the exit of the channel pressing.

They got the mathematical model studied pressing the feed mixture by varying gears tooth module within 8...16 mm, humidity 13...21% and the number of turns gears 20...40 min^{-1}:

E = 30.79321 + + 1,57431t 0,6p -575,379 Q +
+17,95875tQ -6,4125pQ 4863,2Q^2

where E - energy pressing kW / kg,

m - module teeth mm,

n - speed impellers, min^{-1},

Q - supply mix, kg / s.

Behind it is the optimal ratio parameters: speed extruding wheel 29.05...31.45 min^{-1} module 16 mm and podacha material 0.0969...0.1053 kg / s.

Ladygin proposed and dependence to determine the moment of resistance to rotation of the studied newspapers:

$$M_c = \frac{aBД^2\varphi P_0 f}{4e^{2a\rho_0}} e^{2a\rho_0\lambda}$$

where B - width of the wheel, m,

A Ro - permanent,

D - wheel diameter, m,

φ - angle, rad,

f - coefficient of friction,

λ - compression,

ρ_o - density (bulk density) feed mixture, kg / m^3.

It should be noted that most known studies gear pelleting presses dedicated to traditional gear involute gears.

Work [11] is also devoted to the study of the process feed pelleting press gear, preparing granules of feed mixtures of grain crops. They obtained regression mathematical model compression feed in the form of equations to determine the ratio (proportion):

Wud = 122,2323 - 3,69221 - 0,2824l -0,2183T -
0.6902B - (53,71il - 64,12iT + 38,46Bi -
- 13,44lT + 12,70lB - 18,75TB -853,6i2 –
-12,11B^2) 10^{-4}

pellets:

K = 18,18 - 0,6169i - 0,0438l -0,0174T -0,3259B -
0,0175Bi + 0,019i^2 + 9,637 · $10^{-4}B^2$

where B - damp mixture,

l - the length of the particles of the material,

T - temperature,

i - mass fraction feed.

The dependences can determine the degree of wetting of the feedstock to reduce its compression work. According to him the use of curved pressing cameras accelerates relaxation of tensions in the compressed material and can increase press capacity Gear 32...36%.

The resulting temperatyri it at 70 °C, humidity feedstock 19...21% of the length of the feed particles 0.5...0.7 cm mass, maximum recipe, feed particles, granules answered established standards of quality indicators.

Analysis [11] on the study of the process feed material Gear compression pressure of blade impact on Forage mixture showed that it is possible to improve performance by increasing the density in the cavity feed and the total volume of the depressions. It is necessary to use a maximum module output of positive displacement profile of the teeth and the maximum height zyba.

Increased media specific bandwidth 20...23% of the gears with a combination of AF functions Zorin explains the increase in weight of the material supplied to the channel matrix, improved design ring gear and moving trajectory zyba in depression. For gears with a solitary function of increasing bandwidth received them within 35...45%.

He recommends working press with the following parameters: diameter gear by separating circumference of 0.45...0.48 m, tooth module 15...16 mm, engagement angle of 15 °, tooth head height - the maximum, offset output profile teeth 0.25, Matrix channel at an angle 21 °, speed matrix 26.8 min-1 at rozkroshuvanosti pellets to 20%. These options provide the energy matrix gear compression material is not more than 36 kJ / kg, and it was virtually unchanged investigated for their constructive options kolis gear.

The study [14] developed the technology and reasonable parameters press for making zhyrozbahachenyh granules. Made rationale of geometry and kinematics of working presses, providing a reduction in energy intensity of the process and increasing the share performance gear granulator.

Z.V. Matveykina showed the possibility of granules below the compressive strength of 1.6...2.0 MPa and a density of 1000 ... 1100 kg / m^3 at an acceptable level rozkroshuvanosti. Apparent specific feed mixture gears for optimal her data with a combination of the following: zyba module (involute) 0,013 m, the angle of engagement of 10 °, the displacement factor profile rails in the range of 0.14 ... 0.18. The coefficient of head height of about 0.5 zyba recommended.

However, the granulation of them has some significant features that are not tested, and are press-presses not commercially produced.

To improve performance pelleting presses, reducing the energy intensity of the process, increase the durability of workers and improve the quality of the finished product [15] developed a design pelleting presses, which prevents the extruding roller slippage on the contact surface of the matrix, while maintaining the advantages of mechanical limitations wedge-shaped space.

In this construction to the faceplate and tapered device also attached removable limiting ring, but they are in the form of ring gear with internal teeth, and each extruding roller mounted on a carrier rotatably fixed on its axis from the ends equipped tightly connected with it replaceable cylindrical gears. Thus limiting ring gears and cylindrical form internal gear meshing, providing kinematic rigid connection between the matrix and extruding rollers press granulator.

The challenge to improve the performance and reliability of pellet presses the ring matrix, reduce energy granulation process and the complexity of maintenance work, ensuring quality regulation obtained granules are solved mainly by:

• optimization of the number (for extruding rollers) and the geometric dimensions of working extruding mechanism,

• optimize the design of the ring matrix (preferably fil'-yer parameter optimization),

• Improving embodiment of the irregularities on the surface of the cylindrical shell compressed video,

• improving the design of the carrier extruding rollers,

• optimization devices, providing alignment layer material by extruding rollers,

• development of regulating the minimum height of the layer of extruded material (minimum gap) between the extruding rollers and ring matrix and power loads on the working bodies pressed mechanism,

• improving the system of fixing the ring to the faceplate matrix pellet presses.

Morphological analysis of structures, analysis of parametric synthesis of existing and newly designed pellet presses with the ring matrix, and analysis of experimental results workflow they can detect complex design and technological shortcomings and solve some problem of structural synthesis to improve the structures considered pellet presses.

Thus, one of the significant shortcomings in the workflow pellet presses with a ring matrix is lateral extrusion pressed material (material moving in the direction of working ends and squeezing it out of the contact area), which is due to the fact that the contact surface of the matrix and each unclosed extruding rollers to form wedge-shaped space. As the analysis of stress-strain state extruded material in the wedge-shaped space, lateral extrusion is particularly pronounced in the area behind and less intensively - in the area of extrusion in fil'-yery matrix. However, the theory and method of calculation pellet presses with lateral extrusion matrix ring not included.

As a result of significantly reduced side extrusion performance pelleting presses. Some material squeezed out of the work area comes to re-compression, which increases energy consumption for granulation. After extrusion side there is uneven distribution of contact stresses across the width of the work, which is the cause of worsening conditions in the flow of extruded material zone lagging performance in different extreme and central fil'yerah matrix, uneven quality beads in them and uneven wear across the width of the operating matrix and shells extruding rollers.

The process of pressing without lateral extrusion is possible only in conditions when working contact surfaces of pelleting presses form a loop cross-sectional layer of the product. This can be achieved by creating face contact surfaces that can realize a wedge-shaped space plane strain state scheme extruded material.

To this the design was pelleting presses in which to chuck and tapered device for supplying raw attached removable rings that restrict end surface layer of extruded material. The side surface of the restrictive ring facing the ends of extruding rollers in contact with the product formed from the inner surface of the cylindrical cavity ring matrix of input into her extruding rollers [15].

In developing pelleting presses with a face wedge-shaped space constraint formulated requirements that apply to restrictive design of rings:

• restrictive ring should not be associated with a matrix pellet presses,

• should be possible to change the height restricting face contact surfaces rings of the same matrix (through rapid replacement rings),

• should be possible to regulate the gap between the lateral surfaces limiting rings and ends extruding rollers,

• should be possible to change the resistance of extrusion material through the aforementioned gap by regulating the magnitude or optimize its forms (contact surface rings restrictive vertical, inclined, and cycloid etc.).

• restrictive ring contact surfaces should be rough or have non-through perforation,

• the device should not impede the operation of the press granulator.

It is also important to note that the pellet presses equipped restrictive ring becomes more important use of automatic adjustment of the minimum gap between the extruding rollers and ring matrix.

As a result of the mechanical limitations wedge-shaped space with additional contact surfaces in the form of variable restrictive rings provided:

• increase productivity pelleting presses by complete or partial prevention of lateral extrusion process at constant work,

• increase productivity pelleting presses in terms of plane deformation of the pressed material by increasing the length of the district area of its contact with the working bodies, creating optimal conditions for its entry into the area behind and expanding the boundaries of the zone in fil'yery extrusion matrix with the same resistance filyer,

• reducing the energy press granulation process by eliminating the energy to re-compression of the material that is squeezed out of the working area in the press granulator unclosed wedge space,

• increase the longevity of the work, alignment and performance in extreme fil'yerah central matrix and mechanical quality pellets in them by the alignment diagram contact stresses across the width of the ring matrix and shells extruding rollers, and because of the alignment layer extruded material before extruding rollers.

Another significant disadvantage of pellet presses with a ring matrix is the possibility of slippage extruding rollers on the contact surface of the matrix (operates in slipping), due to friction transfer rotation from passive active matrix extruding rollers through a layer of extruded material [15].

Slippage suggests that the actual angular velocity extruding roller is less than its theoretical angular velocity.

Slip phenomenon contributes to the accumulation of extruded material before extruding rollers, roller prevents the formation of stable raw material granulated area at the entrance to the backlog, resulting in reduced productivity pelleting presses. Granulation process in this case is characterized by an additional grinding of raw material (which is determined in accordance with the requirements of the degree of grinding technology) and high dilatansii extruded material. As a result of increased energy consumption for granulation, reduced homogeneity of structural and mechanical properties of raw materials, deteriorating quality indicators granules. Slippage of work is intense and uneven wear of contact surfaces.

Biomass granulation process is continuous rheological system that provides for the partial restoration of the shape and size of the material after unloading. During intensive compaction of 30-40 MPa channel matrix in a process of internal friction and diffusion dry particle size between 1-5 mm, due to the temperature of 90-100 °C, and lignin contained in the biomass is softened, glues dense particles in cylindrical products and promotes the formation of a protective film on the surface of granules [1-6]. For the

production of fuel pellets should ensure such regime parameters: pressure, temperature, flow of water and steam. However, the press presses often receives raw ingredients that are different physical origin, fractional composition, humidity, etc. So, thorough implementation processes is the key to taking advantage of further development and production of biofuel pellets. Our analysis gear pelleting presses and experimental data allow to conclude that the Gear pelleting presses have certain shortcomings when dealing with biomass and are not useful for making fuel pellets from biomass and further studies should be conducted on a matrix pellet presses.

CONCLUSIONS

1. As a result of studies to develop design pelleting presses for processing biomass compressed fertilizer and pellets, analyzes the main work of scientists dedicated to the study of gear pelleting presses, identified ways to improve the performance and reliability of pellet presses with the ring matrix, reducing the energy intensity of the process of granulating and labor service working bodies, ensuring quality regulation granules obtained revealed a complex design and technological shortcomings and whirlpool Chenault specific tasks to improve the synthesis of structural designs pellet presses. The requirements that apply to restrictive design of rings, the development pelleting presses with a face restriction wedge-shaped space.

2. Analysis of gear pelleting presses and experimental data allow to conclude that the Gear pelleting presses have certain shortcomings when dealing with biomass and are not useful for making fuel pellets from biomass and further studies should be conducted on a matrix pellet presses.

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ПУТИ УСОВЕРШЕНСТОВАНИЯ КОНСТРУКЦИИ ШЕСТЕРЕНЧАСТЫХ ПРЕСС-ГРАНУЛЯТОРОВ

Аннотация. С целью разработки конструкции пресс-гранулятора для переработки биомассы на прессованное биоудобрение и топливные гранулы, предоставлена схема разделения шестеренных прессов-грануляторов по основным признакам, проанализированы основные труды ученых, посвященные исследованию работы шестеренных прессов-грануляторов, определены пути повышения производительности и надежности пресс-грануляторов с кольцевой матрицей, снижения энергоемкости процесса гранулирования и трудоемкости обслуживания рабочих органов, обеспечения возможности регулирования качества получаемых гранул, выявлен комплекс конструктивных и технологических недостатков и решены отдельные задачи структурного синтеза по совершенствованию конструкций пресс-грануляторов. Сформулированы требования, предъявляемые к конструкции ограничительных колец при разработке пресс-гранулятора с торцевым ограничением клиновидного пространства.

Ключевые слова: шестеренный пресс-гранулятор, конструкция, гранулирование, повышение производительности, повышение надежности, преимущества, недостатки.