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Function development of a hybrid separation system for combines

The development of a hybrid combine was supported with lab- and field-tests by TU Dresden. The ability of the threshing unit from a walker combine for higher throughput of a hybrid combine was verified. Several parameters were analysed at a test stand, where this threshing unit was integreted in a hybrid separation system with two longitudinal rotors. The threshing drum speed and the rotor speed have the most important influence on the separation. The threshing drum speed should be only so high that the threshing is guaranteed. The rotor speed is a compromise between small rotor loss and low cleaning system load.

Keywords
Hybrid combine, separation, rotor loss
Abstract
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In the development of a hybrid combine the Technische Universität Dresden (TU Dresden) supported the function development of the hybrid separation system. Hereby, separation at the threshing unit and at the rotors were the most important points. Laboratory as well as field trials were conducted. Firstly, laboratory tests were conducted to verify whether the threshing unit of a walker-type combine was suitable for a hybrid combine. Subsequently this threshing system was adjusted, combined with two longitudinal rotors placed side by side, and built into a trial combine harvester. This configuration was field-tested in several countries, the trials being supported by the TU Dresden. A test stand with the hybrid separation system enabled investigation of material throughflow and separation.

Threshing system trials

To investigate the threshing system of the walker-type combine this was rebuilt as a test stand in the laboratory. The threshing unit comprised drum, beater, subsequent rotary separator and corresponding concaves. The straw walker members were removed and replaced by a conveyor belt for transporting material not separated at the threshing unit out of the combine (**figure 1**). It was thus possible to determine performance of the threshing unit alone in separation of grain and non-grain-components (NGC). For the trial, unthreshed wheat was fed into the unit. Thereby NGC throughput of 10-50 t/hour over a test time of 10.4 s was realised. The following parameters were investigated:

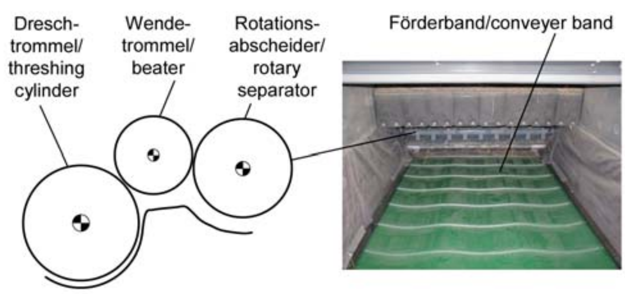
- Drum speed (n = 1 100, 950, 750 1/min)
- Drum concave gap front/rear (v/h = 8/5 mm, 12/9 mm)
- Covers at rotary separator concave (Concave: open, closed at rear, completely closed)

The evaluated parameters were the percentage of separated grain from the total grain material fed into the threshing unit and the percentage of NGC material separated from the total NGC material fed into the system.

As expected, separation performance was reduced as NGC throughput increased whereby grain separation reaction in this respect was linear and NGC separation degressive (**figure 2**). Of the researched adjustment parameters drum speed had a greater influence on separation than concave gap. Thus, e.g., grain separation reduced from 83 to 68 % with a NGC throughput of 40 t/h if drum speed was slowed by 30 %. With a 50 % increase in front concave gap, on the other hand, grain separation was only reduced from 83 to 79 %. NGC separation showed a similar behaviour. A completely covered rotary separator concave reduced grain and NGC separation whereas a concave closed only in the rear area had hardly any effect.

In total it was shown that the threshing unit of a walker-type combine could also contend with the substantially larger

Fig. 1



Schema and conveyer band of threshing unit test stand

throughput of a hybrid combine. The associated increased slip in drive system, however, required an adjustment of the drive to meet the higher loads of a hybrid combine.

Trials with the hybrid separation system

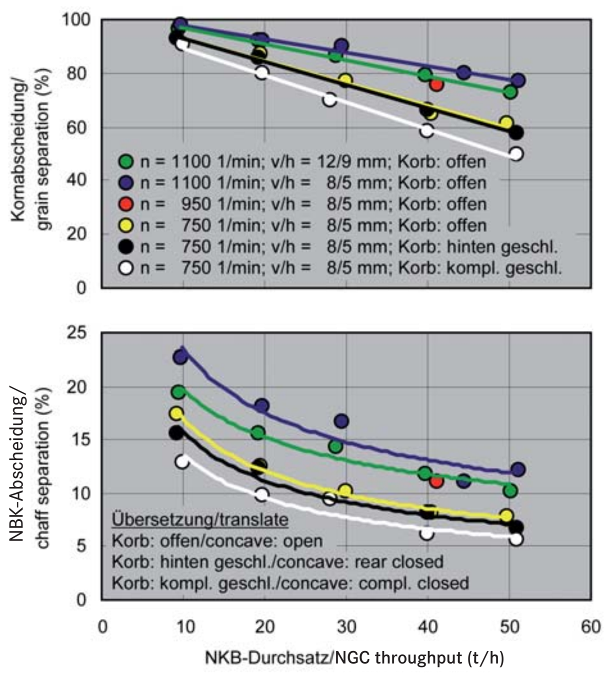
The test stand for investigating the hybrid separation system comprised an altered walker-type threshing system and two added longitudinal rotors with appropriate concaves (**figure 3**). In the threshing unit alterations, the walker combine rotary separator was rebuilt in such a way that it served as a feed-beater, dividing the material flow into two streams for feeding the rotors. As in the threshing unit of the walker combine, a separation concave was provided in the front part of the feed-beater housing. Compared with an actual combine harvester, the test stand has the advantage that separated materials can be collected as different samples along the separation length thus permitting differentiation of the separation process. Drum and beater as well as feedbeater each produce their own samples taken from the entire test stand breadth. The rotors are divided into 6 classes of sample over the length and in 4 classes over the breadth, the latter enabling lateral distribution of separated material to be determined. These trials were also conducted with unthreshed wheat and NGC throughputs of 10 to 50 t/h over a test period of 10.4 s. Calculations from the results of the field trials resulted in a larger concave gap (v/h = 14/12 mm) gap being set. For determining required power, speed and torque of drum, feedbeater and the rotors were measured. The following parameters were investigated:

- Feedbeater speed
- Different concave types of the rotors
- Different wheat varieties and ages
- Covering of concaves at the rotors
- Speeds of drum and rotors

The results recorded during the tests with the threshing unit on its own were confirmed with the hybrid separation system. The linear grain separation and degressive NGC separation reactions at the threshing unit in response to increasing NGC throughput could also be seen here whereby, in this case, the threshing unit comprised only the threshing and beater drums. At the feedbeater and rotors the percentage of grain separation increased linearly with the increasing NGC throughput whereby the percentage of NGC separation in the latter function elements was relatively independent of NGC throughput (**figure 4**).

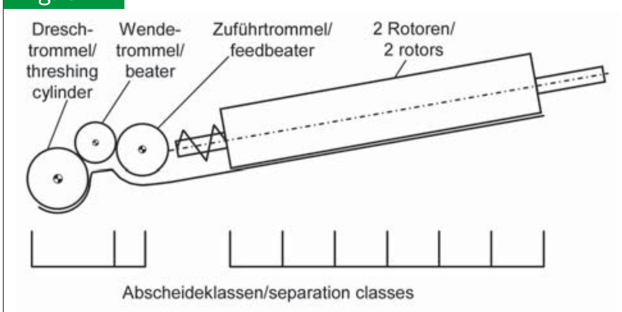
Variation of the feedbeater speed and concave types on the rotors had no important influence on the evaluated parameters. Different wheat varieties and ages influenced, above all, NGC separation. The greatest influence on separation results was threshing drum and rotor speeds. The target for optimising is a reduction of rotor losses (grain losses in the field) with at the same time as low as possible NGC separation so as not to overload the cleaning system. For investigating the optimum combination of threshing drum and rotor speeds a complete diagram of characteristics was prepared. This indicated a variation of drum speeds from 800–1 100 1/min and rotor speeds from 700–1 000 1/min at a NGC throughput of 40 t/h.

Fig. 2



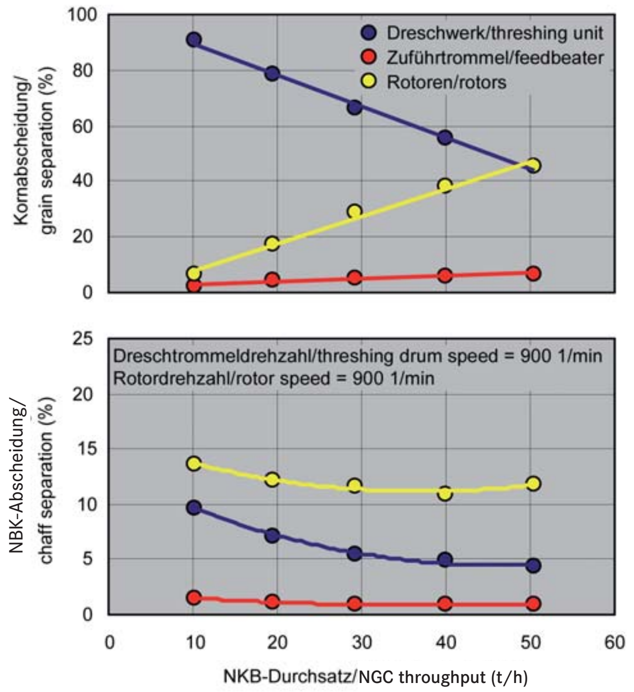
Grain- and chaff separation at threshing unit test stand

Fig. 3



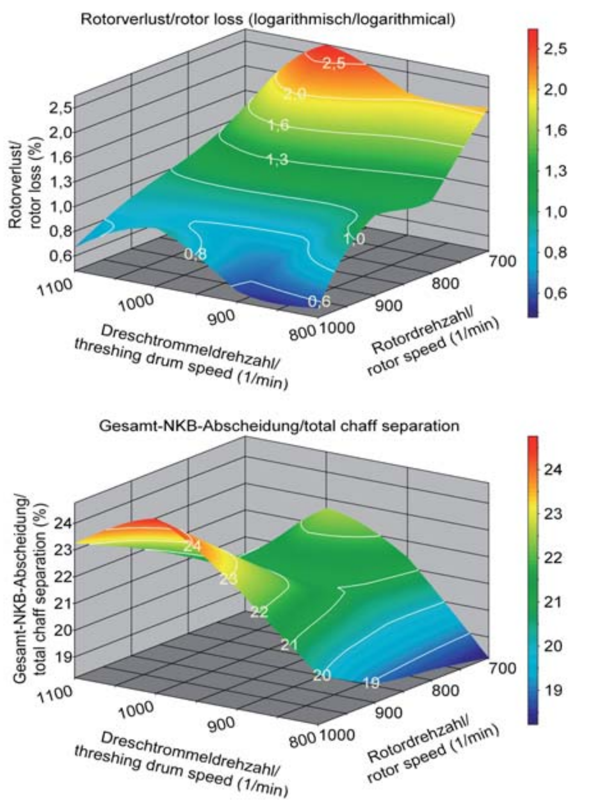
Hybrid test stand

Fig. 4



Grain- and chaff separation at hybrid test stand

Fig. 5



Threshing drum speed-rotor speed-maps

Conclusions

Although grain separation at the threshing unit reduces linearly with reduction in threshing drum speed, rotor losses in the investigated area are relatively independent of threshing drum speed (**figure 5**). This result corresponded with trial findings with walker-type combines whereby a higher threshing unit separation through aggressive threshing did not always lead to reduced walker losses. A reduction in rotor losses was, as expected, achieved by increasing rotor speed. The total NGC separation of the hybrid separation system increased with rising drum speed as well as with increasing rotor speed, whereby the influence of the threshing drum speed was greater (**figure 5**). This appears to support the conclusion that drum speed should be as low as possible and only run at a rate that ensures efficient threshing. The setting of the rotor speed, on the other hand, is a compromise between minimum rotor losses and a low NGC separation.

The power requirement of the threshing unit rose with the increase threshing drum speed. Higher rotor speeds also led to an increasing power absorption by the rotors. The power requirement of the threshing unit was independent of the rotor speed, whereas power absorption of the rotors increased slightly with reducing threshing drum speed.

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