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SELECTED PROBLEMS IN CONSTRUCTION OF GRANULATORS FOR PLANT MATERIALS. PART I

Summary

The paper presents an analysis of structural solutions for plant materials granulator working systems. For the considerations, the criterion of material uniform dosing and its distribution on the surface of the matrix in the granulator working system was adopted. The analysis shows that the working system "flat fixed die–rotating set of compacting rolls" and "annular rotary die–immovable set of compacting rolls" is the best solution ensuring the distribution of compacted material on the working surface of the die. This results in a stable load of the granulator drive system, including increased bearing life and reduced tribological wear of the die and compacting rolls. An innovative solution of the material dosing system was also presented.
***Key words**: plant materials granulator, flat fixed die, rotating set of compacting rolls, annular rotary die, immovable set of compacting rolls*

WYBRANE PROBLEMY W KONSTRUKCJI GRANULATORÓW DO MATERIAŁÓW ROŚLINNYCH. CZĘŚĆ I

Streszczenie

W pracy przedstawiono analizę rozwiązań konstrukcyjnych układów roboczych granulatorów do materiałów roślinnych. Do rozważań przyjęto kryterium równomiernego dozowania materiału i jego rozmieszczenia na powierzchni matrycy w układzie roboczym granulatora. Analiza wskazuje, że układ roboczy „płaska nieruchoma matryca–obrotowy zespół rolek zagęszczających" oraz „pierścieniowa obrotowa matryca–nieruchomy zespół rolek zagęszczających" jest najlepszym rozwiązaniem zapewniającym równomierny rozkład zagęszczanego materiału na powierzchni roboczej matrycy. Skutkuje to stabilnym obciążeniem układu napędowego granulatora, w tym zwiększa żywotność łożysk oraz zmniejsza tribologiczne zużycie matrycy i rolek zagęszczających. Przedstawiono także nowatorskie rozwiązanie układu dozującego materiał.
***Słowa kluczowe**: granulator do materiałów roślinnych, płaska nieruchoma matryca, obrotowy zespół rolek zagęszczających, pierścieniowa obrotowa matryca, nieruchomy zespół rolek zagęszczających*

1. Introduction

Pressure agglomeration (granulation – pelleting, briquetting) of plant materials is widely used in the production of industrial fodder and ecological solid fuels from waste materials.

Both, the process and the design of granulating (pelleting) and briquetting machines are characterized by the complexity and diversity of existing issues and process-apparatus problems [1, 2, 3, 4, 5]. The difficulty is also in the variability of physical, chemical and biological properties of materials subject to granulation (briquetting).

Scientific and research works, initiated by the author (forty years ago) at the Department of Food Machinery and Equipment and implemented currently at the Department of Agri-Food Engineering and Environmental Management (at the Faculty of Civil and Environmental Engineering, Białystok University of Technology) are based on the assumption: *implementation of universal plant equipment for granulating and briquetting plant materials with low production yield, applicable in medium and large farms as well as small and medium plants processing plant materials, popularize the granulation and briquetting technology in the area of industrial feed production and production of ecological solid fuels (from waste materials).*

2. Aim of the study

The aim of the research is to analyze the structural problems in plant materials granulators for small and medium production plants. For the considerations, the criterion of material uniform dosing and its distribution on the surface of the matrix in the granulator working system was adopted.

3. Analysis of selected granulator working systems

Diagrams of possible granulator operating systems are shown in Figures 1, 2, 3, and 4 [1, 2, 4]

The roll arrangement shown in Fig. 2 d, e, f eliminates roller slides relative to the die.

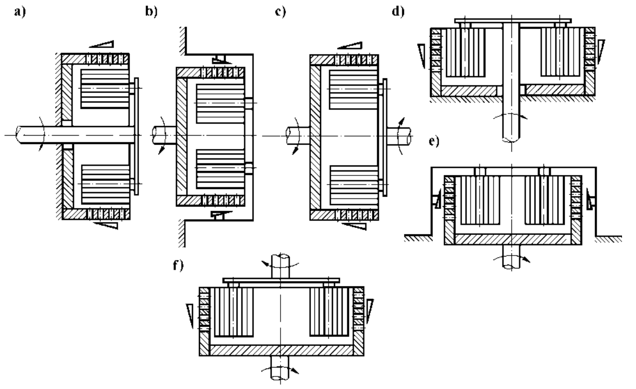

Fig. 1. Diagrams of the "annular matrix – compacting rolls" working system: a) driven roller – fixed vertical matrix system, b) driven vertical die – fixed roller system, c) driven vertical die – driven roller system, d) stationary horizontal die – driven roller system, e) driven horizontal array – stationary roller system, f) driven horizontal matrix – driven roller system [1, 2]

Rys. 1. Schemat układu roboczego "pierścieniowa matryca – rolki zagęszczające": a) napędzany układ rolek – nieruchoma pionowa matryca, b) napędzana pionowa matryca – nieruchomy układ rolek, c) napędzana pionowa matryca – napędzany układ rolek, d) nieruchoma pozioma matryca – napędzany układ rolek, e) napędzana pozioma matryca – nieruchomy układ rolek, f) napędzana pozioma matryca – napędzany układ rolek [1, 2]

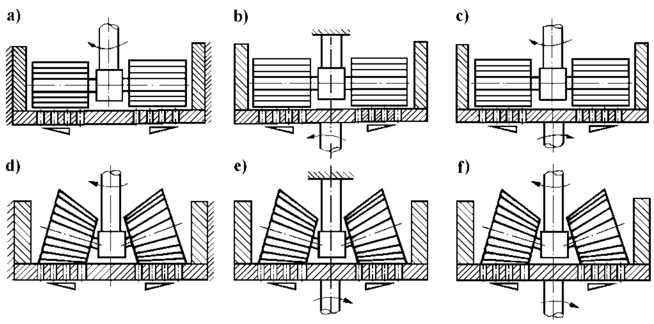

Fig. 2. Diagrams of the "flat die – compacting rolls" working system: a, d) driven roller – stationary matrix system, b, e) driven matrix – fixed roller system, c, f) driven die – driven roller system [1, 2]

Rys. 2. Schemat układu roboczego "płaska matryca – rolki zagęszczające": a, d) napędzany układ rolek – nieruchoma matryca, b, e) napędzana matryca – nieruchomy układ rolek, c, f) napędzana matryca – napędzany układ rolek [1, 2]

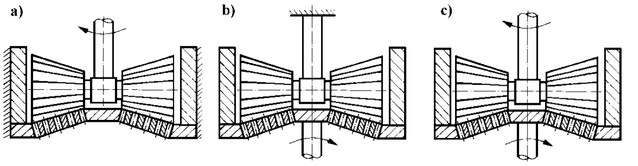

Fig. 3. Diagrams of the "conical matrix – compacting roller" working system: a) driven roller – stationary die system, b) driven die – stationary roller system, c) driven die – driven roller system [1, 2]

Rys. 3. Schemat układu roboczego "stożkowa matryca – rolki zagęszczające": a) napędzany układ rolek – nieruchoma matryca, b) napędzana matryca – nieruchomy układ rolek, c) napędzana matryca–napędzany układ rolek [1, 2]

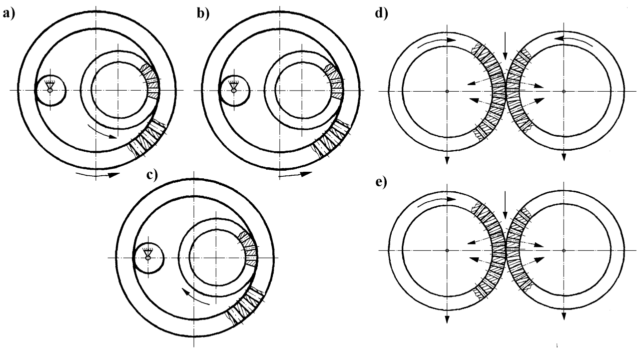

Fig. 4. Diagrams of the "annular die – roll (matrix)" operating system: a, d) driven die – driven roll (matrix), b, e) driven die – passive roll (matrix), c) passive matrix – driven roll (matrix) [1, 2]

Rys. 4. Schemat układu roboczego "pierścieniowa matryca – pierścieniowa rolka (matryca)": a, d) napędzana matryca – napędzana rolka (matryca), b, e) napędzana matryca – pasywna rolka (matryca), c) pasywna matryca – napędzana rolka (matryca) [1, 2]

The granulation mechanism is shown in Fig. 5.

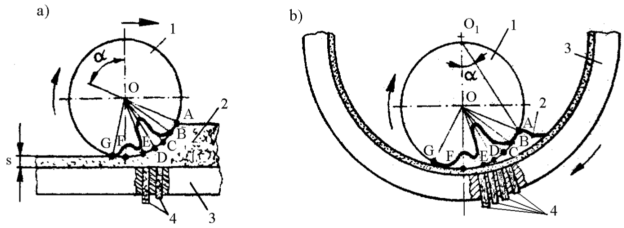

Fig. 5. Working system: a) "flat die – compacting roller", b) "annular matrix – compacting rolls", l - compacting roller, 2 - material, 3 - matrix, 4 - granules [1, 2]

Rys. 5. System roboczy: a) „płaska matryca–rolki zagęszczające", b) „pierścieniowa matryca – rolki zagęszczające", 1 - rolka zagęszczająca, 2 - materiał, 3 - matryca, 4 - granulat [1, 2]

On the AB section, under the effect of compacting pressures, the material particles approach each other, their surface of mutual contact increases and the air contained in the spaces between them is squeezed out.

On BC, the compaction pressure increases and the density of the material increases. The CD cut-out represents the phase in which intensive increase of thickening pressures and further increase of density occurs. At maximum compaction pressures, the material is forced through the holes in the die while the formed granulate is pressed in the holes, which causes a decrease in thickening pressures (DE). The slight increase in compaction pressures on the EF section is the result of pressing the compacted material located on the surface between the holes to the die holes. On the FG section there is a phase of compacted material layer expansion, and then the contact between the roller and the compacted material disappears.

As a result of analysis of working systems possible solutions, as well as the offers of industrial granulators, it can be concluded that:

1. From the group of solutions presented in Fig. 1 it is technically justified the solve b, and possible d, e. The rotating die (solution b) causes that the material is located on its inner surface under the influence of centrifugal forces. The additional scraper element used ensures an even distri-

bution of material on the die. Even distribution of material on the die working surface ensures a stable load on the granulator working and driving system (including the engine). The use of dosing (e.g. dosing screw) along the axis of rotation of the matrix improves the distribution of material in the working system by regularly supplying it in densification zones between the roller and the die, which also reduces the fluctuations in the dynamic loads of the drive motor. This is particularly important because high dynamic loads occurring in the working system are among others the reason for its short durability, at the same time high production costs. In addition, the die performs partly as a flywheel, partly reducing the step changes in the work system loads. This system is commonly used in granules of medium and high yields. Solution 1 d, e does not ensure uniform material distribution on the die working surface, because the material under the influence of gravity focuses in the lower part.

2. From the group of solutions presented in Fig. 2 it is technically justified to solve a, b, d, e and possible c, f. In solutions a, b there are slides between the roller and the die. Solution d, e, due to the conical shape of the rollers, significantly counteracts this kind of slip. Solutions c, f would require double motors and quite complicated drive units. Solutions a, d, provide stable fastening of the die, thus partially reducing the variables, under the influence of high dynamic loads, vibrations. Analyzing the shape of the rollers, it can be assumed that due to the placement of heavily loaded conical or spherical roller bearings, their cylindrical shape is more preferable. As in the solutions shown in Fig. 1, an important element is to ensure even distribution of material on the die working surface.

An example may be the solution for case "a" shown in Fig. 6 and Fig. 7 [6].

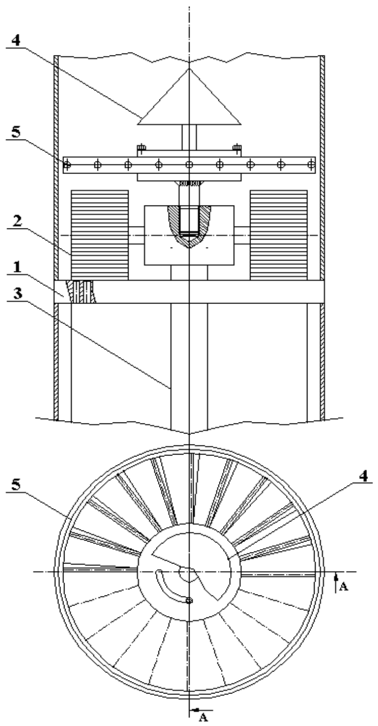

Fig. 6. Scheme of the dosing system – material distributor in the granulator working system: 1 - matrix, 2 - compaction rolls, 3 - drive shaft, 4 - dosing cone, 5 - material separator [6]

Rys. 6. Schemat układu dozowania – rozdzielacz materiału w układzie roboczym granulatora. 1 - matryca, 2 - rolki zagęszczające, 3 - wał napędowy, 4 - stożek dozujący, 5 - rozdzielacz materiału [6]

The essence of the constructional solution lies in the use of adjustable blinds, which ensure uniformity of the material stream getting under the compacting rolls 2. Adjustable opening of the louvre blades also allows adjusting the device's efficiency to the rated power of the drive motor (depending on the characteristics of the material used, e.g. physico-chemical-biological properties). The material falling from the dosing cone 4 (Fig. 6) goes to the arrangement of the louvre blades 5 with their inclination angle adjustment, which allows a certain change in the amount of material to be placed under the compacting rolls. The material dispensing system is attached to the drive shaft 3. Material distributor view is presented (various settings) in Fig. 7.

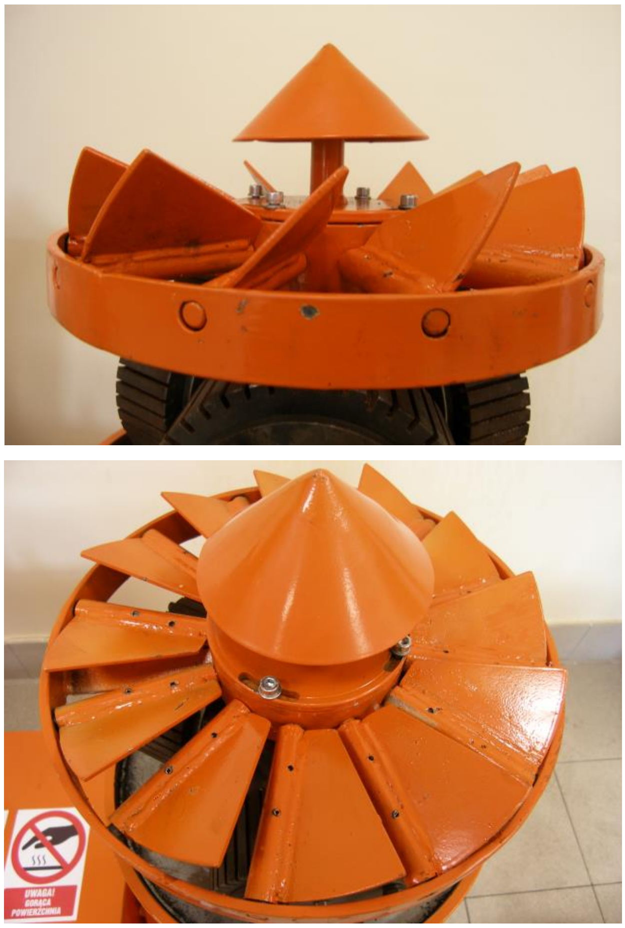

Fig. 7. View of the dosing system – separator (exemplary blind settings) [6]

Rys. 7. Widok układu dozującego – rozdzielacz (przykładowe ustawienia żaluzji) [6]

3. The working systems shown in Fig. 3, due to technological difficulties and matrix manufacturing costs, have no technical justification.

4. The working systems shown in Fig. 4, due to the unbalanced high stresses of the die as well as small angles of material rapture between the roller and the die, have no technical justification.

4. Summary

For the considerations, the criterion of material uniform dosing and its distribution on the surface of the matrix in the granulator working system was adopted. The above analysis of structural solutions of working systems indicates that the solutions presented in Fig. 1b, 2a ensure even distribution of compacted material on the die working surface. Even distribution of the material causes that in the "wedge" A-G (Fig. 5) the course of compaction pressures between the roller and the die is cyclically uniform at the circumference of the roller and the die working surface. This results in a stable load on the granulator drive system, which ensures a longer service life of the bearings and reduces the tribological wear of the die and the compacting rolls.

An innovative solution is represented by the material distributor shown in figures 6 and 7.

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