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BALLERS FOR MOLDING BALES OF SHREDDED MATERIAL

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The article deals with the design and the operation principle of presses for forming cylindrical bales from shredded materials, there has been made an assessment of the quality of silage obtained from beet pulp prepared by a press manufactured by Norwegian company Orkel (model MP 2000 Compactor). It has been proved that quality of the obtained fodder does not differ from the quality of fodders formed in long foil sleeves. It has been found that on the domestic market machines of this type are not available for small and medium companies.

Keywords: *shredded materials, pulp, biogass power plant, silage*

1. Introduction

Shredded materials include: pressed pulp, spent grain, sawdust, tree bark, short straw, and other production materials often referred to as production waste. Products of plant origin are often used as animal fodder for cattle. However, due to limited access to these materials during the whole year it can't be provided throughout it. In such a situation silage of these products seems to be a good solution. Silage of fragmented materials with minimum loss is possible only by maximum reduction of pollution and ensuring oxygen free conditions of storage throughout the whole period of their fermentation, storage and feeding [4,5,6,18]. Such possibilities are provided by the newest – currently offered technology of fodder silage in the form of cylindrical bales. This technology does not apply merely to fodders collected by a round baller (straw, hay, green crop) but also includes solutions basing on stationary machines whose task is to form bales from shredded material with simultaneous protecting it from access of air [5,10,15,19]. The silage quality obtained for the cylindrical bales depends largely on the material density degree and its protection from the air access.

The density degree is affected mostly by physical properties of the material used for silage, that is, dimensions, humidity, elasticity. These properties, apart from their distinct impact on the fermentation process course, also affect the use of consumables (net, foil) as well as the costs of transport and storage [1,8,13,16,20].

2. Review of designs of stationary round balers for shredded materials

In the small group of manufacturers of these machines there are two European companies: Norwegian company Orkel (MP2000 model Compactor) and Austrian (model LT-Master).

Presently, in Poland there are used only two presses by Orkel companies in sugar factories of groups: Pfeifer und Langen and Nordzuker. They are used for silage of beet pulp. The design of this machine (Fig. 1) is based on a uni-axial chassis. In the back part of the machine (Fig. 1b) there is a cutting basket 4, with a horizontal chain - strip conveyor to which the pulp is fed. The basket can be supplied directly from the production line or by means of different types of loaders (grip, head, telescopic loaders, etc.). The main operation system of the machine is an innovative box for rolling bale 2, consisting of powered smooth rollers and two structural rubber belts of length 1.2 m. The operation box is powered by a channel from the top by means of a inclined chain - strip conveyor.

Formation of the bales is based on the principle of hybrid baller. In the initial phase of its operation the rubber belts, run through a stationary rolling chamber and their positions in relation to each other is of 'V' shape (Fig. 2).

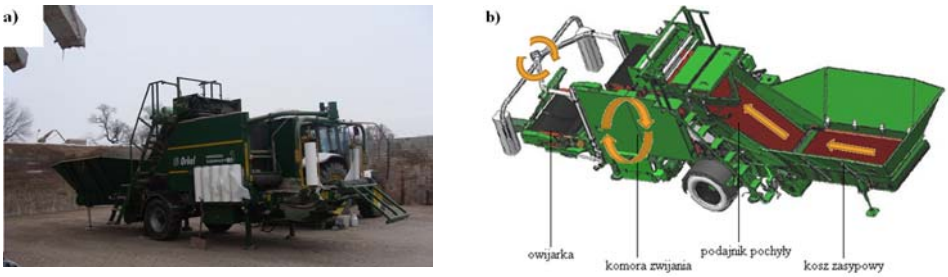

Fig. 1. Press Orkel MP 2000 Compactor: a - general view, b - construction schedule: 1 - wrapper, 2 - chamber collapse, 3 - inclined conveyor, 4 - receiving basket

Along with supplying the pulp, the chamber successively increases and the rubber belts are pressed down to steel rollers. A formed in this way ballot can be protected from falling apart by means of a net or polyurethane foil. This process is continued in the rolling chamber. The ballot after being wrapped by a net goes to the wrapper table where it is protected from the impact of atmospheric factors by 6 layers of standard tensile foil for silages of width 0.75 m. (fig.3).

After being wrapped by a foil the ballot falls freely on the ground along an inclined ramp. Ready ballots can be loaded onto transport means ant carried directly to customers or stored in the sugar company. Operation of the machine MP 2000 Copmactor is fully automatic and all functions of its subsystems are monitored, displayed and programmed by a controller. According to the manufacturer a demand for power is 90 kW and the capacity is within 40-60 bales per hour (to 60 t h^{-1} for the bale dimensions 1.2 m x 1.2 m) depending on the pressed material. The source of power can be both an agricultural tractor and an electric motor [6].

Fig. 2. Folding chamber shape in the initial phase of work (top view): 1-wrapper, 2-coiled material, 3- lateral ventricle wall collapse

Fig. 3. Formed bale wrapping with stretch film

Göweil company offers a press marked with symbol LT-Master (Fig. 4). Its design and the operation principle of the main operating system, that is, the rolling chamber, is quite similar to the press MP 2000 Compactor. The main differences between presses Orkel and Góweil involve: the way of connection with the tractor, the place of drive transmission and the manner of supplying the formed bale on the wrapper table. Change of the transporting position into the operating one and the other way round does not require its disconnection with the tractor [6]. The design of the dumping basket is a big advantage because it can be loaded directly from the self-loading trailer.

Similar solutions are offered by a Japanese manufacturer Takakita Co, Ltd. This company offers presses designed for forming cylindrical bales from fragmented materials with symbol MR - 810 (Fig. 5)., MW 1020 and MW 1220 (Fig. 6). In these machines there is a stationary rolling chamber which is an immovable front part 2 and a movable (lifted and lowered) back part 3. A distinctive feature of this Japanese manufacturer' presses is a dumping basket which rises after being filled, thus facilitating transport of the material to the pressing chamber [6].

Machines with symbols MW 1020 and MW 1220 combine a steady-chamber stationary press with a dumping basket 2 and wrapper 3 with two rotary arms (Fig. 6).

Fig. 4. Baler Gőwel LT-Master: 1-unloading ramp, 2-wrapper, 3-chamber collapse, 4-inclined conveyor, 5-receiving basket

Fig. 5. Japanese business newspaper Takakita Co. Ltd model MR 810: 1-receiving basket, 2- the front part of the chamber collapse, 3-back, moving part of the chamber collapse

Fig. 6. Japanese business newspaper Takakita Co. Ltd model MW 1220: 1-chamber collapse, 2-hopper, 3-wrapper, with two rotating arms

3. Analysis of the fodder quality

An analysis of the quality of fodder prepared with the use of Orkel (model MP 2000 Compactor) has been made. Smples of silage from the pulp in a sugar factory in Opalenica near Poznań belonging to the Nordzucer Polska Group. Silage had been stored for 8 weeks in bales. Samples for assessment were taken from 15 different sites of the bale (7).

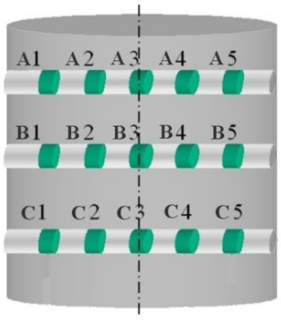

Fig. 7. Scheme of sampling sites

The range of chemical analysis covered marking of the dry mass and raw ash content (according to weedeńska method) and ammonium (by Conwey method) as well as organic acids (Lepper's method): lactic, acetic and butyric acids [2]. Value of pH was marked by means of pH - meter N5172. The main parameters of chemical content and quality of silages prepared from beet pulp in bales have been presented in table 1.

Tab. 1. The chemical composition and quality of pulp silage

Dry matter	pH	Raw ash	Ammonia	Lactic acid	Acetic acid	Butyric acid	Flieg-Zimmer's quality	
g		g kg^{-1} D.M.					points	rating
279,4 ±18,5	3,53 ±0,03	55,03 ±2,05	0,85 ±0,22	68,55 ±16,39	8,95 ±1,40	0,00 0,00	100	very good

D.M. – dry matter

Comparing quantity of the obtained parameters with literature data it should be remembered that the kind of material must be accounted for. Usually the data concerning good silages refer to fodders prepared from green crop or grass papilionaceous plants or corn.

The content of dry mass in the analyzed samples was characteristic for a good silage prepared from pressed beet pulp. Mc Donald at al. [7] claim that the share of dry mass in pressed pulps ranges from 180 to 250 g kg^{-1}. Low concentration of raw ash indicates high purity of the obtained fodder. Wilkinson [17] says that the content of this component in an ideal fodder is below 80 g kg^{-1} of dry mass.

The quality of silages is defined by numerous parameters connected with the process of fermentation, one of the most important being pH [3]. The value of this parameter was lower than the value referred to as the proper one for good silages 4,0 - 4,2 [17]. Fodders with low pH can be the cause of occurrence of acidosis in ruminants [12].

Content of ammonium as a product of protein decomposition is also an index of the silage quality. In the carried out tests the content of ammonium was at a low level. Silages of good quality contain less of this compound than those poor ones [7].

The content of lactic acid shows that the fermentation process during silage runs in a proper way. In fact, its content in good silages should reach the level 100 - 150 g kg^{-1} of dry mass, however, the share of this acid in the sum of all the acids was 88.45%, which is considered to be a proper index.

In the tested silages the content of fungistatic, that is, acetic acid was 2.5 g in fresh mass which does not guarantee the fodder stability in oxygen conditions, after being taken out from the cylindrical bale. High concentration of lactic acid and lack of fungistatic volatile fatty acids inhibiting yeasts, can have a detrimental effect on the silage durability after being taken out from a

container. Only with the content of 8 g of un-dissociated acetic acid in a fresh mass inhibits a development of fungi and yeasts which are responsible for the silage heating [11]. According to Wilkinson [17] an ideal silage can contain from 20 to 30 g of acetic acid in its dry mass.

In the analyzed silages there was no butyric which can be considered as an ideal result [17]. Absence of butyric acid in cylindrical bales of beet pulp silages indicates no effects of Clostridium bacteria operation during fermentation and – apart from the content of raw ash, it is an indicator of their purity. However, low pH can also be considered to be the inhibitor as it limits a growth of these microorganisms [7, 14].

An appropriate ratio of butyric acid tin the sum of the three acids has found reflection in a high assessment of quality. According to Flieg - Zimmer scale the analyzed silages reached the highest grade – very good.

4. Conclusion

Balers forming cylindrical bales from fragmented materials are mainly stationary machines. They are usually powered by a power take off shaft and designed for formation of cylindrical bales from such materials as: beet pulp, spent grain, fragmented corn cobs, corn chaff. As compared to the classical presses instead of a net dipper they have a built-in dumping basket and the bale forming chamber usually consists of powered smooth shafts and two structural rubber belts whose width is equal to the width of the press. Formation of bales is performed according to the rule of hybrid press operation. The ballot, after being wrapped by a net, goes to the bottom of the wrapper where it is protected from atmospheric factors by a few layers of standard foil for silages. The carried out assessment of the obtained silages quality reveled that their quality was very high, though were characterized by low pH.

Due to small content of acetic acid they can't be durable in oxygen conditions. Lack of butyric acid indicates a good hygienic status of the silages from pressed beet pulps prepared in cylindrical bales. It can be stated that their quality is not lower than the quality of fodders formed in long foil sleeves.

The above presented machines are extremely useful for service units and food production companies whose by-products are a desirable fodder for farm cattle.

It can be expected that the technology for silage of different plant materials with the use of presses will be competitive for foil bags (sleeves) formed by a silo press.

It should be emphasized that on the domestic market machines of this type are not available for small and medium companies (maximal capacity up to 10 bales per hour). The concept of such a press has been developed in the Division of Agricultural Technology of the University of Technology and Life Sciences in Bydgoszcz and Department of Agricultural Engineering of the Technological University in Koszalin. Cylindrical bales of different fragmented fodders protected from the air access by a flexible foil, have already become an attractive product available on the market of many countries.

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