ZESZYTY PROBLEMOWE POSTĘPÓW NAUK ROLNICZYCH 1978 z. 203

THE PHYSICAL PROPERTIES OF SHAPED FEEDS

Jiři Fiala, Antonin Jelinek

Modern agriculture is inconceivable without any introduction of new forms of production of the basic products serving both for direct consumption and for following further processing. So that it should be possible to introduce and use these new forms of production it is necessary to base this on the knowledge of the basic properties of the processed material, be it mechanical, electric, thermal, optical, or acoustic properties. It is a fact that much work has already been done, but with regard to the infinite variety of agricultural materials there is still an immense amount of work to be done. Specific heat, further thermal characteristics, and such mechanical properties as are the behaviour of material under pressure and in tension, pressure resistance, impact and cut, the coefficient of friction; all these are selected properties that are constantly present. Knowledge of these properties provides the most important basic data for the construction of machines, for transport, manipulation, processing, and for the storing of agricultural materials.

One of the progressive agricultural materials to which the importance of the knowledge of the basic properties applies especially, are shaped (compacted) feeds. They are used, on the one hand, as a complex feed mixture — as far as they contain all required components in appropriate dimensions of the perticles, and, on the other hand, as supplementary feed mixtures produced at agricultural enterprises, above all from high quality dried materials, from cereals, and from further valuable feeds, fed together with bulky fodders.

At the production, at the machanization and automation of the manipulation and in the storing of these feeds as well as in their feeding, we are faced with a number of problems.

In a majority of cases there is a lack of basic data that would make possible a full analysis of these problems and an evaluation of their suitability for manipulation in their storing and feeding. Therefore an examination was carried out of such properties as most clearly illuminate these technological procedures. These are particularly physical properties — mechanical as well as thermal.

In the group of physical-mechanical properties the following variables were measured:

Per unit volume weight. So as to make possible the use of the pycnometric method, the following procedure was applied with regard to porosity; the briquette or pellet was squared up at both ends so that it should form a cylinder. The cylinder was put into wrappings of plastic foil of a thickness of 0.05 mm that had been prepared in advance and which had an identical circumferece, and the excessive air was sucked out by means of a pump. After the fusing of the wrapper the sample was prepared for the pycnometric measuring. Measured were shaped feeds of a diameter of 20 mm with a volume unit of approx. 900 kgm^{-3} and of a diameter of 30 mm with a volume unit of about 1000 kgm^{-3}.

Volume weight. The volume weight was determined by means of a weighing of the known volume of the group of shaped feeds. It ranged round about 500 kgm^{-3} with a slight decreasing when the diameter of the feed was increased.

Unlike in the case of the volume weight of the group, the measurable weight of the individual briquettes and pellets increases together with the increasing diameter.

Porosity. The porosity of the set of shaped feeds was measured by means of the known method based on Boyle-Mariott's law. In the case of diameters of 20 mm it ranged round about 45 p.c. and in the case of diameters of 30 mm round about 47 p.c.

Settling capacity. As it was not possible to observe this phenomenon at its actual strength, the settling was reproduced in the form of a model. This basis served as the knowledge of the volume weight of shaped feeds, from which the pressure of the layer on the underlay was calculated approximately. In this measuring a height of the stored material of up to 16 m was reckoned with.

With this height of storing the reduction of the settling coresponded to about 100 mm.

Crumbliness. The crumbliness of shaped feeds is characterized by the following relation:

$$D=\left(1-\frac{hp-O}{hp}\right)100 \text{ p.c.},$$

where:

hp — weight of the initial sample,

O — crumbled off material after termination of the test.

Measuring revealed that the crumbliness ranged from 5 to 20 p.c. and that in a majority of samples it decreased with the increasing diameter of the shaped feeds.

I n d e x o f d i s t r i b u t i o n o f p a r t i c l e s. The index of the distribution of particles affects the quality of the set of shaped feeds with regard to weight. After the testing of the crumbliness the crumbled off parts are ranked in five classes, into which also the initial average weight of the set had been divided up.

To each weight group from 20 to 100 p.c. corresponds a coefficient by which its percentage in the set is multiplied, and the result obtained shows the index of the set. The sum of the individual sets indicates the index of the group.

The tests revealed a considerable increasing of the index in shaped feeds of a diameter of 30 mm compared with those of a diameter of 20 mm. This is obviously caused by the fact that briquettes or pellets of a diameter of 30 mm are much shorter when subjected to the testing (the ratio of length to the diameter in the case of a diameter of 20 mm amounts to 4 and in the case of a diameter of 30 mm to about 2). A distinct decreasing of the index was observed also in shaped feeds with a higher straw content.

S h a p e. If we consider the basic requirement that for the feeding of cattle it is necessary that the feed should contain the smallest possible degree of crumbling, which disturbs digestion, decreases ruminal contraction, and retards the process of rumination, it is necessary to choose such a form of the briquette or pellet that would resist crumbling as much as possible.

At the definition of the shape it is necessary to measure some of the dimensional parameters, and in this case it is possible to express the relation between these quantities in a simple two-dimensional system.

Evaluation has shown that, compared with the currently stated dimensions with the diameter ranging between 20 and 40 mm and with a height of the cylinder being about three times as much as the diameter, much more advantageous are the following dimensions: diameter 50 mm and a height of $^2/_3$ of the diameter. Also the dependence of such a shape on the other physical mechanical properties, as, e.g., crumbliness, proved to be substantially more advantageous.

T h e h a r d n e s s o f s h a p e d f e e d s. For the measuring of the hardness of shaped feeds Höppler's consistometer was used, which had been adjusted for the purpose of measuring.

The method of measuring is the impressing of a cone of a vertex angle of 33° 8′ into the material. This vertex angle ensures that the depth of the impression should always equal the diameter of the basis of the impressed cone.

The course of the measuring has shown that a tapered cone has no ideal shape for impressing into material measured by us and that it will be necessary to make the method still more accurate. In its substance shaped feed is no homogeneous material and therefore much depends (especially in the case of lower forces of compression) on which component is encoutered by the point of the tapered cone. We assume that it would be more suitable, with a retention of all conditions of the measuring, to impress into the material a ball, which would rather correspond to the composition of the shaped feed. For a realization of this idea it was necessary to ascertain the relation between the surface of the cone and of that of the spherical cap and the relation between the depth of the impression of the spherical cap and the area of the basic of the spherical cap. Calculation showed the radius of the corresponding ball to be $r = 1.9$ mm.

The courses of the hardening in dependence on the compacting pressure are shown in Fig 1. Hardness was measured after 3 and 48 hours.

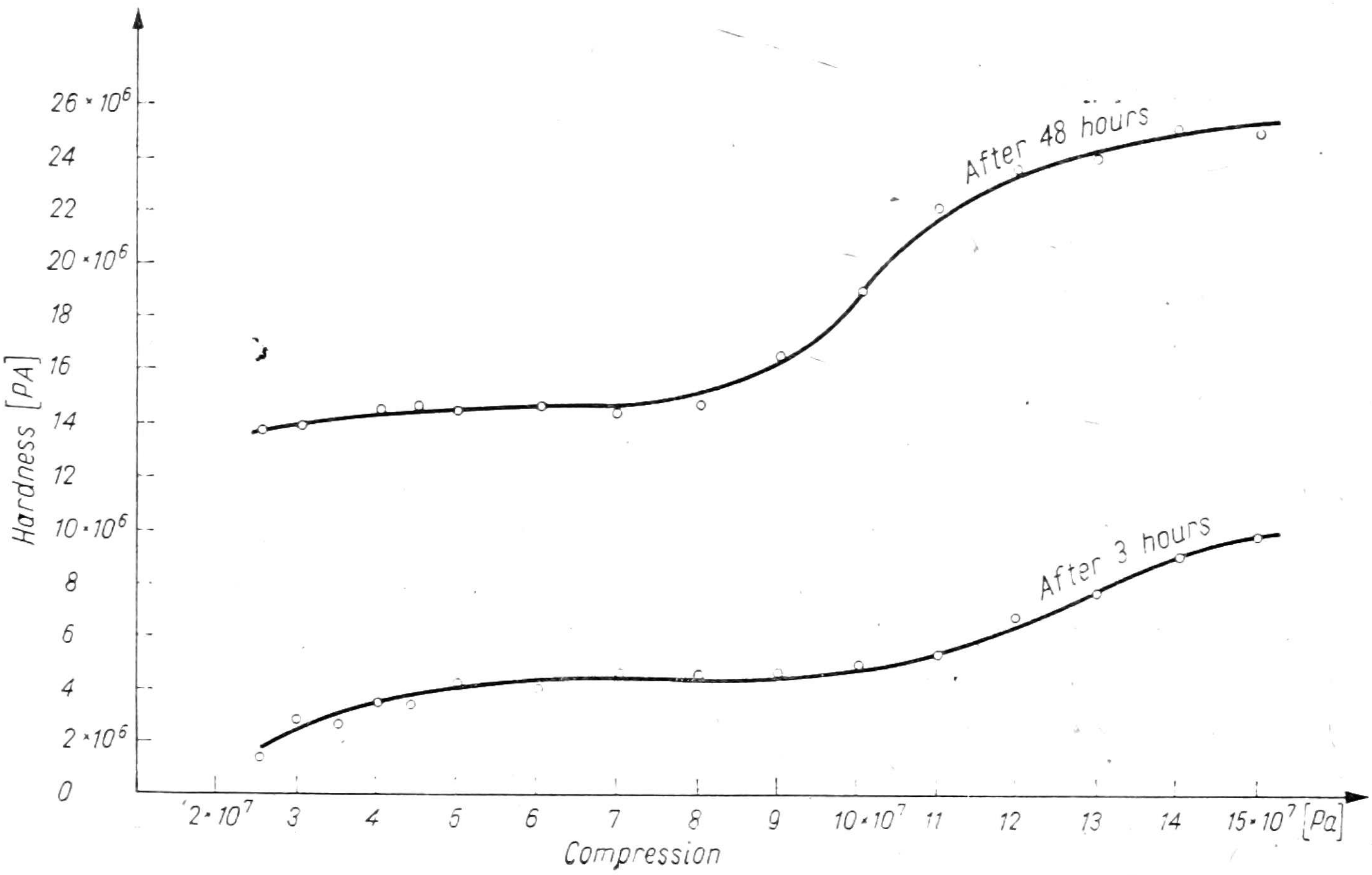

Fig. 1. Hardness of wafers related to compression

From the courses of the curves it can be seen that the hardness increases substantially within limits of pressures of from $25 \cdot 10^6$ Pa up to $50 \cdot 10^6$ Pa, then stabilizes it within limits of pressures of $50—90 \cdot 10^6$ (it increases very slowly), and a violent rising does not set in until at a pressure of $90 \cdot 10^6$ Pa. In the last stage ($120—150 \cdot 10^6$ Pa) there occurs again a slowing down of the growing of hardness.

It may be assumed that at this stage the hardness stabilizes at the final value and that it will not be changed by any further increasing of pressure.

Reversible deformation. After having left the machine the shaped feeds pass through the process of reversible deformation. This deformation depends on the pressure, on the composition, and on the moisture of the material.

Measuring in the group of thermal quantities. For the measuring of thermal quantities use was made of a device that had been developed on the basis of the method used by Prof. Krischer. By means of this method it is possible, with a single measuring, to measure simultaneously the thermal conductivity, the specific heat, and the thermal capacity. With regard to the short time of the measuring (10—20 min.) this method is suitable for the determination of the thermal properties of agricultural materials. It was found that for shaped feeds the thermal conductivity ranges within limits of from 0.16 to 0.2 W m^{-1} °K, the heat conductivity from 0.1 to 0.15 m^2 s^{-1}, and the specific heat ranges between 1700 and 2000 kg^{-1} °K.

CONCLUSIONS

At the time when work regarding this problem was begun there were at disposul almost no data or findings available on which to base this work. First of all a general system of the properties of all agricultural materials was worked out, and on the basis of these typified properties work was begun with a gradual determination of the basic values for shaped feeds. To a predominant extent work was directed towards an obtaining of methods for the measuring of the individual properties that are of primary importance in the practice. Thus almost all important physical properties were determined and the connections existing between them were defined.

In the further stage of the investigation it will be necessary to direct work towards the investigation of the properties of the individual components, and then, according to these, in co-operation with the producers of fodders, to determine such a composition of feed mixtures that would correspond to the optimal properties both from the point of view of feeding and from the point of view of production.

J. Fiala, A. Jelinek

FIZYCZNE WŁAŚCIWOŚCI PASZ ZBRYKIETOWANYCH

Streszczenie

Naukowego podejścia do zagadnienia przetwórstwa płodów rolnych, używanych do konsumpcji lub dalszego przetwarzania, nie można sobie wyobrazić, bez znajomości właściwości fizykomechanicznych tych produktów. Zagadnienie to jest szczególnie ważne przy opracowywaniu technologii wytwarzania pasz brykietowanych, posiadających wszelkie przesłanki dla szerszego zastosowania w produkcji rolnej.

Produkcja tych pasz jest bardzo trudna i z punktu widzenia ich jakości konieczne jest przestrzeganie specyficznych wymogów w odniesieniu do prac związanych z transportem i przechowalnictwem. Ta przysłowiowa pasza jest stosowana w postaci kompleksowej mieszanki paszowej oraz w postaci uzupełniającej do paszy. Do oceny pasz brykietowanych wybrano następujące parametry fizyczne: kształt, wymiary, ciężar objętościowy i właściwy, porowatość, trwałość, odkształcalność sprężysta, szybkość zalegania, pojemność i przewodność cieplna. Właściwości te pozwalają określić zmiany, jakie zachodzą w paszy zbrykietowanej w czasie operacji technologicznych, takich, jak: oziębianie, przewóz, prace załadunkowo-wyładunkowe, przechowywanie i skarmianie. Do pomiarów wymienionych właściwości fizykomechanicznych użyto specjalnie dostosowanych i powszechnie dostępnych przyrządów w ogólnym przeznaczeniu, jak i specjalnie skonstruowanych. Metodyka badań obejmowała również pomiary polowe. Do pomiarów laboratoryjnych przyjęto kilka wariantów pasz zbrykietowanych przeznaczonych do karmienia zwierząt domowych. Wyniki pomiarów właściwości fizykomechanicznych badanych pasz przedstawiono w formie tabelarycznej i graficznej.

И. Фиала, А. Елинек

АГРОФИЗИЧЕСКИЕ СВОЙСТВА БРИКЕТИРОВАННЫХ КОРМОВ

Резюме

Научный подход при обработке сельскохозяйственных продуктов, используемых прямо для потребления или для дальнейшей переработки, нельзя себе представить без ознакомления с их основными физико-механическими свойствами. Этот подход особенно важен при обработке брикетированных кормов. У брикетированных кормов есть все предпосылки для широкого применения в сельскохозяйственном производстве. Производство этих кормов является очень трудным, и с точки зрения их качества необходимо соблюдать также специфические требования к системе погрузочно-разгрузочных работ и хранения. Этот перспективный корм применяется, с одной стороны, в качестве комплексной кормосмеси, и с другой стороны — в качестве дополнительной смеси.

С физико-механической точки зрения были избраны такие свойства, на основании которых проводилась оценка брикетированного корма: форма, величина, объем, удельный вес, объемный удельный вес на единицу материала, раз-

дробляемость, индекс распределения частиц, пористость, твердость, обратная деформация, слеживаемость, теплопроводность, температуропроводность, удельное теплосодержание и теплоемкость. Эти свойства позволяют определить изменения брикетированного корма при технологических операциях, как нпр охлаждение, транспорт, погрузочно-разгрузочные работы, хранение и кормление.

Для измерения приведенных физико-механических свойств были приспособлены обычно доступные приборы общего назначения как и специально сконструированные. Методы измерений были разработаны так, чтобы можно было проводить измерения в эксплуатационных условиях.

Для лабораторных измерений избрали несколько вариантов состава брикетированного корма, широко применяемого в кормлении животных.

Результаты измерений физико-механических свойств брикетированного корма приводятся в таблицах и графиках.

Address of the authors

Dr Ing. Jiři Fiala,

Ing. Antoni Jelinek, Institute of Agricultural Engineering,

Praha 6-Řepy, Czechoslovakia