

The constructions of the pelletizer matrix with the working system "the flat matrix – densification rolls"

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Introduction

Granulating (pelleting) and briquetting are forms of pressure agglomeration of a process during which loose material gets a certain solid geometric shape, as a result of the operating external and internal forces. The products obtained during the pressure agglomeration may have different forms, depending on the requirements of a process. The most common products of the granulation (pelleting) process are granules (pellets) in a cylindrical shape with a diameter ranging from 2.0-2.5 mm to 10-12 mm, whereas the products of the briquetting process have cylindrical shapes (cuboid) with a diameter of 12-30 mm or 40-70 mm. The processes have wide applications in feed industry, chemical industry, pharmaceutical industry and production of ecological solid fuel from vegetable material waste, among others.

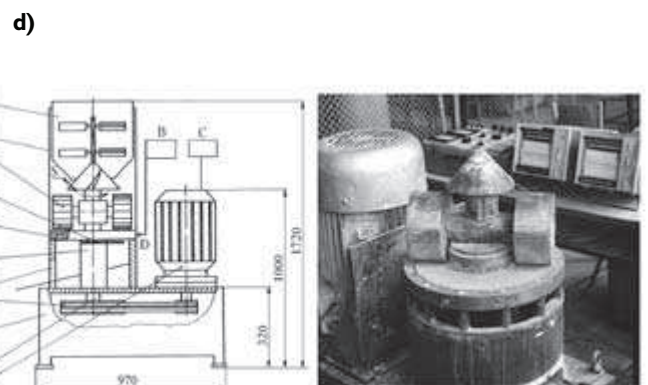
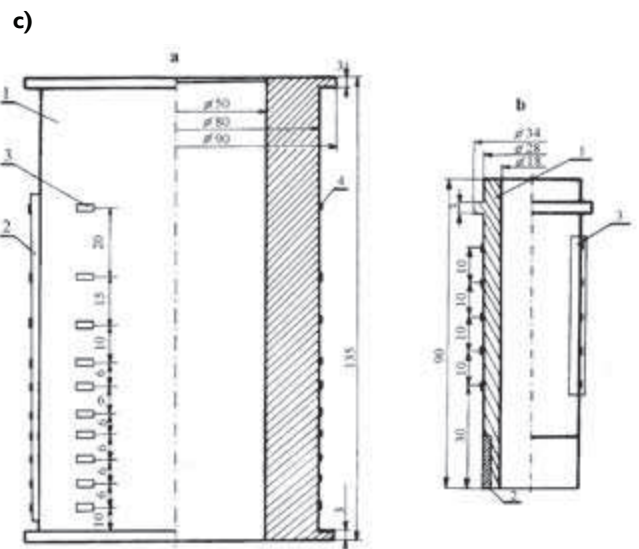
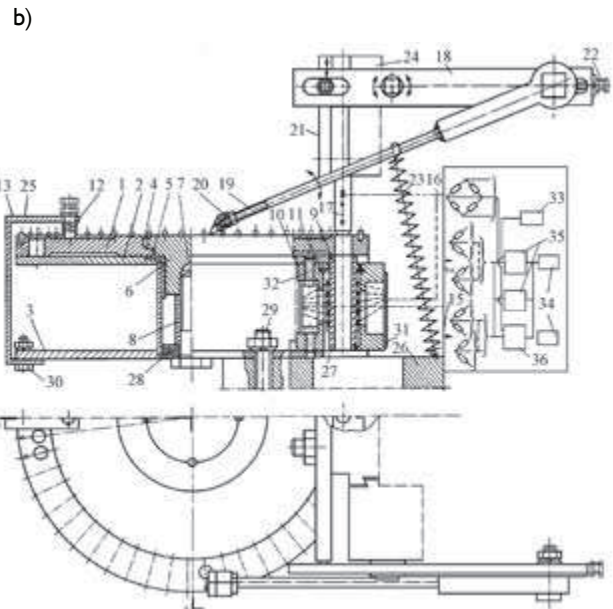
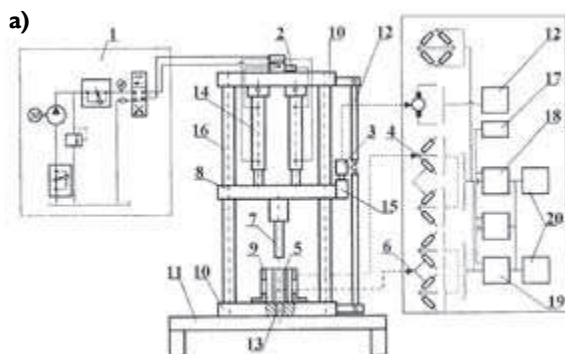
Granulating vegetable material

The authors of this article, have been conducting research on densification of vegetable material for many years, and believe that:

- Universal granulating and briquetting devices for vegetable material with low productivity; they have many applications in small and medium-size plants processing vegetable material, in the areas of feed manufacturing, and producing ecological solid fuel (from waste)
- devices equipped with a "flat, fixed, exchangeable die - densification rolls" working system; they may act as universal granulating and pelleting devices.

Energy consumption, during the granulation process of vegetable material, depends on their physical, chemical, and biological properties, as well as the parameters of the apparatus, and process parameters of the process completion [1, 4, 5].

Research conducted on the energy consumption of granulation process, using research posts presented in Figure 1, showed that the unitary energy consumption during the granulation process of vegetable material in model and laboratory setting (Fig. 1a, 1b, 1c) is within the range of 15 - 30 kJ/kg. On the other hand, research conducted on the unitary energy consumption of the granulation process in a "flat die - densification rolls" working system (Fig. 1d, 1e) yielded values of unitary energy consumption from approximately 115 to 600 kJ/kg. The reason for such great values of energy consumption, in technical conditions of the completion of the process, is high resistance during thickening and forcing the densified material through (with pressing-densification thrust - approx. 80-150 MPa) both on the surface of the die, and on the surface of the densification roll.



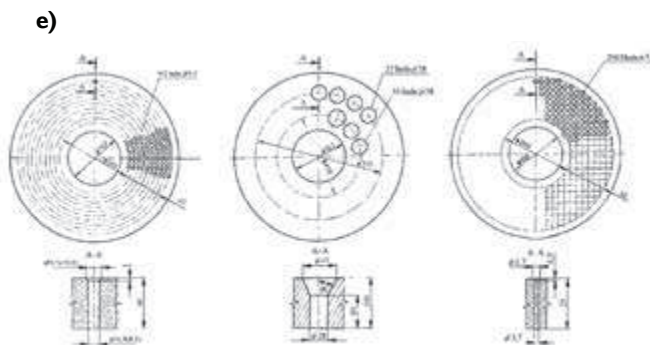


Fig 1. a) the schema of the stand SB-1 to the continuous measurement of physical parameters during the pressure agglomeration **b)** the schema of the stand SB-2 to the continuous measurement of physical parameters during the pressure agglomeration (without the driving gear), **c)** the densification muff (SB1, SB2), **d)** the schema of the investigative stand SB-3: **A** - universal pelleting-briquetting device, **B** - the temperature record- keeper, **C** - the power record- keeper, **D** - thermocouple **e)** the schema of the example aggregate of the pelleting-briquetting matrix (SB-3)

A detailed description of the research posts presented in Figure 1 is available in the monograph [1].

Some of the basic parameters of the dies are as follows:

- the clearance coefficient of the die - the ratio between the surface of the holes and the working surface of the die
- the diameter and the length of the holes of the die. The ratio of these values may vary from 0.1 to 0.5 (depending on the material properties of the raw material that is subjected to the pressure agglomeration process, and on the quality requirements for the product obtained)
- the geometry of the entrance to the holes of the die.

The results of research on the impact of the above mentioned parameters on the density of the final product may be described as follows:

a die with a diameter of the holes $\phi=6.5$

The results of research on the impact of the above mentioned parameters on the density of the final product (granulated product with a diameter of 6.5mm, feed mixture T2), and the unitary energy consumption of the process, showed that changing the clearance coefficient of a die from 0.31 to 0.45 caused a decrease in density by about 128kg/m³ (i.e. approximately 11%), and a decrease in the unitary energy consumption by about 0.014 kWh/kg (i.e. approximately 24%). On the other hand, increasing the length of the hole from 35mm to 40mm caused an increase in density of the granulated product by approximately 54kg/m³ (i.e. about 5%) and an increase in the unitary energy consumption by approximately 0.007 kWh/kg (i.e. about 11%).

The conical entrance to the hole (where the angle between the generating line and the surface of the die equals 30°), compared to a hole without bevelling, increased the density of the product by approximately 42kg/m³ (i.e. about 4%) and the unitary energy consumption by approximately 0.004 kWh/kg (i.e. about 7%).

a die with a diameter of the holes $\phi=8.5$

The results of research on the impact of the above mentioned parameters on the density of the final product (granulated product with a diameter of 8.5mm, feed mixture T2), and the unitary energy consumption of the process, showed that changing the clearance coefficient from 0.45 to 0.54 caused a decrease in density by about 71kg/m³ (i.e. approximately 6%), and a decrease in the unitary energy consumption by about 0.0059 kWh/kg (i.e. approximately 10%). On the other hand, increasing the length of the hole from 35mm to 40mm caused an increase

in density of the granulated product by approximately 49kg/m³ (i.e. about 4%) and an increase in the unitary energy consumption by approximately 0.0035 kWh/kg (i.e. about 6%).

The conical entrance to the holes (where the angle between the generating line and the surface of the die equals 30°), compared to a hole without bevelling, increased the density of the product by approximately 23kg/m³ (i.e. about 2%) and the unitary energy consumption by approximately 0.002 kWh/kg (i.e. about 6%).

a die with a diameter of the holes $\phi=28$ mm

The results of research on the impact of the above mentioned parameters on the density of the final product (briquettes with a diameter of 28mm with a 45% part of straw), and the unitary energy consumption of the process, showed that changing the clearance coefficient from 0.245 to 0.305 caused a decrease in density by about 21kg/m³ (i.e. approximately 2%), and a decrease in the unitary energy consumption by about 0.0084 kWh/kg (i.e. approximately 8%). On the other hand, increasing the length of the hole from 80mm to 100mm caused an increase in density of the briquette by approximately 90kg/m³ (i.e. about 8%) and an increase in the unitary energy consumption by approximately 0.018 kWh/kg (i.e. about 18%).

The conical entrance to the hole (where the angle between the generating line and the surface of the die equals 30°), compared to a hole without bevelling, increased the density of the product by approximately 43kg/m³ (i.e. around 4%) and the unitary energy consumption by approximately 0.01 kWh/kg (i.e. about 10%).

a die with a diameter of the holes $\phi=3.7$ (feed mixture DK)

The results of research on the impact of the above mentioned parameters on the density of the final product (granulated product with a diameter of 4.7mm, feed mixture DK), and the unitary energy consumption of the process, showed that changing the clearance coefficient from 0.3 to 0.365 caused a decrease in density by about 51kg/m³ (i.e. approximately 4%), and a decrease in the unitary energy consumption by about 0.003 kWh/kg (i.e. approximately 7%). On the other hand, increasing the length of the hole from 20mm to 25mm caused an increase in density of the granulated product by approximately 62kg/m³ (i.e. about 5%) and an increase in the unitary energy consumption by approximately 0.004 kWh/kg (i.e. about 9%).

The conical entrance to the hole (where the angle between the generating line and the surface of the die equals 30°), compared to a hole without bevelling, increased the density of the product by approximately 22kg/m³ (i.e. around 2%) and the unitary energy consumption by approximately 0.005 kWh/kg (i.e. about 12%).

The structure of granulating and briquetting dies

The results of research presented above show a significant impact of the geometric parameters of a hole of the die, and the clearance coefficient, as well as material properties of the manufactured product, on the basic parameters of the granulation process: unitary energy consumption and density of the granulated product (briquettes).

As a result, a universal granulating and briquetting device should be equipped with a variety of dies, when processing different raw materials.

This inconvenience can be minimised significantly by using collapsible dies (Fig. 2).

Constructing a die from a specified amount of plates should be preceded by preliminary research (information) on the physical, chemical and biological properties of the material that is being subjected to the granulation process (briquetting).

With the holes with greater diameters (above 25 - 30 mm) exchangeable sleeves may be used (Fig.3). However, using exchangeable sleeves reduces the clearance coefficient of the die.

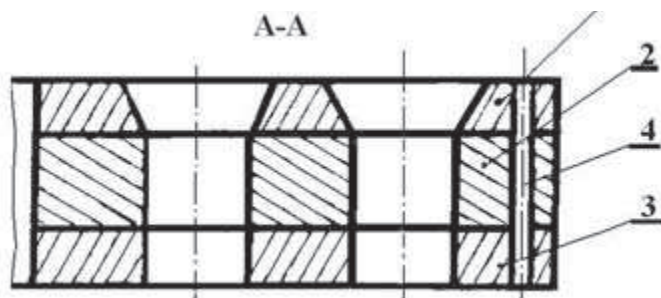


Fig. 2. The schema of the pelleting-briquetting matrix [2]: 1,2,3 - the plate of the matrix, 4- the establishing element

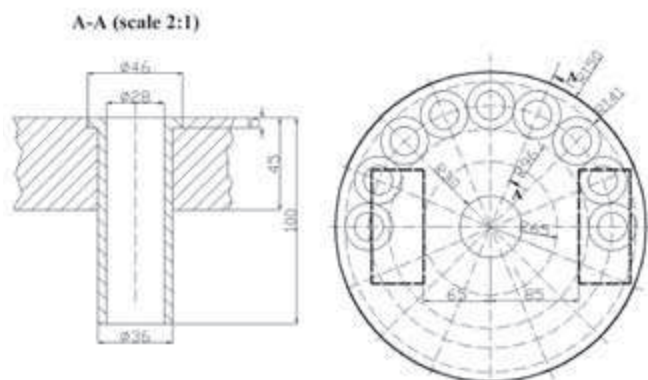


Fig. 3. The schema of the example briquetting matrix with replaceable muffs [3]

The design solution for a die, presented in Figure 3, with exchangeable sleeves, enables saving a significant amount of steel used in its manufacturing. It needs to be noted that highly alloyed steel, after appropriate heat and chemical treatment, is used for manufacturing granulating and briquetting dies. Such a solution allows significant material savings, decreases the energy consumption of the process of die manufacturing, and therefore also the cost of production. It also enables regeneration of used dies, by exchanging the sleeves (it is also possible to regenerate them).

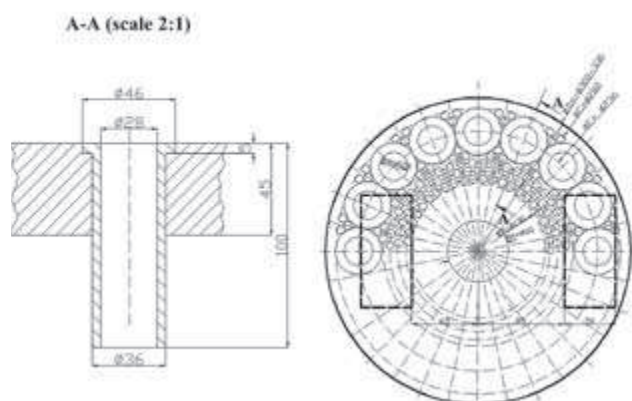


Fig. 4. The schema of the example pelleting-briquetting matrix with replaceable muffs [3]

Given the significant impact of the clearance coefficient of the die on the unitary energy consumption and density of the granulated product (briquettes), as well as its relatively small value for holes used in briquetting, a design solution for a die that produces both briquettes and granulated products, has been presented in Fig. 3. Such a solution significantly increases the clearance coefficient (it eliminates a significant portion of dead spaces between the holes). The die presented may be used in universal devices producing both granulated products (pellets) and fuel briquettes.

Many years of experience of the authors of this study in the area of pressure agglomeration of vegetable materials (granulating, briquetting),

lets them conclude that the universal granulating (briquetting) devices with low productivity should be equipped with a "flat, fixed die - densification rolls" working system.

Summary

The complexity and variety of issues occurring during the granulation process (pelletising) and briquetting in working systems of various designs, together with varying physical, chemical and biological properties of the materials subjected to the process, makes it appropriate to put the universal granulating devices (granulating and briquetting) with low productivity into production.

Granulating and briquetting devices, processing a variety of raw materials, should be equipped with a wide range of dies. This inconvenience can be minimised significantly by using collapsible dies.

The construction designs for dies presented in this article allow significant material savings, enable decreasing the labour consumption of die manufacturing, as well as the cost of their production. Additionally, they allow regeneration of the used dies through exchanging the sleeves (which can also be regenerated).

The design of the granulating and briquetting die allows production of both briquettes and granulated products. Such a solution significantly increases the clearance coefficient (it eliminates a significant portion of dead spaces between the holes), and therefore decreases the unitary energy consumption of the process.

Universal granulating (briquetting) devices with low productivity should be equipped with a "flat, fixed die - densification rolls" working system.

Literature

1. Hejft R.: *Ciśnieniowa aglomeracja materiałów roślinnych*. Biblioteka Problemów Eksploatacji, Radom 2002.
2. Hejft R.: *Plaska matryca do urządzenia granulująco-brykietującego*. Wzór użytkowy nr 53575.
3. Obidziński S., Hejft R.: *Plaska matryca granulująco-brykietująca*. Zgłoszenie patentowe P397986 z dnia 02.02.2012 r. Urząd Patentowy Rzeczypospolitej Polskiej, Warszawa 2012.
4. Obidziński S.: *Energochłonność procesu zagęszczania materiałów roślinnych*. Rozdział 10 w monografii: *Właściwości geometryczne, mechaniczne i strukturalne surowców i produktów spożywczych* (pod red.: B. Dobrzański jr i L. Mieszkalski). Komitet Agrofizyki PAN, Wyd. Nauk. FRNA, ISBN-13: 978-83-60489-05-5, Lublin 2007, 159-168.
5. Obidziński S., Hejft R.: *Energochłonność procesu granulowania materiałów roślinnych*. Materiały seminaryjne. V Konferencja Naukowo-Praktyczna: „Energia w nauce i technice”, Suwałki 2006, 153-159.

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