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Investigation of a Combine Straw Chopper with Precision Cutting

Flail choppers are state of the art for straw comminution in combines. The proven technology is functionally reliable, but there is optimization potential in chopping quality and power requirements. Within the framework of a DFG (German Research Foundation) promoted project the suitability of an alternative chopping system with precision cutting was investigated at the Institute of Farm Machinery and Fluid Technology, where the material to be cut is clamped and the chopping takes place between the cutting edge and the ledger plate.

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Keywords

Combine harvester, straw chopper, cutting principles, efficiency

In agriculture, the principle of precise chopping is widely applied in cylinder forage harvesters, for example. The examination of the suitability of a precision chopper for use in combines is the topic of the studies described in this contribution, which is being carried out at the Institute of Agricultural Machinery and Fluid Power.

In addition to the development of a suitable chopping unit, the present project includes the experimental measurement and evaluation of influences of different design and kinetic parameters on the operating behaviour of the chopper. This allows the general suitability of this technique for combining to be assessed and general conditions for the use of such a unit to be determined.

In order to confirm the suitability of the unit for the mentioned application, other functional requirements must be met in addition to power consumption and chopping quality. For this purpose, a test rig was set up and equipped with measuring instruments.

Test rig

The test rig is shown in *Figure 1* [1]. Above the chopping unit, a force feeder is installed which takes the crops in, compresses them using two funnel-shaped conveyor belts, and feeds them into the chopper. The crops are cut between a countershear and the rotating knives (*Figure 1 right*). This chopping principle, which is characterized by the fixing of the crops and the location of the cut in the countershear area, is termed precise cut. In principle, the unit shown above is a segmented chopping drum with an open design, which has some special design features due to the required variability and the kind of use. Numerous sensors are installed which allow driving power, the rotational speed of the drive, and different process forces to be recorded and thus enable the processes during chopping to be understood. In addition, it is possible to observe the processes with the aid of a high-speed camera.

Measurement results

This trial set-up allows the influence of numerous parameters on the operation of the chopper to be examined. Of these parameters, only a few selected examples are described here.

Below, the effects of the rotational speed of the chopper as a decisive influencing variable will be shown, and a possibility of comparison with the flail chopper will be given. The described measurements were carried out at a throughput of 20 t/h. In the precision chopper, a distance of 0.5 mm between the knife and the countershear was set, and a feeding speed of 0.7 m/s was chosen. The rotational speed of the chopper was adjusted between 850 and 1,450 rpm, which provides an rpm-dependent theoretical chopping length of 15 to 25 mm and cutting speed alteration in a range from 25 to 42 m/s. This influences the chopping process signi-

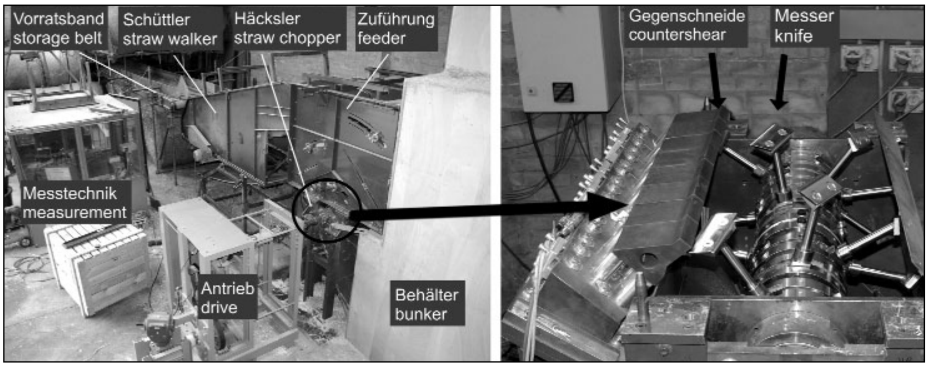

Fig. 1: Design of test rig

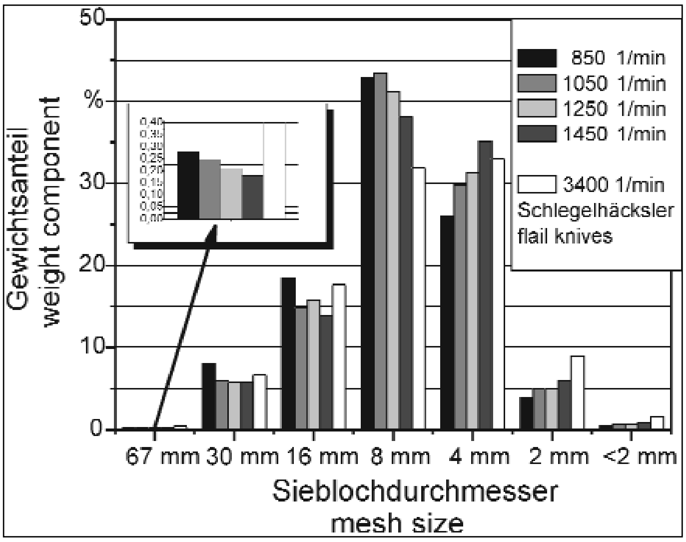

Fig. 2: Analysis of chopping quality

ficantly and results in a large range of variation within this one trial series, which can be compared with a flail chopper.

Measurements taken on the same test rig with a different chopping shaft and free-fall crop intake served as reference. The flail chopper was operated at 3,400 rpm without additional braking bars or counterknives.

Figure 2 shows the chopping quality of the precision chopper at rotational speeds of 850 to 1,450 rpm and the chopping quality of the flail chopper at 3,400 rpm in comparison.

The bars show the weight components of a chopping sample, which was divided into fractions using a multiple-stage sieve with the mesh sizes indicated above (67 mm to 2 mm). Those components which are separated at a mesh size of 67 mm are particularly disadvantageous because very long straw particles (beyond 95% > 120 mm in length [2]) impede optimal distribution and are not broken up sufficiently so that they would rot quickly enough on the field. An enlarged view shows that the use of the precision chopper allowed the percentage of oversized particles to be reduced as compared with the flail chopper. Even for the next coarser fractions (30 mm and 16 mm), precision chopping provides better quality, at least at a rotational speed of 1,050 rpm or more and in the given configuration. The very short fractions of chopped crops (mesh size ≤ 2mm) are also reduced in favour of medium lengths. Thus, the result comes one step closer to the ideal of even chopping length without any oversized fractions for subsequent seedbed preparation [3].

However, chopping quality must be considered in relation to the power requirements because a chopper on a mobile machine may only consume a limited amount of power for both logistic and monetary reasons.

Figure 3 shows the power requirements of the precision chopper in the described trial runs.

The diagram shows that the power consumption of the chopper drive is approximately proportional to the rotational speed of the chopper. This primarily results from the number of cuts, which rises proportionally with the rotational speed of the chopper. In the examined range of rotational speeds, power consumption varies between 20 kW and 34 kW. In addition, approximately 3 kW are consumed for conveyance/precompression by the conveyor belts. The test run with a flail chopper shown in *Figure 2* was carried out with crops from the same field under identical conditions. At about 34 kW, power consumption was at the level reached by the precision chopper at 1,450 rpm. Chopping quality, however, was poorer.

If the driving power required for both chopper variants is compared under the conditions of comparable chopping quality, which means that the flail chopper trial is compared with the precision chopping trial at 850 rpm, the required driving power including the feeding equipment differs by more than 30% in favour of the precision chopper.

Summary

The studies carried out in the described research project examine the question of whether the application of the precision chopping principle to straw chopping in the combine can meet the goals with regard to power consumption and chopping quality. The trial series carried out so far show the great potential of precision chopping for application in the combine chopper, especially since good chopping quality can be reached while power consumption is relatively low and achievable quality can be influenced in a wide range.

In addition to the mentioned points, other factors, such as crop ejection speed, susceptibility to collision during contact with foreign bodies, susceptibility to malfunctions and ease of maintenance will also significantly influence the evaluation of operating behaviour. Therefore, other trials will be carried out with these aspects in mind.

Literature

Books are marked by •

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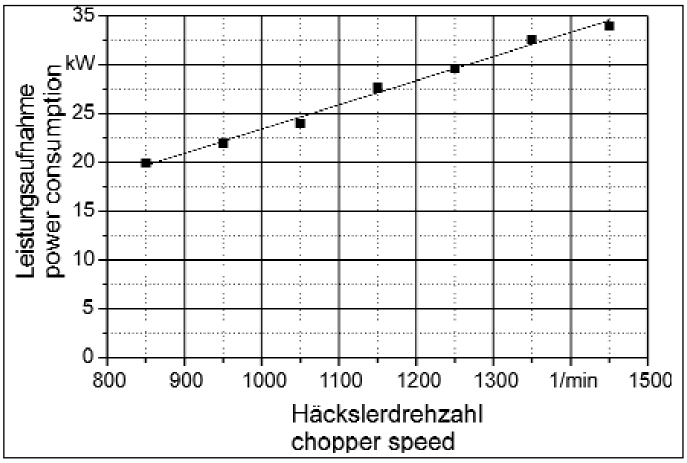

Fig. 3: Power consumption of the chopper at different speeds