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Kernel-detection Sensor in the Return for Improved Combine Harvester Adjustment

To exploit modern combine capacity the machine must be adjusted to the harvesting conditions. Besides the driver's experience, knowledge about the return in quantity and composition is required for targeted combine adjustment. A sensor for detecting kernel return is presented and the use of the kernel return sensor signal, in combination with measuring the return volume for machine adjustment, is illustrated.

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Keywords

Harvester, sensors, cleaning device, return

Literature

[1] *Maertens, K., J. De Baerdemaeker, H. Ramon and R. De Keyser*: An Analytical Grain Flow Model for a Combine Harvester, Part II : Analysis and Application of the Model. J. agric. Engineering Research 79 (2001), no.2, pp.187-193

Increased performance levels of combine harvesters today are achieved through intensive threshing and separating processes in multi-drum threshing mechanisms or axial rotors. This development has lead to the situation that in dry harvesting conditions the cleaning system can become the limiting factor in regards to combine harvester performance. An adjustment according to the current situation of the cleaning system is therefore of high importance to fully utilise the harvester's installed power.

Knowing the amount and the consistency of the returns is a proven help in the adjustment of the cleaning system according to the diverse crops and harvesting conditions. Additionally, changing separation conditions can be seen in the tailings return system before they can be seen in form of higher crop loss or reduced crop cleanliness. Therefore, the tailings return system can be seen as an "early diagnosis system" for excessive crop losses or high foreign material content. As of today, experienced combine operators monitor the tailings return system and / or check the returns amount display to sporadically visualise the operating condition of the cleaning system.

To significantly enhance the proper adjustment of the combine harvester settings, Claas has developed a tailings return system - Grainmeter. This Grainmeter combined with the already existing returns volume display now provides reliable information about the returns amount and its grain portion and thereby the composition of the returns.

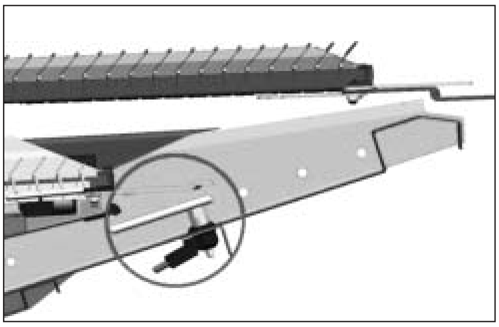

Fig. 1: Tube sensor for detection of the kernel return

Importance of the tailings return system in combine harvesters

To emphasise the importance of the tailings return system in properly adjusting the cleaning system and machine setting, we take a closer look at the tasks and requirements of the tailings return system in combine harvesters.

The task of the tailings return system is:
- to send no-threshed heads and grain, which still has a beard or partial awning back to the threshing system,
- to provide a high rate of cleanliness in the grain tank by returning the crop material with grain which was separated in the last

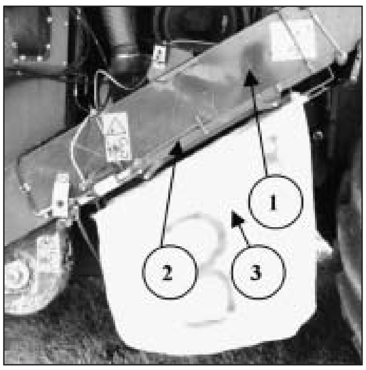

Fig. 2: Test set-up to measure the return

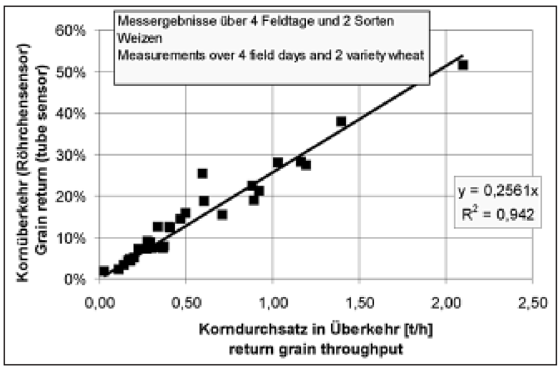

Fig. 3: Measurement results for validation kernel return

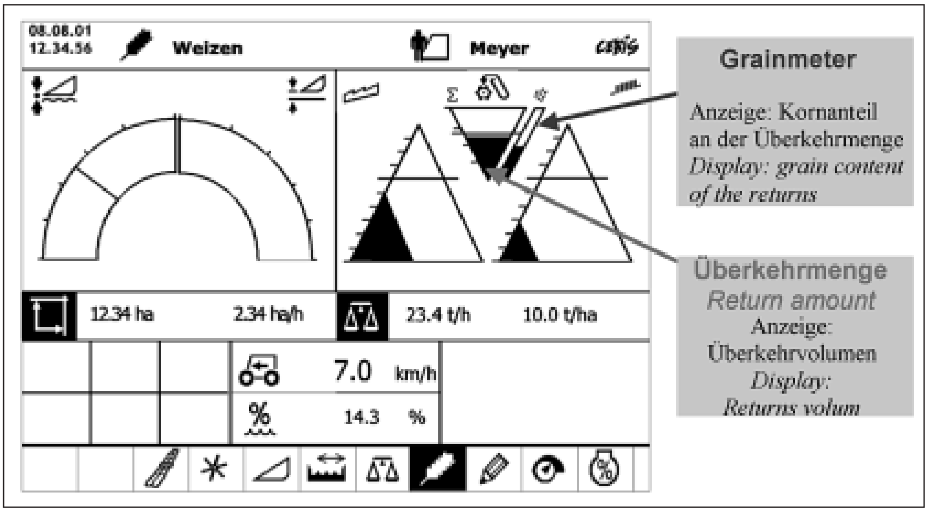

Fig. 4: The return quality display on the Claas CEBIS-Monitor

section of the upper sieve and the lower sieve overflow back to the separation process.

Since the tailings return system loads the separation process in the combine harvester even more, the following requirements have to be satisfied.

The returns should contain

- all non-threshed constituents
- a minimum of clean grain, which would be exposed to an increased risk of crop damage in a secondary threshing process and which would falsify yield mapping results.
- a minimum of chaff, since this leads to an additional load which will cause a reduced performance of the separation and cleaning system.

The separation process within the cleaning system is mainly determined by the varying separation characteristics of the biological product "small grain", and thus the returns underlie vast changes in amount and composition. This influence on the separation process emphasises the high importance of the setting of fan speed and upper and lower sieve opening to achieve a maximum combine harvester performance.

The measuring of the returns

Requirements

The goal of the development of the Grainmeter at Claas was to provide the operator a tool for setting the machine with which he easily can recognise the result of his optimised tailings return system setting. Thus, it was not so important to state the grain flow rate in the tailings return system exactly in t/h, but to supply a reliable quality parameter of the grain portion in the return's amount.

Selection of the measuring principle

Basically, the measuring of the grain portion in the returns and thus the returns composition can take place directly by weighing (mass flow) or indirectly with the use of substitute parameters. The idea of weighing the returns directly can't be pursued because the grain portion is only available together with the chaff and there is no easy way to weigh the returns amount in the tailings return system. Volume measurement, impact sound measurement and capacitive measurement will be considered as indirect measurement principles. Due to the high portion of chaff volume in the returns, the use of the volume measurement - which has been proven in the grain yield meter - is not possible. It is also already used to measure the returns amount. Capacitive measurement can't be used because of high variations in moisture, particularly in the chaff.

Impulse count via impact sound is proven and fully developed at the loss detection sensors, so here is "only" an adaptation for the new type of operation required. Therefore this measurement principle is used.

Choice of point of measurement and type of sensor

The returns grain flow should preferably be exposed at the point of measurement, and the grain should be able to fall on the sensor from a height of > 30 mm. This scenario is given in the area behind the lower sieve and under the upper sieve (*Fig. 1*). Additionally, in regards to time, the signal is available directly at the creation of the returns.

At first, the high grain impulse density rendered the known plate sensor as not suitable. Therefore a tube sensor was used. It is mounted in such a way, that it detects the grain coming from the lower sieve overflow and the grain that has passed the front third of the returns area on the upper sieve. This ensures that the display of the grain meter is representing the grain amount in the tailings return system.

Validation of the grain sensor in the tailings return system

Figure 2 shows the measurement set-up for validation of the grain sensor.

During the field test the tailings return elevator (1) is cut open at the bottom side and closed with an electrically actuated slider (2). The sampling took place after achieving the quasi-stationary phase by opening the slide while the harvester is passing a distance of 10 m. While the sampling takes place the returns are gathered in a bag (3). Afterwards the returns in the bag are separated into chaff and grain and weighed.

Figure 3 displays the measurement results of four test days in two types of wheat. The measurements show that the grain sensor readings in percent (100% is the saturation limit of the sensor) correlate well with the grain throughput in the tailings return system, which was determined in the samples.

Optimal machine settings by the combination of returns amount and Grainmeter

For the operator to work effectively with the returns amount and its composition, an appropriate visualisation is required. Therefore these displays were clearly arranged near the grain loss display on the CLAAS CEBIS-monitor (*Fig. 4*). After a short adaptation phase the driver can see grain loss and returns at a glance and react to it, if required.

Due to the Grainmeter the operator can now easily find the optimal operating point for the cleaning system.