

INFLUENCE OF SELECTED STRUCTURE PARAMETERS OF A PELLET MILL ON THE QUALITY OF THE FINAL PRODUCT

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The paper presents factors affecting the pressure agglomeration process of plant material and the quality of the received product as well as the test results of selected apparatus and process parameters on the density and kinetic durability of the received pellets. The tests were conducted in a technical scale on a SS-2 test stand whose basic component is a pellet mill with a ring working system.

INTRODUCTION

One of the basic criteria to evaluate pellets is its durability *i.e.* preserving its shape during transport, storage and when used for feeding (at the same time considering standards of animal feed) [Hejft, 2002].

The knowledge of the durability of a pellets (its hardness, kinetic durability, resistance to discharge, resistance to cutting *etc.*) is particularly useful although it is often underestimated by producers of pellets.

According to numerous scholars [Thomas *et al.*, 1997, 1998; Walczyński, 2004], a good quality pellets enhances the effectiveness of feeding animals whereas using pellets of low quality has a negative effect on production results.

However, obtaining pellets of good quality is difficult as it is affected by many factors *e.g.* composition of mixture, the extent of grinding of its ingredients, homogeneity of mixture, fat content, method of pelleting, structure parameters of a working system used in consolidation [Walczyński, 2004; Thomas *et al.*, 1998]. When selecting the composition of a mixture one should consider not only its nutritional content but also susceptibility of particular ingredients to pelleting and the extent of their decomposition.

Polish standards do not specify the minimum values of critical kinetic durability of a pellets. Walczyński's research [1996] indicates that the quality of a granulated material can be described as satisfactory when its kinetic durability is above 80%, while a pellets whose durability is over 90% is a product of high quality.

According to a number of papers [Walczyński & Zawisłak, 2000a,b; Czaban, 2000; Hejft, 1991], kinetic durability of a pellets obtained from mixtures meeting quality requirements accounts for more than 90% (according to Pfof's test in accordance with Polish Standard [PN-R-64834:1998]).

The objective of the present study was to determine the influence of the tested structure parameters of a pellet mill working system with a ring die on the quality of the pellets.

MATERIALS AND METHODS

Tests were carried out on the full-portion fodder DK- Finisher, with humidity of 16%. The tests were conducted in a technical scale on a SS-2 test stand (Figure 1) whose main component is a working system with a ring die [Obidziński, 2005].

Density of the pellets was measured with METTLER TOLEDO scales (Figure 2). Measurements involved weighing 15 randomly chosen pellets in the air and then in a liquid (toluene) at a given temperature. The difference in weight is a displacement which makes it possible to determine the density of the pellets.

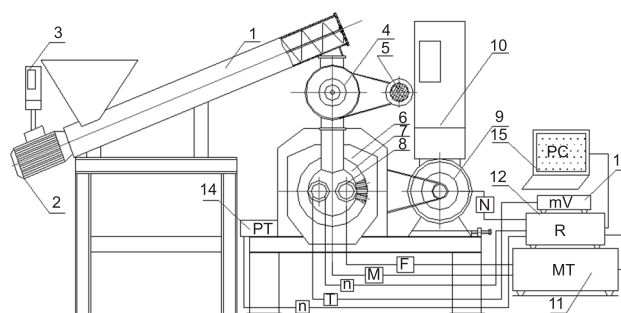


FIGURE 1. SS-2 test stand [Obidziński, 2005]: 1 – feeding screw, 2 – feeder's engine SG1 KMR 80G, 3 – frequency converter ACS 401000432, 4 – mixer, 5 – mixer's motor (electric engine SF112M6K), 6 – charge of raw material to the pellet mill, 7 – revolving die, 8 – compacting rollers, 9 – pellet mill motor (electric engine 3SG 180L6), 10 – frequency converter ACS 800-01-0040-3+E202, 11 – extensometric bridge KWS/6a-5, 12 – recorder MC201A, 13 – millivoltmeter, 14 – digital multtachometer DMT21, 15 – desktop PC.

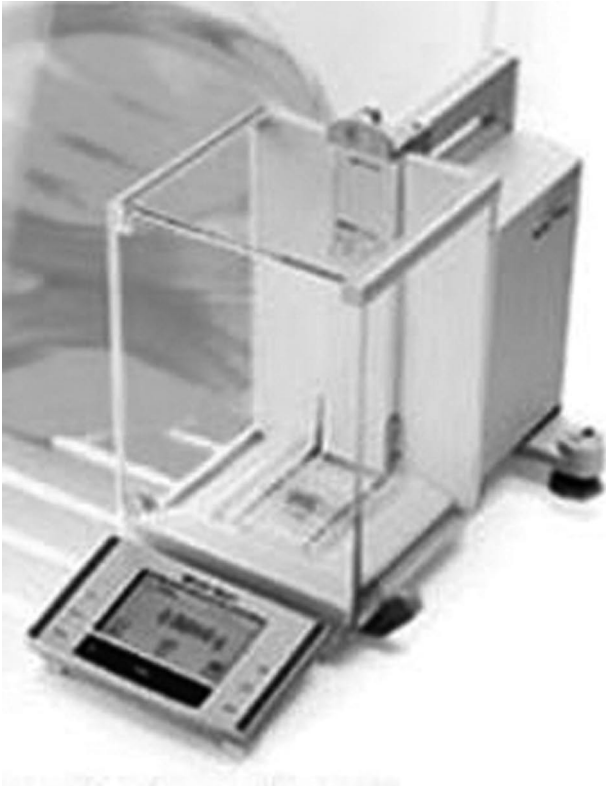


FIGURE 2. METTLER TOLEDO XS scales.

Kinetic durability of the pellets was determined with the Pfof's method in accordance with Polish Standard [PN-R-64834:1998] on a test stand shown in Figure 3.

Twenty four hours after pelleting, the final product was sifted in a sieve with holes 4 mm in diameter (1 mm smaller than the diameter of pellets) in order to remove smaller elements. Then, 5 samples were prepared each weighing 500 ± 0.5 g. They were placed inside a tester (Figure 3). Rotational speed of the tester's chamber was 50 rpm. After 10 min each sample

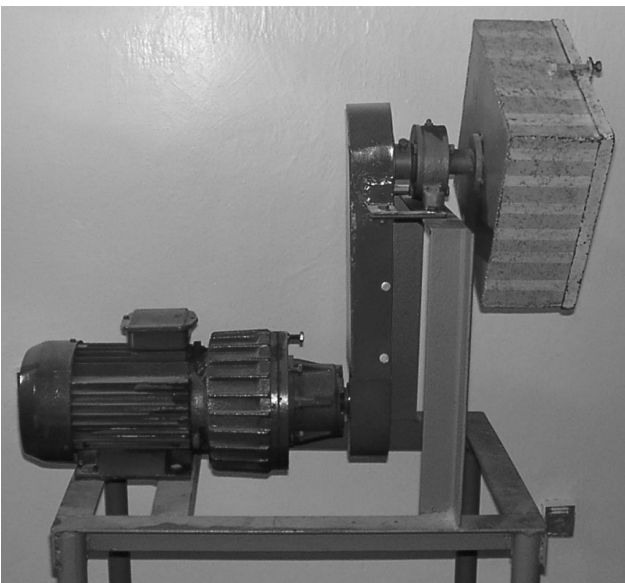


FIGURE 3. Test stand for measuring the coefficient of kinetic durability of a pellets.

was sifted once again. The pellets which remained in the sieve were weighed exact to ± 0.5 g. Kinetic durability was determined with the following formula:

$$P_{dx} = \frac{m}{m_o} \times 100\% \quad (1)$$

where: m – mass of the pellets after the test and sifting the damaged elements (g), m_o – mass of the pellets before the test and after sifting the damaged elements (g).

The paper presents results of tests on the influence of structure parameters of a working system on the density and kinetic durability of the end product at rotational speed of the die $n = 280$ rpm and the flow of raw material at $\dot{Q} = 350$ kg/h. The following parameters were tested: the length of a hole in the die l and the size of a gap between the compacting roller and the die.

RESULTS AND DISCUSSION

Table 1 and Figure 4 show results of tests on the influence of the length of holes in a die and the gap between the roller and the die on density of the pellets obtained from the fodder DK-Finisher; whereas Table 2 and Figure 5 show the influence of the length of holes in a die and the gap between the roller and the die on the kinetic durability of the pellets.

Extending the length of holes in the die l in the ring die of the pellet mill results in the increase in both the density and kinetic durability of the pellets. For instance extending a hole which is 52.5 mm long to 62.5 mm (with the rotational speed of the die at $n = 280$ rpm and mass intensity of raw material at $\dot{Q}_s = 350$ kg/h) results in the increase of the coefficient of kinetic durability of the pellets by $P_{dx} = 3.44\%$.

Due to the fact that the length of holes in the die is extended the mixture remains longer in the holes of the die and simultaneously the time when temperature affects the elementary portions of mixture is prolonged. This results in the increased extent of starch gelation in the mixture and appearance of more stable bonds in the end product, what is more the density of the pellets and at the same time the coefficient of its kinetic durabil-

TABLE 1. Results of tests on the influence of the length of holes in a die and the gap between the roller and the die on the density of the pellets.

Length of holes in a die (mm)	Density of the pellets (kg/m ³)		
	$h_r=0.4$ mm	$h_r=0.6$ mm	$h_r=0.8$ mm
52.5	1215.36	1221.78	1232.99
57.5	1222.85	1232.18	1245.32
62.5	1240.58	1247.71	1261.41

TABLE 2. Results of tests on the influence of the length of holes in a die and the gap between the roller and the die on the kinetic durability of the pellets.

Length of holes in a die (mm)	Kinetic durability of the pellets (%)		
	$h_r=0.4$ mm	$h_r=0.6$ mm	$h_r=0.8$ mm
52.5	89.79	90.69	91.76
57.5	90.81	91.87	93.09
62.5	92.88	94.21	95.18

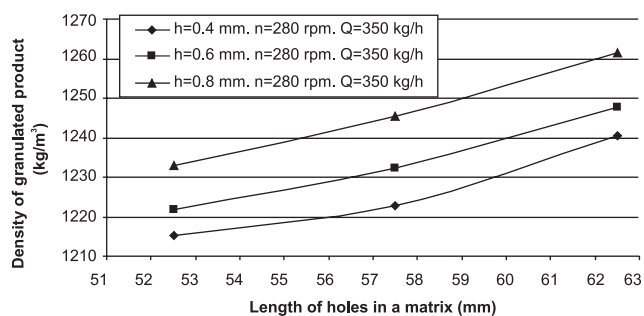


FIGURE 4. The relation between the density of the pellets and the length of holes in a die and the gap between the roller and the die.

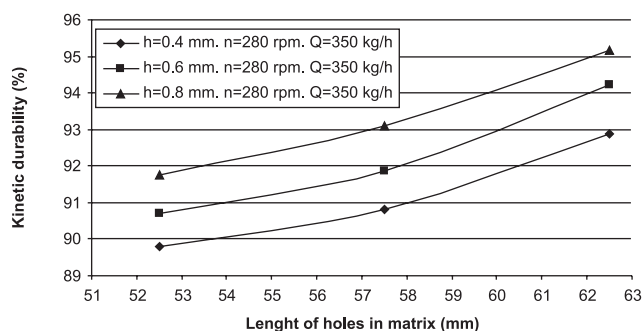


FIGURE 5. The influence of the length of holes in a die and the gap between the roller and the die on the kinetic durability of the pellets.

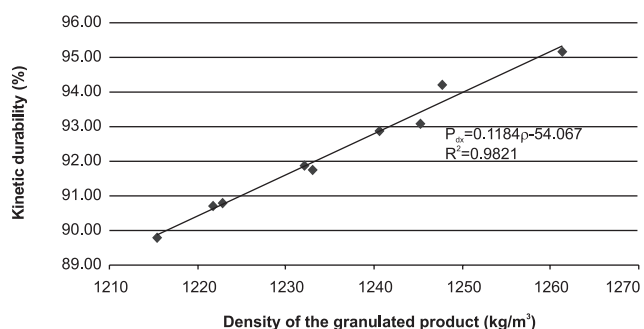


FIGURE 6. The relationship between the kinetic durability of the pellets and its density.

ity are observed to increase. Since the mixture remains longer in the hole the stress relaxation time in the pellets is extended, which has a positive effect on the durability of the pellets.

If the gap h in the pellet mill is extended from 0.4 mm to 0.8 mm there occurs a slight increase of density and the coefficient of kinetic durability of the pellets. For instance, if the rotational speed of the die is $n = 280$ rpm, the length of a hole in the die is $l = 52.5$ mm and the mass intensity of the raw material is $\dot{Q}_s = 350$ kg/h the density of the pellets increases by 1.5%.

The increase in the density of the pellets and the coefficient of kinetic durability along with the extension of the gap is associated with extending the layer of the material which undergoes compaction during one cycle of compacting. Since the pellets is built of layers, a reduction in the number of layers (due to the increase in the amount of material in one layer) in the produced pellet results in the increase of its kinetic durability. Extending the gap also results in the increase in the number of fine particles in the compacted mixture. These particles are produced

as a result of breaking up of material which is not forced into the holes in the die. This results in the increased density of the produced granulated material as well as its kinetic durability.

The obtained test results suggest that there exists a linear relationship between kinetic durability of the pellets and its density (Figure 6).

The influence of the length of holes in a die and the gap between the roller and the die on the density of the pellets and its kinetic durability can be described with the equation (2):

$$\rho(P_{dx}) = A \cdot e^{B \cdot x} \quad (2)$$

where: A , B – coefficients of the equation, x – the tested parameter (the length of a hole in a die or the gap).

CONCLUSIONS

1. Extension of the length of holes in a die and the working gap between the roller and the die results in the increase of both density and kinetic durability of the pellets.
2. Test results indicate that there exists a linear relationship between the kinetic durability of the pellets and its density.

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WPLYW WYBRANYCH PARAMETRÓW KONSTRUKCYJNYCH UKŁADU ROBOCZEGO GRANULATORA NA JAKOŚĆ OTRZYMANEGO PRODUKTU

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W pracy przedstawiono czynniki mające wpływ na przebieg procesu ciśnieniowej aglomeracji materiałów roślinnych i jakość uzyskanego produktu oraz wyniki badań wpływu wybranych parametrów aparaturowo-procesowych na gęstość i wytrzymałość kinetyczną otrzymanego granulatu. Badania przeprowadzono w skali technicznej na stanowisku badawczym SS-2, którego podstawowym elementem jest granulator z pierścieniowym układem roboczym.