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# Influence of the straw alignment on the cutting quality of a combine's straw chopper

Besides the harvesting process the cutting of threshed straw and its uniform distribution is of major importance during the grain harvest. The stochastic orientation of less stable stalks in a combine's straw chopper causes uneven cutting lengths. According to the working conditions uneven cutting length could cause problems during their distribution on the field due to fines. Overlong cut stalks induce problems at following cultivation operations. The Institute of Mobile Machines and Commercial Vehicles (former Institute of Agricultural Machines and Fluid Power) at the Technische Universität Braunschweig researches the correlations and parameters of the influence of straw alignment on the cutting quality of a combine's straw chopper by using simulation and practical experiments.

**Keywords**
Combine harvester, straw, simulation

**Abstract**

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During the grain harvest the cutting of threshed straw and its uniform distribution is of rising importance. An even and short cutting length of straw is desirable for undisturbed soil preparation and sowing especially in conservation tillage systems. As the power requirement of the chopper increases with reduced cutting lengths, the cutting length of the straw has to be as uniform as possible in order to avoid unnecessary cutting operations. However, in practice the cutting length of a combine's straw chopper varies significantly [1 – 3] as the less stable and quite short stalks are supplied to the blades in an unsorted mat. Further aspects of the theoretical considerations and information on the current state of the straw orientation in a combine's straw chopper can be found in [4; 5].

## Experimental setup to examine the alignment angle's influence on the chopping quality

A stationary test rig is used to research the influence of the straw alignment on the chopping quality practically in addition to theoretical considerations. The configuration of the chopper with 32 knives and its optional equipment with a cross blade, counter knives and a grating element is representative for up to date combine's straw choppers. The width of the chopper is equal to half of the drum width of a six walker combine. A horizontal conveyor belt is used for the continuous feeding of the chopper. A defined amount of straw is placed on it before each experiment. The appropriate instrumentation of the test rig allows the measurement of the input speed and the torque of the chopper shaft. Furthermore, selected experimental settings could be recorded with a high speed camera to enable an optical evaluation of the processes in the chopper. **Figure 1** displays the layout of the test rig.

An oscillating screen with six different screen diameters is used to get information on the cutting length distribution of the cut straw. Mainly the separated straw at the large screen diameters of 30 mm and 67 mm is of importance as the overwhelming weight component of overlong stalks is separated at these. The overlong stalks can cause problems at following tillage and

Fig. 1


*Test rig for experiments with a combine straw chopper*

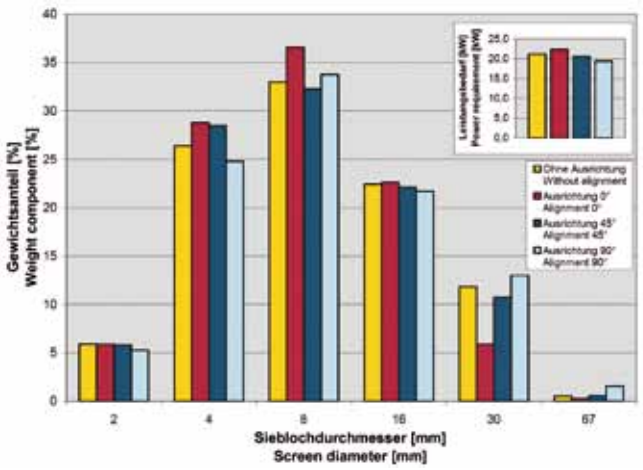
seeding operations. Furthermore, the fraction of the smallest screen with a screen diameter of <4 mm should also be considered in the evaluation of the cutting quality as the separated fines can cause problems with the uniform distribution of the chopped material on the field.

## Experiments and selected results

The stalks are aligned manually on the conveyor belt to research the influence of the stalk orientation on the cutting quality. The stalks are aligned as parallel as possible. The alignment angle defines the deviation from the optimal alignment of the stalks in relation to the knives. For the experiments the orientation of the stalks is set to an alignment angle of 0°, 45° or 90°. Accordingly optimally aligned stalks have an alignment angle of 0°.

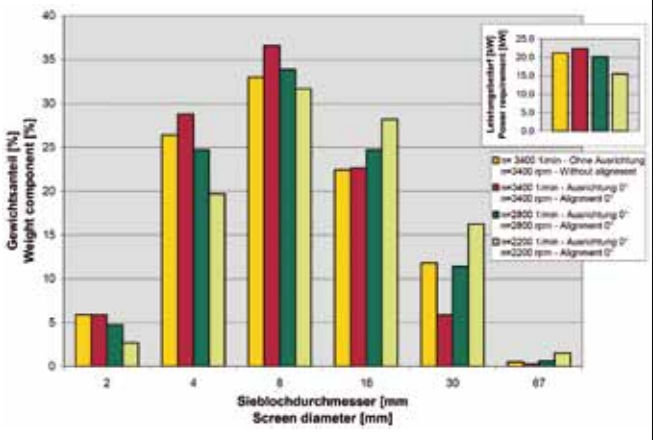
Selected results of the experiments are displayed in **Figures 2** and **3**. **Figure 2** shows the cutting length distribution according to the alignment angle with a straw throughput of 2.8 kg/s and a chopper speed of 3400 rpm. For the experiments the chopper is equipped with a cross blade and counter knives.

Fig. 2




*Cutting length distribution according to the alignment angle*

Fig. 3




*Cutting length distribution according to the chopper's speed n*

Unifying and optimizing the straw alignment decreases significantly the excess length at the screens with 30 mm and 67 mm screen diameter without a significant increase of fines. The improvement in chopping quality is connected to only a small increase of power consumption.

**Figure 3** shows the cutting length distribution according to the chopper speed n with optimally aligned stalks. The straw throughput is again 2.8 kg/s with an identical equipped chopper with a cross blade and counter knives. Due to the optimally aligned stalks the chopper speed can be reduced to 2800 rpm without significant loss of cutting quality compared to the experiment without special stalk alignment. However, by reducing the chopper speed a slight decrease in power consumption of the chopper can be detected. With a further reduction of the chopper speed to 2200 rpm a significant increase in the excess length is visible.

The experimental results demonstrate that a significant improvement of the chopping quality is possible by optimizing the alignment of the straw in a combine's straw chopper. Furthermore, the improved straw alignment can also be used to reduce the chopper speed in association with a reduction of the power requirement.

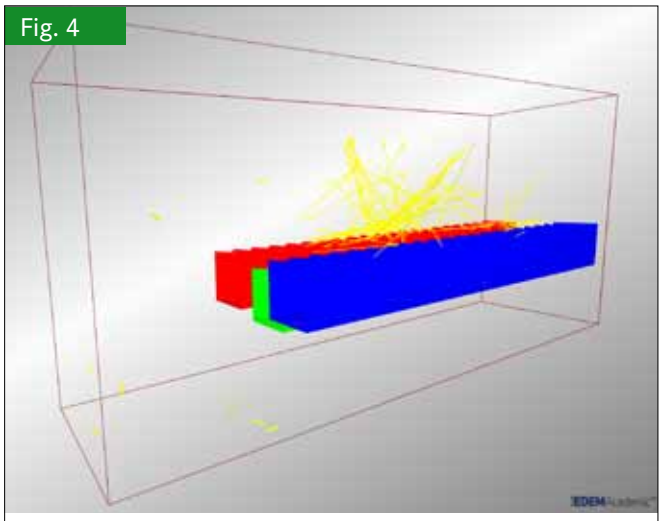
## Simulating the characteristics of straw to develop an alignment device

The above described experiments display an obvious dependence of the chopping quality from the stalk alignment. Therefore, it is useful to examine approaches of mechanizing the alignment of the stalks. In a first step the potential of modifications of the standard straw walker of a combine are investigated to unify the straw alignment.

The "Discrete Element Method" (DEM) is used to simulate the behaviour of straw during the transport and alignment process on the straw walker. The structure of the stalk model is based on the approach described in [5]. The stalks are modelled as chains of connected balls in a first approximation. The connections between the balls are flexible so that a bending of the stalks is possible. The geometrical dimensions of the stalk model are based on the measurement and weighing of 60 threshed wheat stalks.

The current state of the simulation model is presented in **Figure 4**. The stalks are given in a random alignment on the right side of the three walkers. They are transported by oscillation of each walker to the left side. The walkers oscillate with a phase-shift of 120° to each other. The side frames of the walkers are extended to arrange the stalks during the transport process in longitudinal direction on the bottom of the walkers. The first evaluation of the simulation indicates that this experimental setup is able to align straight stalks satisfactorily. The consideration of kinks in the stalk model and adapting its level of detail to reduce the simulation time is part of the current research work. The verification of the simulation will be provided on the test rig.

Fig. 4



*The behaviour of straw in a DEM-simulation*

## Conclusion

Based on the theoretical considerations and practical experiments the presented project offers high potential for optimizing the cutting process. The selective alignment of stalks can be used on the on hand to improve the chopping quality and the other hand to reduce the power consumption of a combine's straw chopper. Simulating the behaviour of straw provides an important tool to support the research work. The adjustment between the level of detail and the requested application is of great importance in order to achieve meaningful results in a reasonable simulation time.

## Literature

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