Influence of gathering elements in plate granulator of the course of the process

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Please cite as: CHEMIK 2012, **66,** 5, 370-375

Introduction

One of the methods often used in the production of pellets is non-pressure granulation [2, 3, 4, 10]. The process may follow two schemes, i.e. when the molecules of the powdery product combine without a catalyst in a form of another material, or when the forces binding the molecules are carried by material bridges built from connective substance [4, 5, 6, 7]. Most often the connective substance is water [4]. Interactions between the solid body, the liquid and the air can be observed during the pouring motion of the moisturised charge. The presence of another phase between the molecules of the solid body causes the formation of material molecules of a higher basis weight. This process takes place in inclined plate granulators [2, 3, 4, 5, 6, 7, 8, 10]. Such a technique serves the purpose of obtaining granulated agricultural fertilisers of specific dimensions, shapes and properties [1, 5].

Purpose of the study

The purpose of this study is to assess the impact of scraping parts of a plate granulator on the length, efficacy and quality of the granulated material.

Investigated material

In this research, the powdery raw material used was supplied by a company producing agricultural fertilisers. The average size of the seeds in the investigated material used was d_z=0.52 mm. The grain composition of the raw material was determined using mechanical sieve analysis, which is presented in Figure1. The initial moisture of the raw material subjected to granulation was 2.8%.

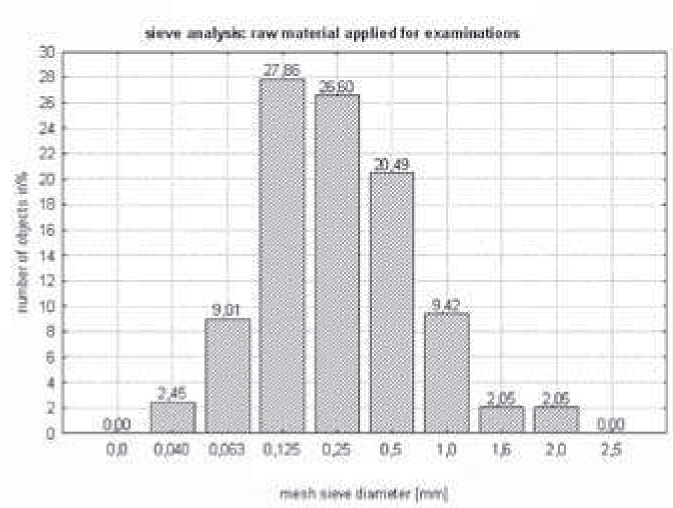

Fig. 1. Disintegration of raw material subjected to the granulation, get with the screen analysis

Site description

The examination of granulation process was conducted in a plate granulator. The description of the site is presented in Figure 2.

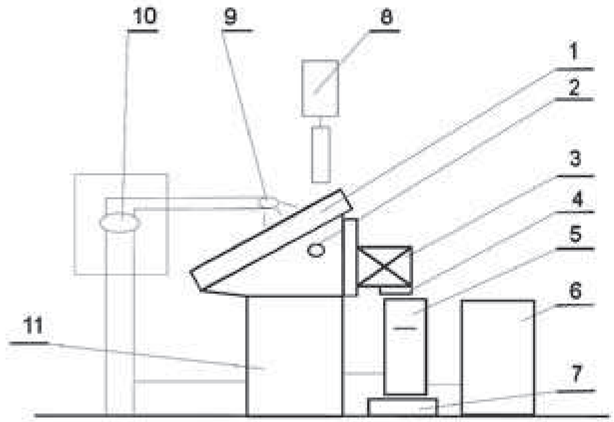

Fig. 2. Outline of the research post to the granulation: 1-exchange granulational plateful, 2-toothed mechanism, 3-electric engines with the belt transmission gear, 4-converter, 5-container of moistening liquid, 6-compressor, 7-weight, 8-dispenser of the raw material, 9-nozzle, 10-rotametr, 11- supporting structure.

The granulation plate 1 is propelled by an electric motor, through belt power transmission 3. The transmission of power from the belt to the granulation plate takes place through a toothed mechanism 2. A frequency converter 4 was used to determine the constant rotational speed of the plate. The amount of the moisturising liquid taken was shown on the display of the scales 7, to which a container with the moisturising liquid 5 was attached. The liquid was supplied though rubber ducts with positive gauge pressure generated by a compressor 6. The raw material was being dispensed in the lower part of the plate through a feeder 8 and humidified through a spray nozzle 9 in its upper part. The rotation of the plate ensured that the liquid was being supplied to the surface of the bed of the pouring powder material. A rotameter 10 was used to ensure a constant intensity of supply of liquid. The granulation plate together with its instrumentation was mounted to a supporting structure 11.

Methodology

The examination of granulation process was conducted in a plate granulator with a diameter d=0.5 m, height of the rim h=0.165 m, with a constant rotational speed of the plate n=53 rpm, with a constant mass of the granulated charge m=1.84 kg, which equals ϕ=5% of the degree to which the plate was filled. The rotational speed of the place was chosen based on preliminary research. The angle of inclination of the plate in relation to the horizontal plane was α=50°.

Distilled water with a temperature of 17 °C was used as a moisturising liquid. It was being supplied to the granulating bed through a pressure nozzle manufactured by Danfoss. The degree of moisturisation was determined as the ratio of the mass of the granulated charge to the mass of added moisturising liquid and the amount of turns of the plate during the moisturising process [9]. The raw material was being moisturised until reaching the degree of moisturisation In=0.002.

Granulation process was conducted without blade, with blade no. 1, with blade no. 2 and with both blades no.1 and 2. The parameters of blade no. 1: width $b_1 =$ 0.143 m, height $h_1 =$ 0.094 m, and blade no. 2: b_2=0.200 m, h_2=0.107 m, respectively. The angle of inclination of the blade in the granulator was =50 °. It was determined with a scale on the bottom of the granulation plate. A single blade, no. 1 or no. 2, was placed at 0.2 m distance, whereas both blades no. 1 and no. 2 were placed at 0.35 m and 0.2 m respectively, from the right rim of the plate.

The parameters of the process and the structure ensured the pouring character of the motion of the bed on the plate.

During the granulation process the following phases were determined: initial phase of moisturisation of the raw material, initial phase of granulation, final phase of moisturisation of the raw material, granulation after the completion of the moisturisation process. After the completion of moisturisation, the process was continued with constant degree of moisturisation in the granulator.

Throughout the process, samples of the granulated product were being collected, starting from the beginning of the process, in two-minute intervals. Subsequently, they were dried in a laboratory dried for 24 hours in the temperature 73÷76°C (chosen based on preliminary research).

The mean diameter of the obtained granulated material was measured using computer analysis of the image. A strength abrasion test was conducted on the dried granulated material, using mechanical and pneumatic methods (in Pfost apparatus and Holmen test apparatus respectively). The measurements of the strength of the granulated material were conducted using Erwek apparatus TBH 200 D. Each time 20 granules were used for the purpose of measurements.

The initial moisturisation of the raw material and the final moisturisation of the obtained granulated material was determined using weight-drier WPE 300 S manufactured by Radwag.

Test results

The results of the study are presented in Figure 3. In all four cases (granulation without blades and with blades) an increase in the size of the granules during the process can be observed. Throughout the process of granulation, the granulometric composition of the charge changes as a result of interactions between the grains of raw material. Porous agglomerates containing gaseous phase in its volume form initially. During the pouring motion, phases can be observed when the size of the obtained molecules (the mean diameter of the granulated material) decreases temporarily. However, mechanisms causing the formation of successive agglomerates and the increase in its size during the granulation process decidedly dominate in the entire bed.

Analysis of the obtained results demonstrates the impact of using the granulation blades in the granulation process. On the basis of the obtained results, we can conclude that the material was subject to further densification when it hit the blade, which led to a quicker increase in the diameter of the granulated material. As a result of dynamic interactions the rapid increase in size of the granules took place, due to which the granulation process was shorter.

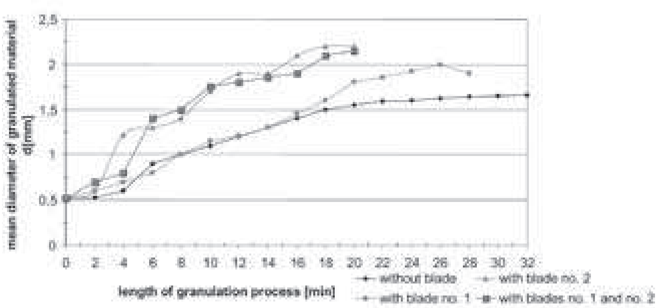

Fig. 3. Influence of using the spatula to the total duration of the process of the granulation

The use of a single granulation blade, as well as two granulation blades (no. 1 and no. 2) caused the coalescence process (the binding of molecules) to shorten. A significant increase in the mean diameter of the granules could be observed, as well as the shorter time needed to complete the process (shorter by 10 minutes) compared to the process conducted without blades or with blade no.1.

Not only the mean size of the obtained molecules, but also the strength of the granulated material measured through mechanical and pneumatic methods, demonstrates its quality. The values describing the abrasion strength of the obtained granulates determined through both methods are shown in Figure 4.

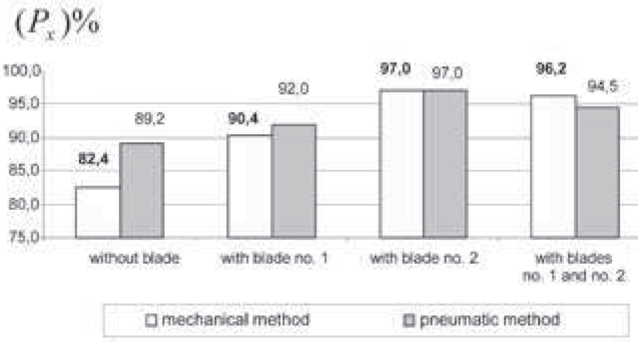

Fig. 4. Resistance to wiping pellets produced in laboratory conditions off

The highest abrasion susceptibility (lowest strength) was observed for granulated material obtained without the use of granulating blade. The use of blade (no. 1 or no. 2) determines the higher abrasion strength of the obtained granulated material. The granulated material obtained with the use of blade no. 2 is characterised by higher abrasion strength than the granulate material obtained with the use of blade no. 1. In this case the working surface of blade no. 2, that equalled S_2 =0.0214 m^2, played the crucial role. It is greater than the surface of blade no. 1 (S_1=0.013 m^2).

The variation of the mean size of the granules for different degrees of moisturisation of the charge is shown in Figure 5. It has been observed that an increase in the degree of moisturisation of the raw material results in a quicker increase in its size during granulation simultaneous with moisturisation (experiments with the following degrees of moisturisation: 3.6 % and 4.0 %).

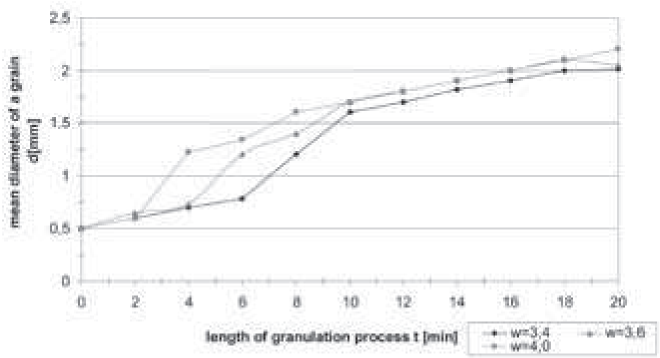

Fig. 5. Change of the average diameter for different humidities of the batch. Process of the granulation with the spatula no. 2.

The curves of grain distribution for granulated materials obtained without blades and with blade no. 2 are shown in Figures 6 and 7. The equivalent diameter of the obtained granulated material was d_z = 1.68 mm for the material obtained without blades, and d_z =2.37 mm for granulated material obtained with blade no.2.

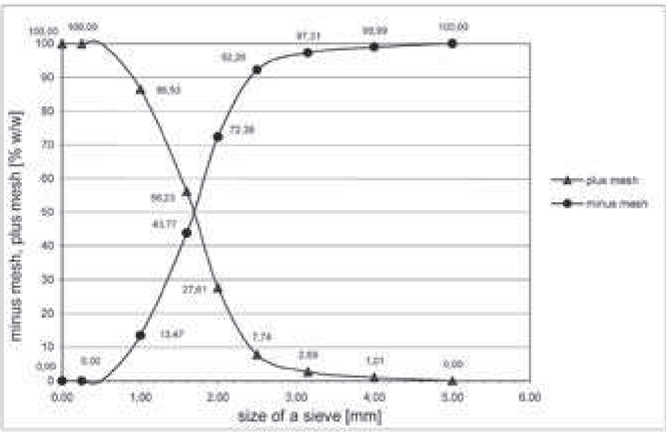

Fig. 6. Size fraction definition granules obtained without shoulders

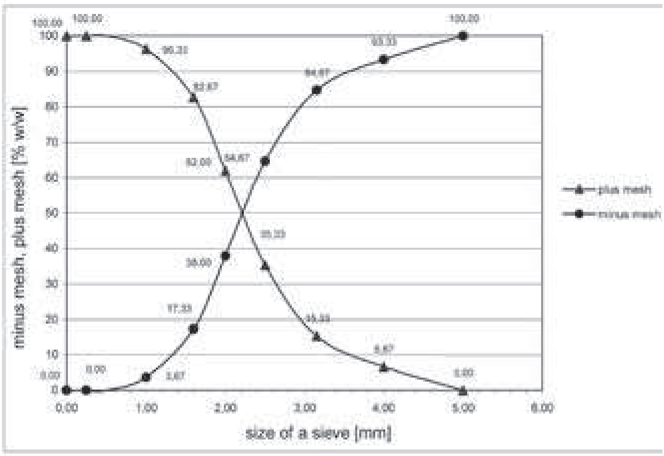

Fig. 7. Size fraction definition granules obtained from streaky number 2

Based on the mechanical sieve analysis results for granulation processes conducted without blades and with blade no.2, the product was obtained, for which the portion of granules from the range of: 1.6÷2.5 mm constituted 53-54% for granulated material obtained without blades, and 67-33% for granulated material obtained with blade no.2.

The results of measurements of compression strength of the granules and their diameters, conducted using Erweka apparatus TBH 200 D are presented in Table 1.

Table 1

Endurance of pellets produced in laboratory conditions

No. of sample	Mean diameter of granulated material [mm]	Strength, N
without blade	1.66	13.23
with blade no.1	1.92	22.05
with blade no.2	2.39	30.87
with blades no. 1 and no. 2	2.21	20.07

The experiment has shown that granulated material obtained through granulation with blade no. 2 has the highest compression strength. Additionally, the mean size of the granulated material is dominating here, and amounts to d_z =2.39 mm (where raw material amounts to d_z=0.52 mm). The working surface of the granulation blade played a crucial role (similarly while determining the abrasion strength). It should also be noted that granulated material obtained through granulation with two scraping parts (blades no. 1 and no. 2) has a lower strength than the material obtained just with blade no. 2.

Conclusions

1. The use of scraping parts in the working system shortens the time of the granulation process.
2. The working surface of the granulation blade has a significant impact on the parameters of the quality of obtained granulated material. Granulated materials obtained with the use of a granulation blade with a greater working surface are characterised by better strength properties that materials obtained without blades.
3. The use of granulation blade in the process of granulation increases the portion of a specified fraction in the granulated material.

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11. The research was conducted as part of an independent study no. W/WM/17/2011.

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