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Working performance of cleaning units of combine harvesters on sloped fields

The performance of a combine harvester is determined by the maximum throughput at acceptable grain losses. At optimum throughput, the cleaning system reacts very sensitive to variations of the inclination, whereby the influence of lateral inclination is much higher than the influence of longitudinal inclination. The influence of inclination up to 15 % on the performance of cleaning units with lateral hillside modulation was analyzed. For this purpose several combines of equal type of construction have been analysed in different crops using large-scale parcel tests. The deployed measurement instrumentation corresponds to the series-production status of the combine harvesters. Various testing conditions and systematic errors make the handling of the collected data very complex. However, it enables the evaluation of the measurement characteristics of different sensors at variable inclination. The results display a possible triplication of cleaning losses in different throughput ranges between 15 and 55 t/h already at a lateral inclination of 10 %. The influence of longitudinal inclination is marginal.

Keywords

combine harvester, cleaning unit, grain loss, slope, control system

Abstract

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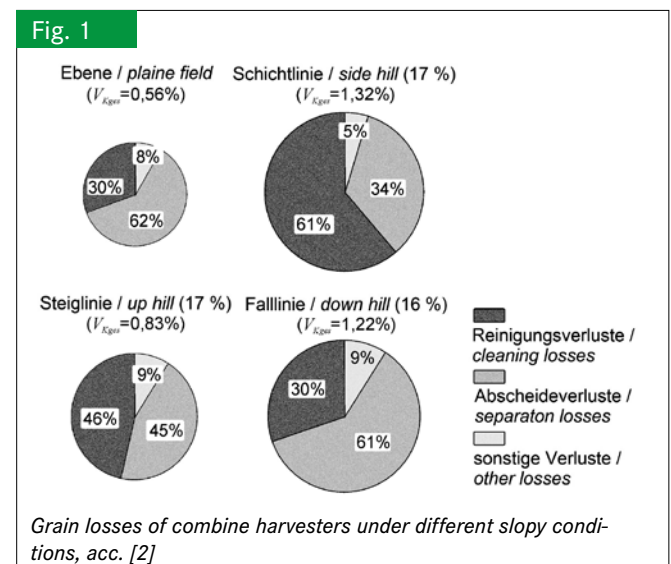
■ Cleaning units in combine harvesters are using air flow through the oscillating sieves. The working performance of these units is very sensitive to inclinations. In Germany for example the biggest part of the agricultural fields are nearly flat. But 30 % of the field area has inclinations of over 5 %, **Figure 1**. Due to his overall tasks the adjustment of the cleaning unit to the inclination of the machine can only partly adopted by the driver of a combine harvester. And this adjustment is difficult due to the continuous change of the inclination during work. Therefore the fundamentals for an automatic control of the settings of cleaning units in actual combine harvesters working on slopes have to be developed [1].

Grain loss behavior of combine harvesters on slopy fields

The tendency of the grain loss behavior of combine harvesters working on hillside is known. Surely there are differences in quantity between single models. But the published tendency

of Pfahler is still valid [2]. He analyzed test reports of the DLG (German Agricultural Society) about 16 different combines with walkers. The main results are summarized in **Figure 1**.

On plain fields the cleaning losses are 30 % of the total losses. The total losses increase about 135 % when working on side hill with 17 % slope. The cleaning unit itself reacts more sensitive and their share increases up to 61 %. Working downhill the total losses are something less as on side hill. But the



share of the cleaning losses is comparable to the situation on plain fields.

The dynamic behavior of cleaning units during the transition from plain field to hill side and back are not described in literature.

The different manufacturers are offering several solutions to reduce the grain losses of cleaning units under slopy harvest conditions.

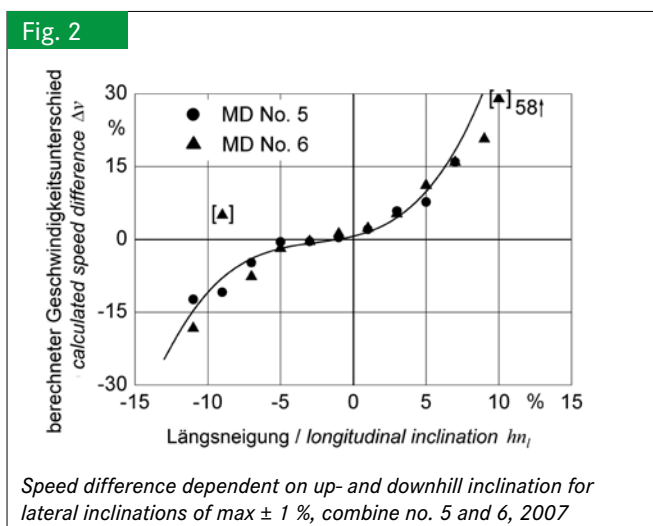
Test set up and execution

For the evaluation of the grain loss behavior of cleaning units under practical conditions seven combine harvesters (Claas Lexion 580) were equipped with data loggers. They recorded automatically measurement values via the CAN-bus system of the combines, e.g. driving speed measured by the rotation of the driven wheels, inclination longitudinal and lateral, GPS-position, machine adjustments, signals from the grain loss sensors and throughput. The combines were used on a farm in the Thuringia Basin. On 4 200 ha combinable crops were planted. 1/3 of the area was more inclined than 5 %, but only 3 % of the area has more than 15 % inclination.

Data processing

All recorded data were checked for plausibility, uncertain data sets were filtered out and corrections and calibrations for different data were done. For example exemplary measured values of machine inclinations were checked with the real inclination in the field. However effects from the bigger deflections of the tyres at the downhill side could not be considered.

As another example the driving speed, calculated from the rotational speed of the driven wheels, was compared with calculations from GPS-position data. With increasing inclination the slip increases disproportional (Figure 2). An inclination of 5 to 10 % results in an error for the speed measurement of approximately 15 %. The quantity of this error depends also on other parameters like soil moisture, mass of the machine, tyre inflation pressure and driving speed. This error has influence on the calculation of harvested area and on yield.



Also the time lag between the different measured and calculated values was taken into account for the further analysis.

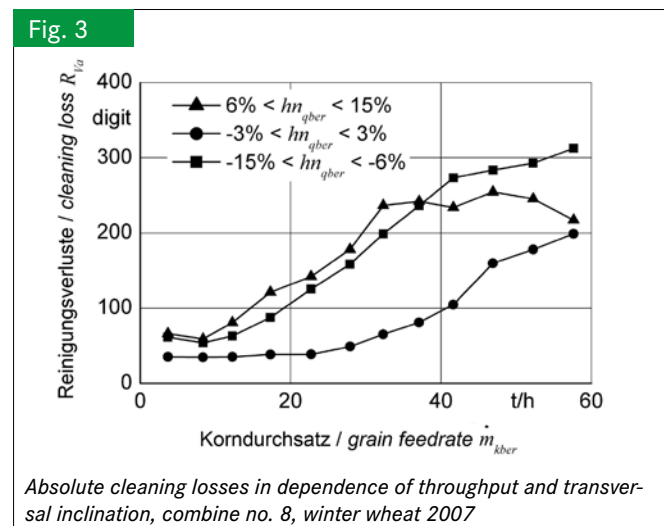
Impulse blade sensors are not measuring exactly the grain losses on combine harvesters. The portion of grain kernels hitting the sensor surface is not constant. It depends on harvest conditions (e.g. throughput, inclination of the machine) and on crop properties (e.g. crop moisture, straw brittleness). Under nearly constant conditions the tendency of the grain loss sensor signals is correct and represents a value for the absolute grain losses. Referring this signal on the actual throughput helps to assess the relative grain losses.

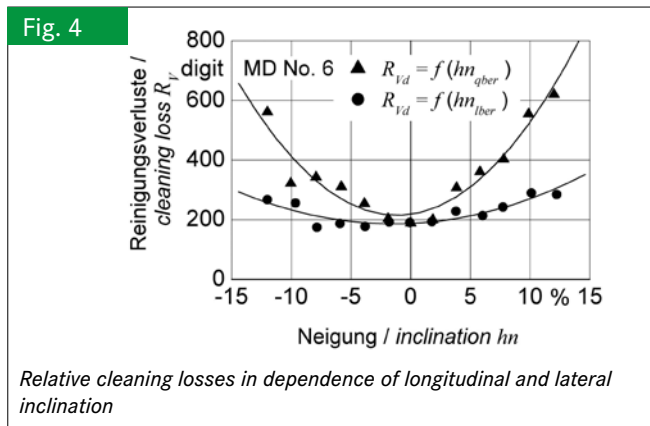
Results

The test results are reflecting among other things also the difficulty for the drivers to react on changing yields. Variable yields cannot be compensated totally by adapting driving speed. So often high throughputs are achieved with high yields and small throughputs are caused by low yields. This results in variable operating conditions for the combine harvesters in practice.

The characteristic performance of a cleaning unit could be confirmed: high losses at low throughputs due to the overblowing of grain, light losses at medium and increasing losses at high throughputs due to the insufficient loosening of the bulked material layer. If the cleaning losses were analyzed with regard to their absolute values, then they are nearly constant at lower throughputs (Figure 3).

Working at sidehill conditions has a big influence on the cleaning losses. It has to be emphasized that the 3D cleaning system has worked correctly and that the losses would be bigger without this system. With inclinations of 6 to 15 % the cleaning losses are increasing with nearly factor 3 with respect to the losses under nearly flat conditions. Under very high throughputs the increase levels out. This is probably due to the bulked phase when less numbers of loss kernels are separated from the material layer and hit the loss sensor. Additionally, the amount of data at throughputs of 50 t/h and more, especially at inclinations, is really small and their quality is less covered.





The influence of longitudinal and lateral inclinations on the relative cleaning losses is summarized for one combine in one season in one type of crop (**Figure 4**). There is nearly no difference between up- and downhill working conditions on the relative losses. At 15 % longitudinal inclination they increase approximately by 50 %. At 15% lateral inclination the losses increase up to 250 %.

Dynamic analysis was also done from the recorded data. Focus was laid on the behavior during filling and emptying of the combine harvester while entrance and exit from the crop. During this passage the driver has to adjust driving speed, header height and also he has to steer. So he is not able to adopt additionally the adjustment especially of the cleaning fan to the changing conditions and the losses are for a short time very high. Based on these detailed measurements an automatic control of the fan speed for a loss reduction during these phases is possible. Further results are in the stated literature [1].

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Literature

- [1] Fliege, L. (2011): Einfluss der Hangneigung auf die Leistungsfähigkeit von Reinigungsanlagen im Mähdrescher. Dissertation Universität Hohenheim, Forschungsbericht Agrartechnik des Arbeitskreises Forschung und Lehre der Max-Eyth-Gesellschaft Agrartechnik im VDI (VDI-MEG) Nr. 495. Aachen, Shaker Verlag
- [2] Pfahler, K. (1986): Einfluss der Hangneigung auf die Verfahrenstechnik am Beispiel des Anbaus von Getreide und Körnermais – eine Grundlage für die Bewertung hängiger Flurstücke. Dissertation Technische Universität München, Forschungsbericht Agrartechnik des Arbeitskreises Forschung und Lehre der Max-Eyth-Gesellschaft Agrartechnik im VDI (VDI-MEG) Nr. 119

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