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Yield recording with square balers

On the basis of an existing patent, standard components were used in the construction of a weighing system for square balers. First trials indicate that the error margin is less than 7% with continuous baling. Decisive here is that the complete bale lies as long as possible on the weighing roller. This can be achieved through raising the weighing roller above the level of the bale chute by 8 mm. Weighing precision increased in-line with increased length of bale.

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Keywords

Yield mapping, square baler, weighting

Site-specific yield mapping in forage crops gives additional information which should ease management decisions. Solutions in this context have already been presented for the silage harvester and round baler. With the latter, yield mapping is achieved through permanent weighing of the complete baler [1, 2, 3]. The heaviness of square balers (~ 8 t) means this system cannot be applied.

Reflections on this problem led to ideas featuring the development of the bale chute as a weighing element, whereby on this point there already exist solutional concepts legally protected by patent [4, 5, 6].

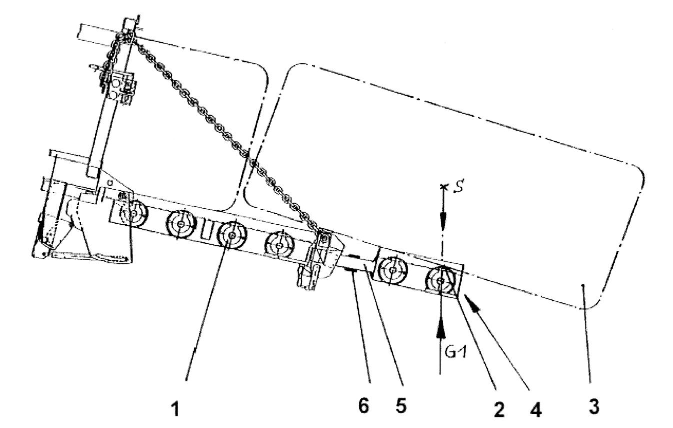

Fig. 1: Weighting device for loading slides

As an industry research commission the Bavarian State Institute for Agricultural Engineering was given the task of developing a method for determining bale weight. This method was not to interrupt the bale production process. The resulting weighing unit had to be universally applicable, i.e., able to be fitted to other makes, and also free from third party patents. The electronics had to be based on standard components and easy to operate. Weight was to be determined with a maximum error of 7%. Here it proved possible to refer to system already patented (patent letter DE 19835163) for CASE Harvesting Systems GmbH [7].

Function

A frame for additional rollers (2) was constructed for translation of the patent into practice. This was attached to the end of the original bale chute by two shear force sensors (5) (*fig. 1*). The individual bales (3) are carried by the chute (1) until each tips over onto the additional rollers. At this moment the total weight of the bale (G1) is supported by the rollers. The weight is measured by the shear force sensors, and the measurement signal is amplified (500 Hz) for recording on a robust PC.

Determining bale weight

The amplified analogue measurement signal of the shear force sensors is recorded with a mobile data recording instrument. At the same time, the moment when each bale arrives at the weighing point, or leaves it, is recorded through interruption of a light beam mounted before the weighing roller.

Bale weight is determined through averaging of 450 readings. With a recording rate of 500 Hz this represents an averaging calculation over a period of 0.9 seconds. The bale weight is derived from the maximum measurement from the shear force sensors taken whilst the bale is in position – a situation notified by the interruption of the aforementioned light beam.

Naturally, the expected precision of bale weight determination will be dependent on different parameters such as machinery settings, bale length and/or bale weight. For this reason trials with wheat straw were carried out. At a forward speed of 8 km/h, bales of different lengths (1.5, 2.0 and 2.4 m) were produced. With the same material and baling

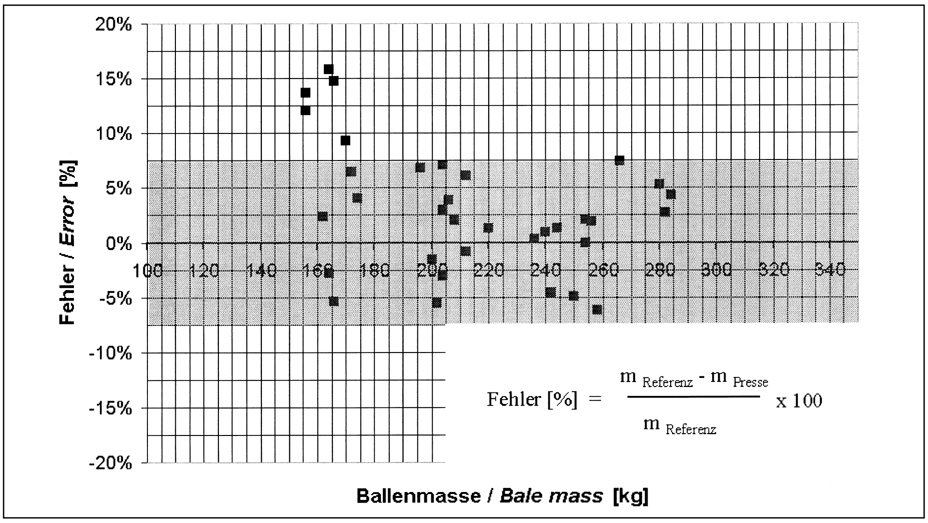

Fig. 2: Relative error of the bale mass with different bale masses

pressure, bale length and weight remained in direct relationship so that in this trial the results could not be attributed to a single parameter.

The results are shown in *figure 2*. In this trial the weights of all bales of over 200 kg (length 2.0 and 2.4 m) could be determined with an error of ≤ 7%. With shorter/lighter bales (1.5 m/ 160 kg) the relative errors were greater. Five from 10 bales were too light with an error >7%. This result was also reflected in absolute figures. Thus, an average variation of 8.6 kg was calculated for the 2.4 m long bales. The results with shorter/lighter bales differed by an average of 13.9 kg from the reference weighing.

Determining the harvest area

Through an extension of this measuring system, the harvest area can be simultaneously calculated. The track of the baler was identified by GPS. A further light beam in the bale chamber recorded whether or not the baler was actually collecting material (material flow sensor).This enabled identification of when the baler was running empty and when it was working. This allowed the geographical representation of the swath positions in the field.

An inductive sensor reported exact time of knotting as this operation represented the completion of one bale and the beginning of another. This allowed the swath to be divided into sections each representing the swath distance required for a single bale. With the application of the known bale weights a swath-related yield map could thus be produced. Methods for developing the swath sections into field sections, e.g., through applying the working width of the tedder, have still to be checked.

This yield mapping method was tested during hay harvesting on a 0.7 ha meadow. The grass was tedded into seven swaths formed left to right one directly after the other. The position-recording signals and the impulses from the light beam determining material flow allowed the swaths positioning to be mapped as shown in *figure 3*. On both headlands, individual material flows were signified although the baler was running empty. This was probably caused by sporadic blades of grass activating the light beam signal within the baler. This mistake could probably be avoided through the fitting of two light beams measuring the material flow independently of one another. Through the position data registered during the knotting and the known working width of the tedder (5.0 m) the swath could be divided into sections as shown in figure 3.

Conclusion

On the basis of an existing patent, standard components were used in the construction of a weighing system for square bales. The first trial results indicated that the method could determine bale weights with an error lower than 7% whilst the baler was in continuous action. The accuracy of the measurements increased in line with bale length. With the help of GPS systems and further sensors for recognising material pick-up and bale knotting, the bale weights could subsequently be related to their material production area. Whether in this way a dependable yield map can be produced must be tested by further investigations.

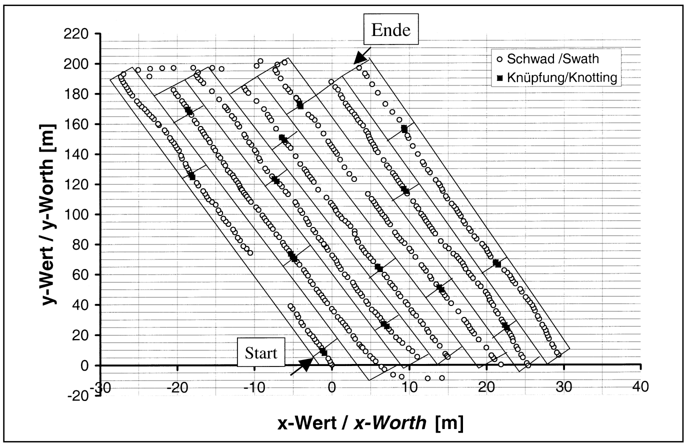

Fig. 3: Geographical representation of the swaths

Literature

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