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Output of round balers

Introduction

There is available a wide and varied range of machines for dry bulk fodders harvesting in the form of bales. Apart from the traditional strongly-pressing balers, there are machines forming the harvested material into large cylinder or rectangular bales. Full mechanization of large-sized bales is simpler compared to the solutions applied in the technologies based on classic, strongly-pressing balers. Large sizes of bales with high density do not allow for manual loading or storing activities. Round balers, characterized by a simple construction and high reliability have become more popular and spread in many countries with well-developed agricultural engineering. The French market of agricultural machines may serve as an example. In two years (1984-1985) about 12.5 thousands of pick-up balers were sold and 82% of them were round balers. A similar direction of change in production profiles was recorded in the USA. Since 1975 the agricultural machines industry in this country has significantly reduced the production of traditional balers for straw and hay harvesting. In just three years (1976-1978) the output of strongly – pressing balers dropped from 26.1 thousands to 23.3 thousands. The production of round balers increased in this period from 11 thousands to 18.5 thousands. By 1979 the agriculture of this country had already got 80 thousands modern type balers [5].

Special attention is deserved by the market of agricultural machines in Germany. The agriculture of this country bought about 3.3 thousands of pick-up balers in the season 1993-1994, including almost 2500 round balers. The classic pick-up balers found only 270 purchasers [3].

An analysis of the development of machines for dry bulk fodders harvesting in the form of bales implicates concern about the reasons for this significant elimination of the traditional strongly-pressing balers, giving way mainly to round balers. For a full answer to this question, however, one must take into consideration the unquestionable advantages of classical pick-up balers (high output, convenient form of the harvested material) [1, 9,12,13].

Small rectangular bales of high density ensure good exploitation of transport means load-carry ability. Such a form of the harvested material allows to store it in rooms of relatively small size, egg. utility attics. Thus it is possible to say, that the main reason for their more and more limited use is not directly involved in the functioning of the harvesting machine. Actually, it is rather concerned with the realization of further stages of this technological process (harvesting bales from a field, storage, distribution). Large bales turned out to be more convenient for the mechanization of the above-mentioned activities, which allows to significantly increase the efficiency of the whole technology and at the same time to reduce human labour [6, 8, 10].

Efficiency of round balers

A farmer faced with increasingly great economic and social challenges has to look for more and more efficient machines. It concerns the machines used for stalk fodder harvesting, as well. Growing areas of farms force farmers to seek machines with higher output, whose massive application can decrease the cost of their use. Expectations of many farms can be fulfilled by a purchase of a round baler whose exploitation advantages allow for a fast and

efficient harvesting of dry bulk fodders (straw, hay) and can be used in the technology of green forage ensilage in the form of cylinder bales [7, 8, 11].

Results of exploitation tests on round balers conducted by numerous scientific centers in many countries often differ significantly. Efficiency results of a machine of the same type (model, company) obtained in one scientific institution not rarely differ significantly from those obtained in another testing centre. Thus, a comparison of exploitation indexes is usually difficult or even impossible, due to scarce information as to the method and conditions of their determination. The data in table 1 can serve as an example of this situation. The round baler of Welger company designated with the symbol RP 200 (fixed chamber, the bale forming unit constructed with from driven rolls) obtained output in the range from 10.4 $t \cdot h^{-1}$ to 12.7 $t \cdot h^{-1}$ in tests carried out by the German Agricultural Society (DLG). The same machine proved to be much less efficient (3.28-5.59 $t \cdot h^{-1}$) in the evaluation by Tremblay, Savoie and LePhata [13].

However, it is worthwhile to notice, that significant differences in the output of RP 200 machines result mainly from running meter mass of the collected material's swaths and the applied working velocities. In the experiment conducted by DLG the weight of 1 m length swath of a hay was 2.3 kg, and the time of forming one bale (harvesting of material, wrapping the bale, unloading) was about 75 seconds. The Canadian research results state that the time of forming one bale was almost 300 seconds.

One of the most significant factors deciding on a reduction of round balers outputs is the delays needed for wrapping and throwing bales out of machine [2, 13]. High efficiency of bale forming (harvesting of material) cannot compensate for time losses resulting from auxiliary activities. The percentage of time indispensable for wrapping and throwing bales out of machine in the total working time of a shift depends on size and density of the formed bales as well as on the method of their wrapping. The results of comparative tests conducted by Fairbanks, Fransen and Schrock [4] proved that balers forming bales of large sizes (from 2.09 m^3 to 3.46 m^3) achieved outputs even 4 times higher than the machines with a small volume of the working chamber (table 2).

The currently produced round balers are usually equipped with two-twine systems of bale wrapping or with units allowing to wrap bales in a net. Compared to the traditional wrapping (using twine), wrapping bales in a net brings significant benefits. The output of a harvesting machine rises by about 15% then.

In numerous articles concerning evaluation of round balers it is stressed that their output is also largely dependent on the density of shaped bales and humidity of harvested material. The first of the mentioned factors does not directly affect the capacity of the machine during bale shaping (harvesting of material), it merely decides on the number of delays needed to realize the auxiliary activities (wrapping and throwing bales out of machine). This is confirmed, among others, by the results of exploitation tests on a round baler of the company Krone designed by the symbol 130 (bale width 120 cm, bale diameter 127 cm). From the dependencies presented in table 3 it can be seen that the output of the round baler was 1.1 $ha \cdot h^{-1}$ during harvest of green forage with humidity of 80%. This value is only as much as 52% of the output achieved during forming of bales from fodder dried up to 60% of dry matter content. In the conditions of the conducted research it was shown that the density of forage bales with low dry mass content reached about 90 $kg \cdot m^{-3}$, which, compared to the density of fodder with 40% humidity, is almost two times less.

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Table 1 – Results of exploitation tests on round balers with different working chamber design [2]

Item	Harvested material								
	Wilted green fodder			Hay			Straw		
	John Deere 575	John Deere 590	Welger RP 200	John Deere 575	John Deere 590	Welger RP 200	John Deere 575	John Deere 590	WelgerRP 200
Moisture of the harvested material, %	37	36	36	12	11	10	11	11	10
Weight of 1 m lenght windrow, kg	4,4	4,5	4,3	2,3	2,2	2,3	1,9	1,9	1,9
Working velocity, $km \cdot h^{-1}$	6,4	6,4	6,4	9,5	9,5	9,5	9,5	9,5	9,5
Bale diameter, m	1,32	1,39	1,32	1,35	1,33	1,39	1,41	1,39	1,46
Bale volume, m^3	1,61	1,80	1,69	1,70	1,64	1,86	1,84	1,78	2,09
Bale weight, kg	524	528	495	270	237	279	200	217	218
Theoretical output (1), $t\ s.m. \cdot h^{-1}$	17,8	18,4	17,6	19,3	18,6	19,7	16,1	16,1	16,3
Effective output, $t\ s.m. \cdot h^{-1}$	13,2	14,2	12,7	12,8	12,6	12,6	10,3	11,2	10,4

(1) – during bale forming (disregarding the time for both wrapping and unloading bales from round baler)

Table 2 – Results of exploitation tests on balers forming round bales of different sizes [4]

Item	Machine (manufacturer)			
	Allis Chalmers	Hesston 5400	Hesston 5800	Gehl 1500
Hay yield, t·ha^{-1}	4,39	3,32	5,67	3,07
Bale weight, kg	19,61	140,59	519,28	382,09
Bale volume, m^3	0,17	2,09	3,46	2,79
Bale density, kg·m^{-3}	111,35	67,23	150,08	136,94
Output, t·h^{-1}	3,25	9,82	13,98	6,25

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Table 3 – Results of exploitation tests on Krone 130 round baler [8]

Moisture of the harvested green fodder (hay), %	Bale weight, kg	Bale density, kg s.m.·m^{-3}	Output$^{(1)}$, ha·h^{-1}
80	630	82	1,1
70	590	115	-
60	535	139	1,9
50	477	155	-
40	411	160	2,1
30	339	154	-
20-30	256	133	2,0

(1)- dry matter yield of 3400 kg·ha^{-1}

Research conducted by Karyś [8] was concerned with the harvesting of straw with round balers differing in construction and size of chamber as well as in the method of bale wrapping. The results of this research proved that round balers efficiency is dependent on the density and size of the formed bales as well as on the method of their wrapping in the harvesting machine. The lowest efficiency was achieved by the baler Z-279 Farma, whose average effective output reached 4.72 t·h^{-1} (1.21 ha·h^{-1}). The presented value is almost two and a half times higher compared to the output of the Polish machine. The effective output of the fixed chamber baler Rollant 46 was almost one and a half times higher compared to the machine Z-279 Farma, which allowed to form bales of low weight. It should also be mentioned that the most significant factor deciding on an output of a Polish round baler was manner of wrapping the bales (one-twin system). The percentage of time for bale wrapping (starting the unit, wrapping, opening of the working chamber, bale unloading, chamber closing) was over 57% of the effective working time of this type of machine. This value is over five times higher than the one in a variable chamber machine Vario Pack 1800, equipped with a net-wrapping system (mean time of wrapping bales in a net in this machine was about 13 seconds).

Conclusion

On the basis of literature survey it is possible to say that the output of round balers is influenced by two main groups of factors. The first involves the parameters of the harvested material. The highest output is achieved by round balers during the harvesting of green forage with about 50% humidity. The shaping of bales from green forage of high humidity (directly after mowing) is a much less efficient process. The greatest differences in round balers efficiency result from the size of a thickened bale. Machines shaping bales of large volumes can achieve even four times higher outputs than machines with smaller working chambers.

References

1. Braun O. 1997. Drei Rundballenpressen DLG-anerkannt. Profi Test, 16: 16-23.
2. Buhlmann E. 1988. Rundballen im Netz. Lohnunternehmen, 6: 322-325.
3. Erntemaschinenmarkt Deutschland. Verkäufe in der Saison 1993/1994. 1994. Eilbote, 48: 6-7.
4. Fairbanks G.E., Fransen S.C., Schrock M.D. 1981. Machine made stocks compared with round bales. Transactions of the ASAE, 24(2): 281-283.
5. Gieroba J., Nowak J. 1991. Wybrane zagadnienia zbioru i transportu bel słomy i siana formowanych prasami zwijającymi. V Sympozjum pt. „Problemy budowy oraz eksploatacji maszyn i urządzeń rolniczych". Wrzesień, 23-24. Płock: 115-118.
6. Herrmann A. 1994. Transportverfahren in der Landwirtschafts. Neue Landwirtschafts, 12: 78-80.
7. Herrmann A. Sorgo R. 1993. Rundballenladewagen. Landtechnik, 7: 355-358.
8. Karyś M. 2003. Ocena technologii zbioru słomy w formie wielkowymiarowych bel. Rozprawa doktorska. AR w lublinie.
9. KRONE – rúllubindivél. Búvélaprófun. 1991. Rannsóknastofnun Landbúnadarins. Bútaeknideikd, Hvanneyri, nr 619.
10. Miserque O., Tissot S., Oestges O. 1995. Etude technico-économique des chantiers de récolte des fouragges. Station de Génie Rural, CRA-Gembloux. Note technique 58.
11. Mitterleitner H. 1992. Ballen laden, stapel, transportieren… Top Agrar, 6: 68-71.
12. Nagl T. 1992. Ballenbergung mit der Groβballentechnik. Praktische Landtechnik, 5: 7-10.
13. Strasser H., Mühlebach J. 1987. Schlagkräftiges Ballenladen ist teuer. Lohnunternehmen, 8: 450-454.
14. Tremblay D., Savoie P., LePhat Q. 1997. Power requirements and bale characteristics for a fixed and variable chamber baler. Canadian Agricultural Engineering, 39(1): 73-76.

В статті проведений літературний огляд, присвячений аналізу основних техніко-економічних показників різних конструкцій пакувальних пресів (пресопідбірачів) для прибирання соломи і сіна. Установлено, що ефективність роботи пакувальних пресів залежить в основному від двох факторів: вологості (найвища продуктивність досягається при збиранні рослинної маси з вологістю, близької до 50%) і розмірів пресованого матеріалу (кіпи). Обгрунтовується, що пакувальні преси, які формують кіпи великих розмірів, можуть забезпечувати підвищення продуктивності при збиранні врожаю рослинної маси в 4 рази.

В статье проведен литературный обзор, посвященный анализу основных технико-экономических показателей разных конструкций упаковочных прессов (пресподборщиков) для уборки соломы и сена. Установлено, что эффективность работы упаковочных прессов зависит в основном от двух факторов: влажности (наивысшая производительность достигается при уборке растительной массы влажностью, близкой до 50%) и размеров прессованого материала (кипы). Обосновывается, что упаковочные прессы, формирующие кипы больших размеров, могут обеспечивать повышение производительности при уборке урожая растительной массы в 4 раза.