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Comparing Short-chopping Self-loading Forage Wagons

Specific Power Requirements of Rack and Rotor Wagons

Experiments in practice with short-chopping self- loading forage wagons with a rotor and with a rack aggregate were carried out at the TU-Dresden, to compare both systems regarding load compaction, loading characteristics and driving power and simultaneously record data of different operating conditions as a basis for the following optimization.

Basically two technologies can be distinguished in the area of self loading forage wagons. The wagon with feeder rake (rack) has fingers, which are controlled by means of a cam track or an eccentric. The fingers draw the material through fixed knives. After cutting, the rakes compact the forage against a forage pile in the boot and afterwards the rakes are pulled out horizontally of the forage pile.

The feeder rotor of the second configuration presses the forage with its fingers through fixed knives, without pulling the fingers out of the material. Additional strippers are installed.

Since the comprehensive lab tests described in [1], no further detailed investigations of cutting-, conveying- and compacting processes, especially on rotor feeder technology were published.

In different practical tests it was determined that wagons with feeder rotor are able to achieve higher throughputs with a better cutting quality than a wagon with feeder rake, but with up to 30% higher total specific power requirements [2]. Unfavourable on wagons with rake technology are the high number of moving parts, which lead to increased wear and increased service costs, compared to wagons with rotor feeder.

Design and setup of measurement

Essential criterion for the comparing different loading wagon technologies is the specific power requirement under comparable operating conditions and with different throughputs. The determination of working speed, the measuring of the torque, the speed of tractor p.t.o. and the exact mass of the material from test track are necessary for a later evaluation.

The measuring of the power requirements was carried out with a newly developed analyzer, which is mounted and arrested on tractor p.t.o. Within the analyzer, the data are transferred contact-free with telemetry from the revolving to the stationary part. For evaluation of the throughput, the mass of every test run was determined. Two wheel scales were used. The length of the windrow and the driving speed were defined.

For determination of density of the forage above the rotor and the rake feeder, samples were taken with a core-drilling machine and the samples were weighed. With the help of those samples, a first indication for material density, dependent on height of filling in the boot were derived. The moisture of the samples were determined in a drying oven.

Implementation of measurements under field conditions

For measurements under field conditions, the following self-loading wagons were used:

- Self-loading wagon with feeder rake FE 6.37C, manufacturer Maschinenfabrik Stolpen GmbH; conveying element: cam

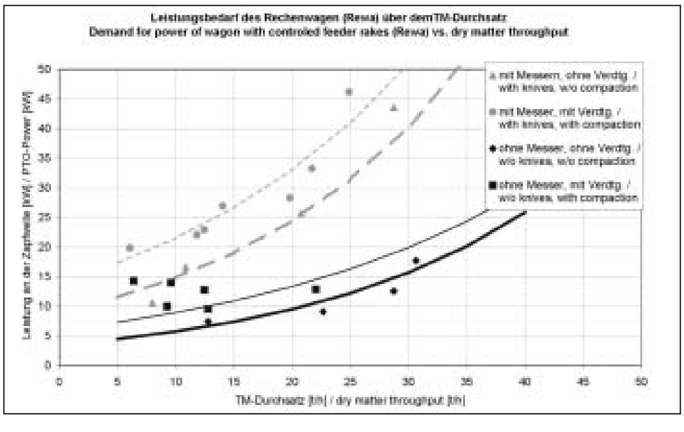

Fig. 1: PTO power vs. dry mass throughput for the self-loading wagon with rack technology

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Keywords

Power requirements, self-loading forage wagons

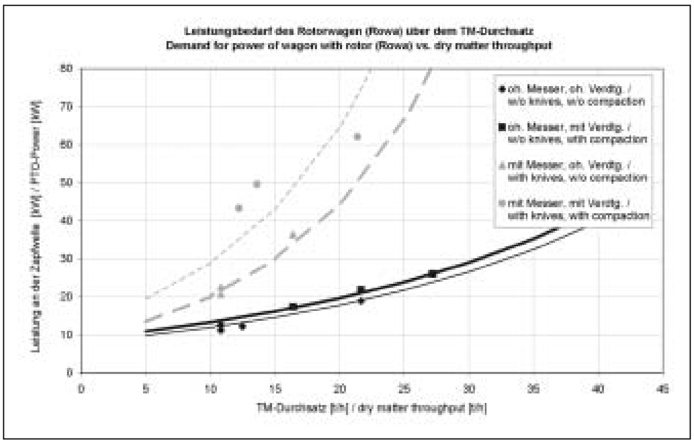

Fig. 2: PTO power vs. dry mass throughput for the self-loading wagon with rotor technology

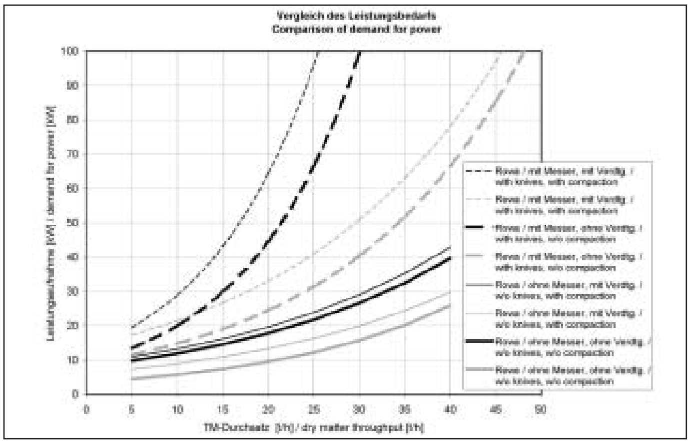

Fig. 3: Comparing pto power requirement between the two self-loading technologies

track controlled conveying motion link; cutting unit: ensiling cutting unit with total 33 knives, arranged on two levels, one level pivoting, knives on second level individually removable, theoretical cutting length 45 mm, p.t.o. speed 540 min^{-1}

- Self-loading wagon with rotor feeder K 9.55 (X1 16t), manufacturer Maschinenfabrik Stolpen GmbH, conveying element: bolted rotor with 9 rows of rakes, cutting unit: ensiling cutting unit with total 35 knives, arranged on one level; theoretical cutting length 40 mm, p.t.o. speed 1000 min^{-1}

The distance for every single test run was 30 m. The dry mass throughput during the tests varied between 6.1 t/h and 30.6 t/h, driving speeds varying from 2.5 km/h to 9.6 km/h were measured. For the investigation of operating properties, the loading wagon was filled completely in the automatic mode and the capacity data were recorded. The degree of filling within the loading wagon could be controlled by actuation of the floor conveyor. Before and after every test run, the loading wagons were weighed. Furthermore, investigations on compactness of the packing within the wagon were carried out.

Evaluation of the field tests

The results of the investigations on compactness of packing in the tested self-loading wagons can be seen in *Table 1*. Longterm experiences at the chair of agricultural machines support the theory that it is almost impossible to have comparable testing conditions for harvesting wilted grass. Especially the fast drying of the forage during testing makes it more complicated to compare tests, which are run one after another. Therefore the standardisation of test results on the basis of comparable dry mass (DM) was used. The loading wagon with rotor feeder was not able to produce a higher compaction in the boot. The question is, whether the complex design and compaction process in the conveying channel is in a passable ratio to the degree of compaction within the boot.

Table 1: Data of the measurements on bulk densitiy in the store with different methods of filling

Self-loading forage wagon	Rack	Rotor
Theoretical chopping length [mm]	40	40
Volume loaded [m^3]	24	36
Forage mass loaded [kg]	3640	7560
Forage moisture [% DM]	36	27
Mean density (fresh mass) [kg/m^3]	152	210
Mean dry matter density [kg/m^3]	55	57

Those test runs with both self-loading wagons were repeated with different throughputs to measure the torque requirement dependent on throughput of material. The results are depicted in *Fig. 1* and *Fig. 2*.

A comparison of both basic designs is easily possible by means of a regression curves (*Fig. 3*).

Regarding the dry mass throughput, the following can be deflected: the percentage of compaction performance of the rotor feeder (Rowa) is 20 to 30 % when operating with knives, and when operating without knives 8 to 12 %.

For the rake feeder, the percentage of compaction performance when operating with knives, is 20 to 30 % and when operating without knives 20 to 35 %. The rotor feeder needs 50 % more power for compaction than the rake feeder (comparison of the values "Ohne Messer" "without knives"). The necessary power for chopping is increasing faster with increased throughput (exponentially) for the rotor feeder than for the rake feeder (about twice the power requirement at 20 t/h DM).

Conclusion and Perspectives

During field tests, two different self loading wagons were investigated. The fundamental objective was to determine the necessary power requirements for the chopping and compacting processes on two different types of self-loading wagons. The necessary power for different throughputs was measured for both wagons. The following findings can be outlined: the percentage of performance for compaction for both technologies is about 20 to 30 % of the total power requirement. The necessary power for cutting increases faster with increased throughput for the rotor feeder than for the rake feeder. The reason is the different movement of the rakes. For pure compaction, the rotor feeder has a 50 % higher power requirements.. With higher throughputs, a better cutting quality could be observed for the rotor feeder. The compaction in the boot is very different and the range is from "not compacted" to "very high compacted" for both designs.

The results show that until now no existing design of a self-loading wagon fulfils all requirements. Self-loading wagons are used almost only in Central Europe. A cost effective and high quality forage harvest is necessary for an economically successful milk production in Central Europe. A self-loading wagon, which combines the advantages of both designs, can contribute to this.

Literature

Books are marked by •

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