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Opto-electronic sensors for on-line measurement of the seed rate during drilling

The realization of path-independent metering drives for drills requires that the seed rate setting be controlled by sensors. The currently available optoelectronic sensors are unable to measure the grain flow with sufficient precision. For error correction techniques, measuring accuracy is insufficient as well. Changed installation locations of the sensors as well as developments in automation technology could lead to a solution of the problem.

While during precision drilling the number of grains per area unit can be set and kept precisely, the technique usually applied during drilling is seed volume metering, which requires controlling the seed rate with the aid of a calibration test. Current, path-independent metering drives for seed drills and the thus realizable site-specific seeding of grain, rape, and leguminous plants enable the seed rate during the seeding process to be changed. For the control of the actual seed rate, sensors which allow the number of grains to be measured on-line are desirable.

Through the comparison of the set- and actual seed rate value, a control loop for the seed rate can be implemented, which allows the calibration test to be dispensed with and significantly increases the precision of this seeding technique. The optoelectronic registration of passing grains in the seed tube by a light barrier is being considered as a promising method. At Hohenheim University, optoelectronic sensors available on the market and prototypes were comparatively tested and evaluated with regard to their measuring accuracy.

Demands on Sensors

For an accurate measurement of the current seed rate, seed quantity should not be indirectly deduced from weight or volume because this may lead to significant deviations due to different influences. Instead, the number of grains passing per time unit must be determined precisely without the uncertainty factors of changing thousand-grain weight, altering seed density, and metering imprecision. If individual grains in the seed tube are intended to be detected by optoelectronic sensors, one must expect measuring accuracy to be influenced by the size of the seeds, the number of passing grains per time unit (grain frequency), and the uniformity of the grain sequence [1]. Especially in pneumatic drills, the measurement should be carried out by contactless sensors without interference with the seed flow.

In an individual seed tube, grain frequency for different kinds of seeds can be deduced according to figure 1. The shown lines of identical grain frequency enable current grain frequency, the seed rate per m^2, and the driving speed at a fixed coulter distance of 12.5 cm to be correlated.

During grain seeding, grain frequency amounts to approximately 250 Hz. For rape, the size of the seeds rather than frequency can be assumed to be the limiting factor for detection by optoelectronic sensors. Larger seeds, such as peas and broad beans, put lower demands on detection because grain frequency is very low. The reliable detection of the seeds must also be possible if the grain sequence is very uneven, as in most seed drills [2]. The tolerable maximum measurement error was limited to 5% in order to

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Keywords

Seed drill, seed rate, sensors

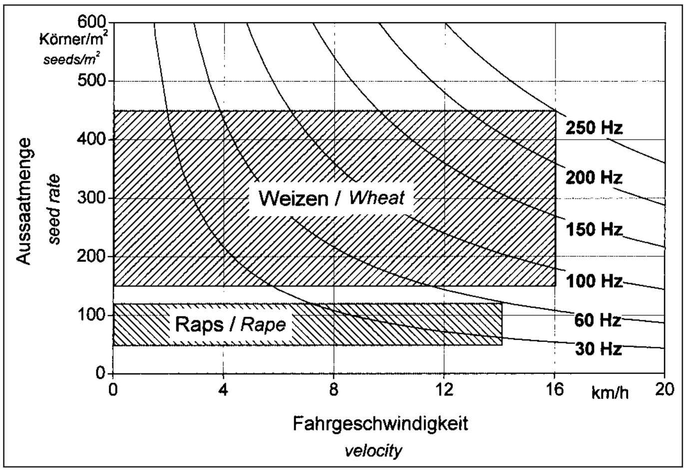

Fig. 1: Grain frequency in a seed tube depending on driving speed and seed rate

guarantee reliable control precision under practical conditions.

Measuring Technique

In addition to a conventional fork light barrier with several parallel ray paths like the systems used in industrial engineering, two sensors were employed to measure the seed flow in the seed tube. Both sensors featured three infrared diodes/receiver pairs each. As an additional measuring instrument, the „OptosensorMatrix 190“ of Hohenheim University was used, which is usually employed to measure the quality of longitudinal grain distribution during drilling [3]. Due to an alternating arrangement of the emitter-/receiver pairs, this sensor is characterized by a small distance between the ray paths and enables the receivers to be scanned individually within the measuring window.

For the establishment of a precise correlation between the measurement error and the kind of seed as well as grain frequency, the sensors were tested in two different experimental set-ups at very low grain frequencies. A grain counter was used as a metering system for very low grain frequencies of up to 20 Hz. For higher grain frequencies and grain sequences, a drill metering system within a stationary measuring set-up was employed. During the measurements, the sensors were considered comparatively in both experimental set-ups at the same grain flow rate. The total number of the passing grains during a measurement was checked both manually and using a grain counter. In addition to the metering element of the grain counter being used for measurement, it was also employed as a reference after initial examinations because no measurement error was observed up to a certain adjustable metering frequency if the seeds were clean.

Results

The dependence of the sensor measurement error upon grain frequency and the size of the seeds was able to be confirmed in the experiments carried out. Since in all cases fewer grains were registered than actually passed the sensors, the measurement error has a negative sign here (*fig. 2*).

A relatively heavy increase in the measurement error at low grain frequencies of up to 20 Hz must be attributed to seed metering by the grain counter. With growing grain frequency, the grain counter produced a more uneven grain sequence, which caused a disproportionate decrease in measuring accuracy with growing grain frequency. During seed delivery by a conventional drill metering system, only the influence of growing grain frequency on the measurement error could be observed because the composition of the grain sequence over all frequency ranges is approximately identical. The three sensors tested did not achieve sufficient measuring accuracy for them to be used in the seed tube for seed rate measurement. During measurements with rape, only slightly better measurement values were able to be gained despite the considerably reduced grain frequency, which reached a maximum of 80 Hz. Despite the low measuring accuracy of the sensors, the dependence of the measurement error upon linear grain frequency suggests the application of an error correction technique. Here, the calibration curves can be deduced from the measurement results. Nevertheless, such a method cannot be recommended in this case because sophisticated calibration curves would have to be established for each sensor and each kind of seed as well as all seed drills. In addition, the goal of a grain frequency measurement cannot be considered reached if a percentage of more than 20% of the values gained is only based on an estimate.

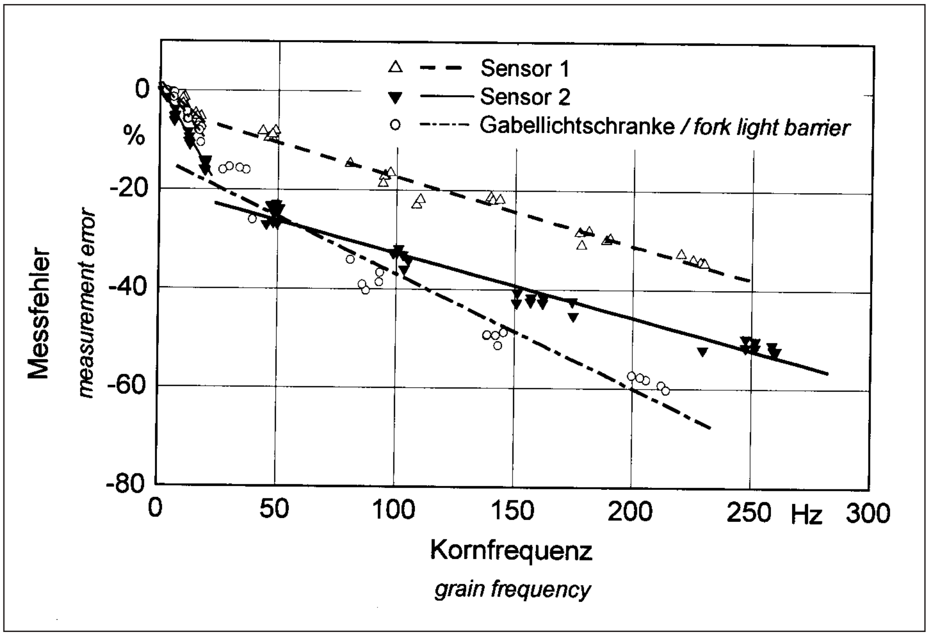

Fig. 2: Measurement error of tested sensors at rising grain frequency of wheat

Conclusions

Currently available optoelectronic sensors are unable to measure the grain flow with the accuracy needed for seed rate control. The application of error correction techniques also requires significantly higher measuring accuracy. The possibility of improving the accuracy of optoelectronic sensors should be examined. Individual scanning of the emitter-/receiver pairs allows the measuring accuracy of multiple ray light barriers, such as those in the OptosensorMatrix 190, to be increased. In addition to considerations regarding other installation locations within the seed drill, the view of those developing such a seed rate measuring sensor should also be directed to other areas, such as automation technology in industry, where some very similar solutions in process control have already been realized.

Literature

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