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Investigation of the Grain Pan of Combine Harvesters

The threshing capacity of combine harvesters has been constantly increasing, e.g. thanks to additional threshing and separating cylinders. These cylinders hackle the straw more, which increases the loads in the cleaning shoe and causes higher grain losses. In Hohenheim, a test rig for grain pan investigations has been constructed. The influences of pre-demixing and, hence, on the process quality of the cleaning shoe were examined.

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Keywords

Combine, cleaning shoe, grainpan

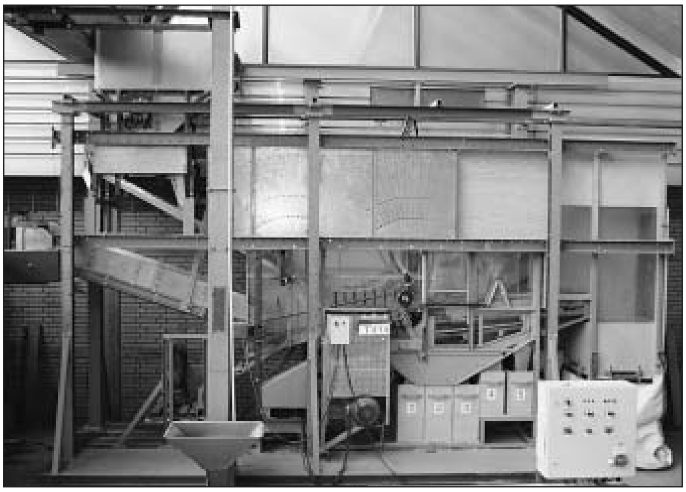

Fig. 1: Test rig with grainpan and cleaning shoe

The performance of the cleaning shoe can be increased by improving de-mixing on the grain pan [1]. It is the task of the grain pan to catch the mixture of grains and material other than grain (short straw, chaff, parts of leaves, weed seeds, dust) separated by the threshing unit and the grain-straw separating units and to convey this mixture to the cleaning shoe for separation. During conveying, the mixture is pre-demixed by gravity. The grains lie underneath, whereas the lighter material other than grain (MOG) lies on top [2, 3]. Many studies [4, 5, 6] showed that improved pre-demixing on the grain pan had a very significant effect on cleaning losses.

Test Rig and Realization of the Test

For the examination of the grain pan, a new test rig was constructed at the Institute of Agricultural Engineering in Hohenheim (*Fig. 1*).

The grain pan has a large adjustment range so that edge areas of the grain pan can also be examined. The working width of b_{VB} = 500 mm roughly corresponds to the sieve width in the combine between three separators. At this width, the edge influence of the side walls made of acrylic glass is small.

The adjustment range of the grain pan is dimensioned such that the falling step is always the same even if grain pan settings vary. With the aid of a hole grid, the longitudinal inclination of the grain pan can be varied from –15° to +15° in steps of 3°. The frame is suspended from four arms. At each of its ends, one rubber damper element is installed, which also serves as a pivot bearing. The length of the arm can be varied in four different lengths from 600 to 1,200 mm. The inclination angle can be adjusted in steps of 3° from –9° to +42°. Thus, a change in the angle of the grain pan corresponds to an alteration in slope inclination while geometry remains the same. Additionally, the length and the inclination angle of the front- and rear arm can be altered independently, and the transmission angle between the front arm and the connecting rod (coupler) can be varied. This allows acceleration in the vertical and the horizontal direction to be examined regardless of the inclination angle. The length of the connecting rod can be adjusted to between 1,000 and 1,500 mm. The grain pan is driven directly by a gear motor via a crank mechanism. Frequency can be varied in a range between 3 and 6 Hz, while an eccentric allows for stepless amplitude adjustment from 5 to 55 mm.

For the trials, a series grain pan having a length of l_{VB} = 1,880 mm and a step profile of 30•10 mm was used.

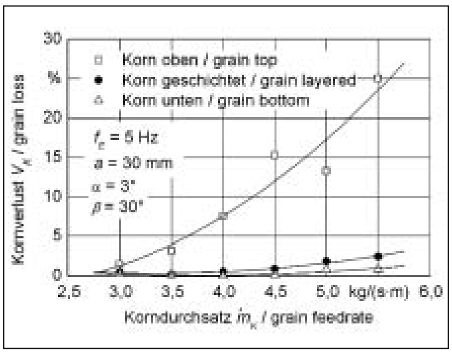

Fig. 2: Influence of layering on the grain loss

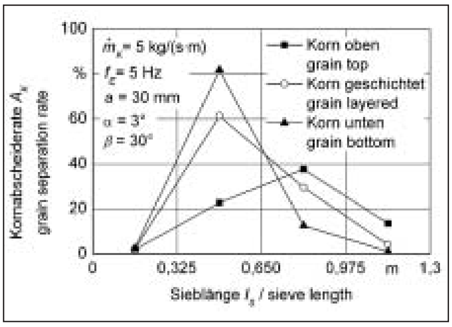

Fig. 3: Influence of layering on the grain separation rate

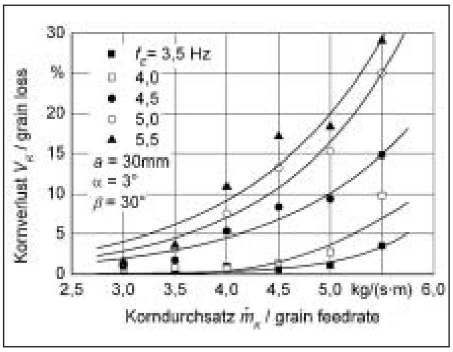

Fig. 4: Grain loss versus different frequencies

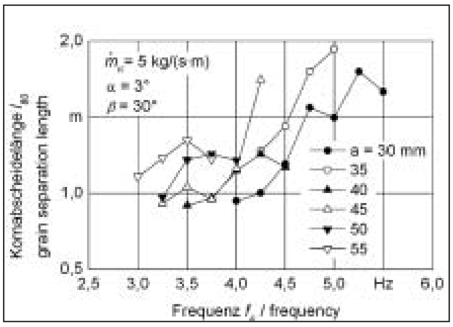

Fig. 5: Influence of frequency on the grain separation length l80 at different amplitudes

In order to determine the work quality of the grain pan, a series cleaning shoe was installed behind the grain pan as an indirect measuring method. The width of the sieve shoe was adjusted to the width of the grain pan. The sieve shoe was divided into four separating sections in order to be able to carry out an evaluation over the length of the sieve. In the fifth section, the tailings are caught. Sieve losses are collected in a bag at the end of the sieve in order to determine grain losses.

Instead of the radial fan, a cross flow fan was installed in order to gain the necessary space for the adjustment of grain pan inclination. The MOG was fed into the system by a 14 m long conveyor belt, which was evenly loaded by hand with chopped straw.

For the even metered addition of the grains onto the MOG layer, a grain metering system is used. In the standard grain-MOG setting, the grains are fed onto the MOG layer in a ratio of 70 : 30 %. Grain throughputs of up to $\dot{m}_K$ = 5.5 kg/s.m) are examined. In order to prevent the material from de-mixing at the transition from the conveyor belt to the grain pan, the grains are added to the MOG layer on the grain pan directly after transition.

For material speed measurements on the grain pan, a high-speed camera which takes 250 photos per second was used.

Results of the Investigation

So far, trials at different grain throughputs, frequencies, and amplitudes have been carried out.

Influence of Material Layering

Figure 2 shows the influence of layering. The significant influence of the kind of grain layering on grain losses can be clearly discerned. The influence of the throughput is particularly pronounced if the grain layer is on top. In comparison, grain losses remain low if the grain is at the bottom. This applies even if grain throughputs are high. The “grain layered” curve, for which the grain was distributed on 1/3 of the MOG, is at a slightly higher level.

Figure 3 shows the influences of layering on the course of the grain separation rate over sieve length at a throughput of $\dot{m}_K$ = 5 kg (s.m). If the grain is at the bottom, a high grain separation rate is already reached in the second separation section, whereas it is significantly lower at the beginning of the sieve if the grain is on top.

Influence of Frequency

Mechanical stimulation exerts a significant influence on the conveying speed of the material layer on the grain pan, the relative motion of the material particles in relation to each other and the vibrating surface, the loosening of the material layer, and, finally, the selection of the material particles by the straw grid. *Figure 4* shows grain losses as a function of grain throughput at different frequencies. At all frequencies, grain losses increase with growing grain throughput. At lower frequencies, they remain at a lower level due to the longer dwell time. At larger grain throughputs, grain losses grow disproportionately.

Figure 5 shows the influence of frequency at different amplitudes. With growing frequency, the dwell time decreases significantly due to the higher conveying speed. At large grain throughputs, this time is no longer sufficient for the complete de-mixing of the grains from the lower MOG layer.

Figure 6 shows conveying speeds as a function of frequency at different amplitudes. With growing frequency, conveying speed increases more significantly at larger amplitudes than at smaller ones. At larger amplitudes, material trajectories grow, which results in higher conveying speed.

Summary

Numerous trials at different grain pan settings have already been carried out on the test rig, which has proven to be highly reliable in terms of function. The parameters were able to be set without difficulties so that different parameter variations were possible.

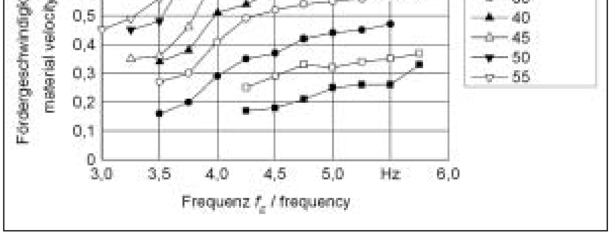

Fig. 6: Influence of frequency on material velocity at different amplitudes

Literature

Books are marked by •

[1] *Segler, G., und T. Freye*: Vibro-pneumatische Trennung von Stroh, Korn und Spreu im Mähdrescher. Grundlagen der Landtechnik 27 (1977), Nr. 4, S. 101-108

[2] • *Rochell, P.*: Untersuchungen über den Fördervorgang auf dem Schwingförderer unter besonderer Berücksichtigung der Reinigungsanlage im Mähdrescher. Dissertation, Universität Stuttgart, 1975, Forschungsbericht Agrartechnik VDI – MEG Nr. 4

[3] • *Botschkov, N.*: Obosnovanie optimalnih reschimov raboti i konstrukzii transportnoj doski sernouborotschnogo kombajna (Begründung des optimalen Betriebes und der Konstruktion des Förderbodens des Mähdreschers). Dissertation, Institut für landwirtschaftliche Maschinen, Rostovna-Donu, 1972

[4] • *Spittel, A.*: Optimierungsuntersuchungen eines Rücklaufbodens der Reinigungseinrichtung, dargestellt am Beispiel des Mähdreschers und der Fruchtart Weizen. Dissertation, Universität Dresden, 1980

[5] • *Beck, F.*: Simulation der Trennprozesse im Mähdrescher. Dissertation, Universität Stuttgart, 1999, VDI-Fortschritt-Berichte, Reihe 14: Landtechnik/Lebensmitteltechnik Nr. 92

[6] • *Zhao, Y.*: Einfluss mechanischer und pneumatischer Parameter auf die Leistungsfähigkeit von Reinigungsanlagen im Mähdrescher. Dissertation, Universität Hohenheim, 2002, Forschungsbericht Agrartechnik der VDI-MEG Nr. 387