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INFLUENCE OF MIXTURE TEMPERATURE AFTER CONDITIONING ON KINETIC STABILITY OF PELLETS

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Key words: pelleting, conditioning, kinetic stability, process efficiency

The course of the pelleting process, its energy consumption, and pellet quality are determined by conditioning itself. Here, conditioning should be understood as additional warming along with additional moisturizing of a mixture just prior to its pelleting. Softening of fodder components and partial gelatinization of starch occur during that process. Steam that can be sometimes replaced by water is commonly used for conditioning. Experiments were aimed at evaluating the influence of lower temperatures applied during conditioning on the pelleting process depending on matrix compression level, as well as on kinetic stability of pellets and process efficiency. Fodder mixture for poultry was the material for study. A compression level of 1:21 in an industrial granulator allowed for achieving high stability of pellets (94-97%) for all samples. In the laboratory system where compression level was 1:17, the dependence of kinetic stability on conditioning temperature could be observed. The increase of mixture temperature after conditioning process was accompanied by stability increase (from 58%-82%).

INTRODUCTION

Progress in methods of processing the raw materials and fodder mixtures applied in animal feeding leads to utilization of newer and newer technological processes. Barothermal processes, that use the combination of three factors as moisture content, temperature and pressure, are commonly applied [Panasiewicz *et al.,* 2003].

Pelleting, extrusion, and expanding are some of barothermal processes. Pelleting is widely applied in the fodder industry, whereas extrusion, that is more energy-consuming than pelleting, did not find its wide application in the fodder industry. It is used only to produce fodder for pets, mainly dogs, cats and fish [Panasiewicz *et al.,* 2003].

Agglomeration of ground and loose material takes place – simply speaking – in a chamber of matrix in a form of open tube, from which the difficulty of the process optimization results. The main factor that makes the pressed "rod" is produced from loose material is a result of friction between that material and the wall surface of a hole. Loose material with a characteristic physical and chemical properties (moisture content, particle size, texture, chemical composition, *etc.*) is added with water up to about 17-18% using water or steam, enriched (not always) in liquid additives (*e.g.* molasses or fat), and as homogenized due to stirring, is directed to pressing device [Knight, 2001; Li, *et al.,* 2000]. The above description indicates that the course and effect of pelleting can be influenced by many factors of not completely recognized nature. And variable pressing conditions resulting from the pelleting device construction should be added. Physical and chemical properties of raw material determine its susceptibility to pelleting. Well susceptibility means that material can be concentrated at lower energy input, and that the resultant pellets have good stability. Raw material's ability to agglomerate depends on moisture content, temperature, granulometric composition, internal friction coefficient, looseness, *etc*. Moreover, chemical composition, mainly protein, starch, fiber, and fat contents, significantly affects the course of the process and pellet quality, because these substances are subjected to different physicochemical transformations due to high temperature, pressure, and humidity [Aarseth *et al.,* 2003; Thomas *et al.,* 1998, 1996, 1997; Wood, 1987].

Raw materials applied for fodder mixtures are often infected by aflatoxins, *i.e.* toxic agents produced by moulds, hazardous for people and animal health. Good effects of aflatoxins degradation can be achieved due to preliminary processing of material or a mixture subjected a temperature and humidity, *e.g.* conditioning, and then pressure processing [Fasina, 1996].

The course of the pelleting process, its energy consumption, and pellet quality are determined by conditioning itself. Here, conditioning should be understood as additional warming along with additional moisturizing of a mixture just prior to its pelleting. Softening of fodder components and partial gelatinization of starch occur during that process. Steam that can be sometimes replaced by water is commonly used for conditioning [Panasiewicz *et al.,* 2003].

Depending on specific heat of materials, technical status of installation, and steam characteristics, it is accepted that the steam

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addition required to elevate mixture's temperature by 10°C makes the increase of moisture content by 1% [Panasiewicz *et al.,* 2003].

Literature references [Panasiewicz *et al.,* 2003; Thomas *et al.,* 1998, 1997; Wood, 1987] indicate that optimum temperature of a mixture after conditioning process should be about 80°C. However, due to applying specific nutritional additives, it is recommended not to exceed 60°C after conditioning. Examinations carried out within the range of 50-65°C were aimed at revealing, how such temperatures of a mixture after conditioning influence the agglomeration process and what stability of a final product can be achieved.

Experiments were aimed at evaluating the influence of lower temperatures applied during conditioning on pelleting process depending on matrix compression level, as well as on kinetic stability of pellets and process efficiency.

MATERIAL AND METHODS

Material. Fodder mixture for poultry was material for study. Table 1 presents general physical properties of the fodder mixture subjected to conditioning, then pelleting processes.

TABLE 1. Physical properties of the tested mixture.

Loose density (kg/m^3)	Shaken density (kg/m^3)	Repose angle (°)	Moisture content (%)	dg (mm)
624.64	691.91	45	12.2	0.824

Analyses. Examinations included: (1) measurement of mixture temperatures after conditioning and at the outlet of granulator matrix; (2) measurement of granulator efficiency depending on work parameters of conditioner; and (3) evaluation of pellets quality.

A GR-2 granulator equipped with a matrix with 3.8-milimeter holes was the main component of the production line. The ratio of hole diameter to its length in matrix was 1: 21.

In the laboratory, granulator with matrix of 1: 17 ratio and 3.5-mm holes was installed.

Scheme of experiments is presented in Figure 1.

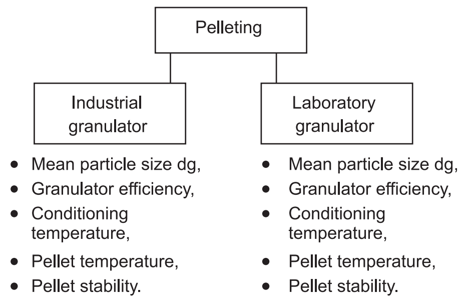

FIGURE 1. Block diagram of experiments.

RESULTS AND DISCUSSION

Figures 2-5 present results from measurements.

Figure 2 depicts the dependence of pellet temperature *vs*. mixture temperature after conditioning and the so-called level of matrix compressing.

In an industrial granulator, where compressing level was 1:21, temperature increment was 24°C for mixture conditioned at 50°C. At 60°C of mixture temperature after conditioning, the increase was 15°C, and at 65°C – 13°C.

The achieved results revealed an apparent influence of mixture temperature after conditioning on the final temperature of a product.

Similar dependencies were found during pressing that mixture in a laboratory granulator. Lesser temperature differences in the industrial line between mixture after conditioning and final product result from the fact that the applied matrix was characterised by a lower compressing level (1:17).

An analysis of results presented in Figure 2 shows that matrix with a lower compression level (*i.e.* 1:17 or less) should be applied in order to achieve pellets heated to not more than 70°C.

Figure 3 presents changes of industrial granulator efficiencies depending on mixture temperature after the conditioning process. Increase of that temperature by 15°C (from 50°C to 65°C) caused the increase of pelleting process efficiency by 15%. Figure 4 illustrates the granulator efficiency in the production line. In that case, the increase of conditioning temperature from 50°C to 65°C affected the increase of efficiency only by 4%.

Increase of pelleting process was more apparent using matrix with a higher compression level.

Measurement of kinetic stability was another parameter of pellet quality evaluation. Pellet kinetic stability achieved from laboratory and industrial lines for three different mixture temperatures after conditioning is presented in Figure 5.

The compression level of 1:21 in an industrial granulator allowed for achieving high stability of pellets (94-97%) for all

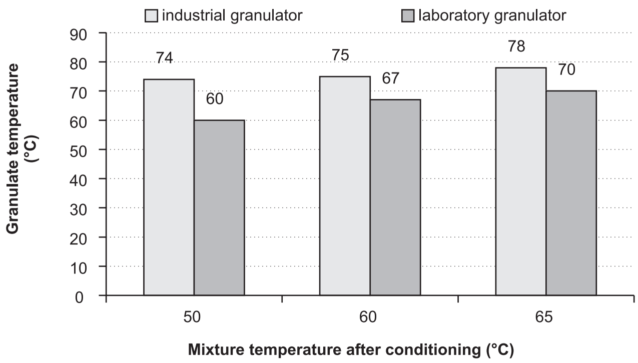

FIGURE 2. Pellet temperature depending on conditioning parameters.

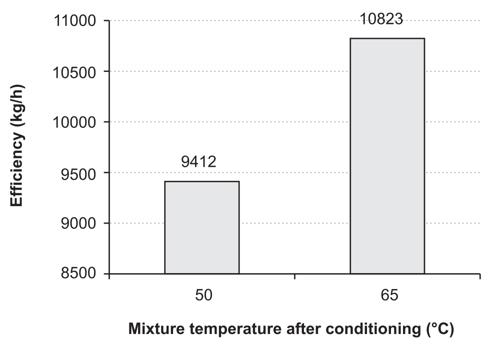

FIGURE 3. Efficiency of industrial granulator depending on conditioning process.

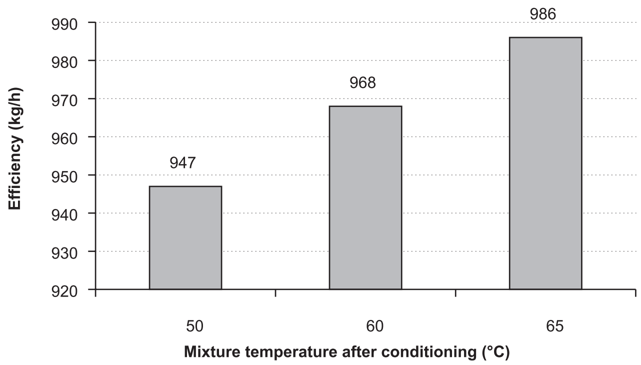

FIGURE 4. Efficiency of laboratory granulator depending of conditioning process.

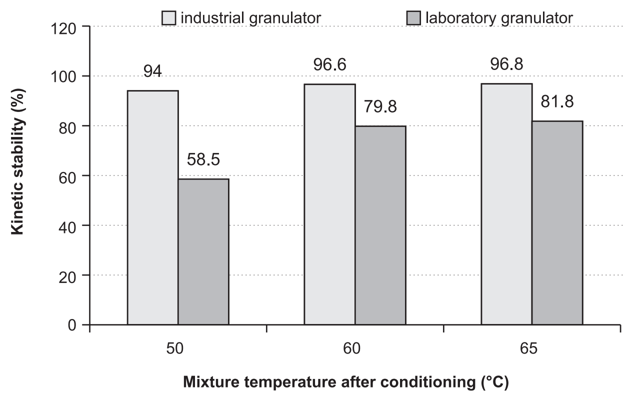

FIGURE 5. Pellet kinetic stability depending on conditioning temperature.

samples. In the laboratory system, where compression level was 1:17, the dependence of kinetic stability on conditioning temperature could be observed. The increase of mixture temperature after conditioning process was accompanied by stability increase (from 58%-82%).

From the results of Thomas *et al*. 1[996], Mohsenin *et al*. [1976] it can be concluded that pellet quality and pelleting behaviour is dependent on the composition of raw material and their rheological behaviour. Increasing the hold time of the material under compression increases the relaxation of stresses in materials, so durability of the feed increases.

The pelleting process is a combination of: conditioning, pelleting and cooling. But conditioning process are process variables such as steam and water and system parameters: residence time and pressure [Thomas *et al*., 1997, 1998]. However, the use of cost and pellet quality and amount of steam is a more decisive factor then steam pressure. It can be concluded that pellet hardness and durability rise is dependent on feed formulation, temperature of feed mash and cooling air characteristics.

CONCLUSIONS

1. Increase of mixture temperature after conditioning affects the increase of pelleting efficiency, namely on matrix with a high compression level.

2. Increase of a compression level during granulated mixture production has larger effects on pellets with higher kinetic stability than the increase of conditioning temperature.

3. Temperature of mixture conditioning influences kinetic stability at a lower compression level.

4. Pellets with final temperature not exceeding 70°C can be achieved by warming the mixture in a conditioner till 60-65°C along with applying a compression level of 1:17.

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WPŁYW PROCESU KONDYCJONOWANIA NA TRWAŁOŚĆ KINETYCZNĄ GRANULATU

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Przebieg procesu granulowania i jego energochłonność a także jakość granulatu zależą w decydującym stopniu od kondycjonowania. Rozumie się pod tym pojęciem proces dogrzewania z równoczesnym dowilżaniem mieszanki tuż przed granulowaniem. Jednym z kluczowych procesów podczas produkcji aglomeratów jest proces kondycjonowania. Podczas tego procesu następuje rozmiękczanie składników paszowych oraz częściowa żelatynizacja skrobi. Do procesu kondycjonowania używa się pary wodnej, która sporadycznie zastępowana jest wodą. Celem przeprowadzonych badań było określenie wpływu procesu kondycjonowania na jakość uzyskiwanego granulatu, a w szczególności na jego trwałość kinetyczną i wydajność granulatora. Badania przeprowadzone na granulatorze laboratoryjnym oraz przemysłowym. Akceptowalną, wysoką trwałość granulatu uzyskano dla wszystkich prób w granulatorze produkcyjnym, niezależnie od temperatury kondycjonowania. Natomiast w linii laboratoryjnej zaobserwowano zależność trwałości kinetycznej od temperatury kondycjonowania. Istotne różnice wystąpiły przy temperaturze kondycjonowania 50°C (trwałość w granicach 60%), co może być spowodowane nie przetworzeniem skrobi w mieszance. Natomiast w granulatorze produkcyjnym zastosowana matryca o dłuższej komorze wytłaczania, a co za tym idzie większej sile aglomeracji spowodowało uzyskanie trwałego granulatu.