Markus Demmel, Freising

Mass Flow and Yield Measurements in Harvesting Machines

State of the Art

High performance machines are mostly utilized in multi-farm machinery cooperation for harvesting agricultural crops nowadays. In addition to work execution, information about yield variations within the fields is extracted from farm management in many cases, too. With mass flow and yield measurement equipment integrated into harvesting machines, local yields can be recorded and information about local yields and field heterogeneity registered automatically through a local positioning system. Documenting yield conditions is a first step towards precision farming.

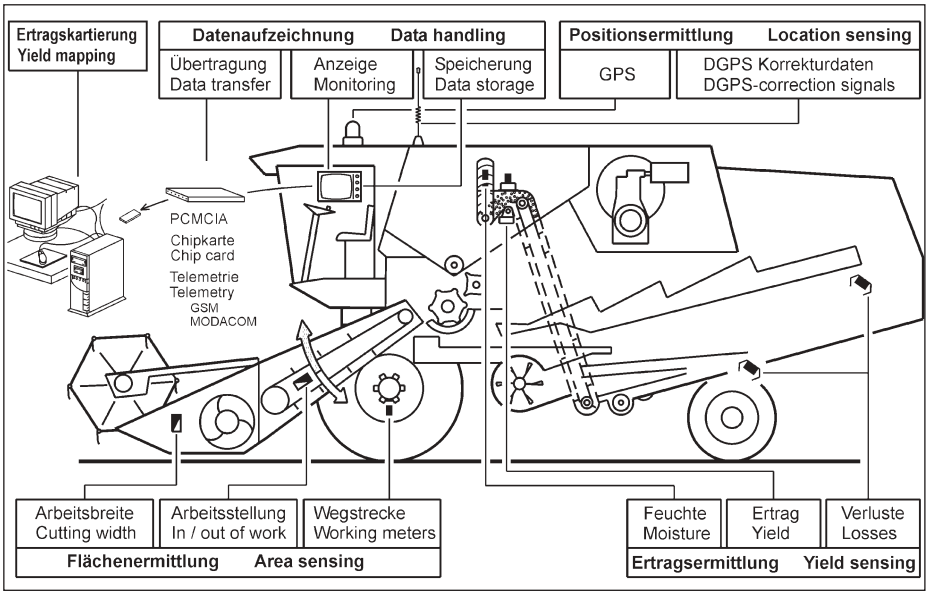

Fig. 1: Components for local yield detection in combine harvesters

During the past 20 years continuously working mass flow measurement systems, working directly on the harvesting equipment for local yield detection of agricultural crops, have been developed and evaluated at many institutions worldwide, especially at the Chair of Agricultural Systems Engineering of the Technical University Munich [1, 2]. The combination with positioning systems makes the geo-referencing of the information possible. Components for most local yield measurement systems include (*Fig. 1*)

- Mass flow sensor
- Measurement system for field capacity (speed and working width)
- Position detection system
- Processing, monitoring and data storing unit
- Data transfer to office computer

Yield detection for combinable crops

For the continuous mass flow and yield measurement, all combine manufactures offer sensors. They work on different measurement principles [3]. A few meters are based on the volume measurement principle (light beam measurement system), but most use the force/impetus measurement principle ("impact measurement with "baffle plates", "curved plates" or "impact fingers"). One system is based on the absorption of gamma rays by mass [4]. Although the measurement principles are quite different, several years and comprehensive tests showed that the different meters have similar errors, with standard deviations between 3 and 4 % [5].

Harvested area or field capacity is produced from the measured threshing distance and the entered cutting width. For automatically detecting the cutting width, no operational solution is available until now [6].

Geo-referencing yield data to positions in the field is done using Global Navigation Satellite Systems (GNSS). Predominantly data protocols standardised by the "National Marine Electronics Association NMEA" are used.

For data processing and display, either electronic devices integrated in the combine harvesters or universal terminals together

Dr. Markus Demmel is head of the work area Plant Production Engineering at the Institute for Agricultural Engineering and Aninmal Husbandary of the Bavarian State Research Center for Agriculture (LfL), Voettinger Str. 36, 85354 Freising;
e-mail: *markus.demmel@lfl.bayern.de*

Keywords

Mass flow measurement, yield measurement, combine harvesting, forage harvesting, root crop harvesting

Literature

Literature references can be called up under LT 07SH03 via internet http://www.landwirtschaftsverlag.com/landtech/local/literatur.htm.

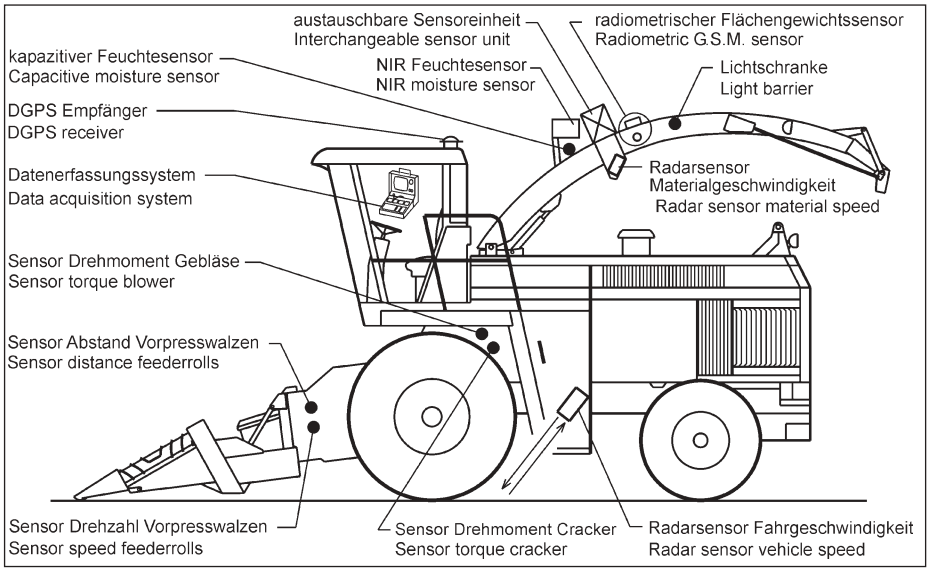

Fig. 2: Systems for mass flow and yield detection in forage harvesters

with electronic control units (ECU) are used. Data storage and data transfer to the farm computer are realised via different types of data storage cards.

Finally appropriate software is needed to generate yield maps. Different approaches are available for this task. Often simple visualisation programs are provided together with yield detection systems. Besides this, ambitious data analysis programs based on geographic information systems exist. But one should be concerned that currently neither rules nor standards exist to analyse georeferenced yield data and to generate yield maps.

Market prices of yield measurement systems for combine harvesters vary between 4 000 and 12 000 €. In most top combine models yield detection systems are standard equipment.

Substantial for the deduction of yield zones is the availability of yield maps over several years. Because typical rotations in western Europe do not only consist of combinable crops, yield detection technology for further crops and harvesting equipment is needed.

Yield detection for forage crops

Forage maize for silage is the second widest spread crop in respect of acreage, behind combinable crops. Different measurement systems for self propelled forage choppers have been developed and evaluated (*Fig. 2*)

Beside volumetric mass flow measurement, based on the detection of the displacement of the feed rolls [7, 8], force/impetus measurement systems in the spout [9], as well as a radiometric measurement system were successfully tested. The accuracy of the investigated systems corresponds with the level of errors of yield detection systems for combinable crops [9, 10, 11, 12]. Two manufactures offer (volume flow based) yield detection systems for self propelled choppers.

Research and development on systems for local yield detection in round balers, square balers and self-loading trailers did not result in products on the agricultural equipment market [13, 14, 15].

Since 2000 three research groups have published their work on the development of mass flow measurement technology for tractor mounted grass mowers. The systems were based on belt weighing technique, on force and torque measurement [16, 17, 18].

Yield detection for root crops

First sensor applications to continuously detect mass flow and yield on harvesting machines for potatoes and sugar beet have been presented and evaluated 15 years ago and retrofit systems are available since 10 years (*Fig. 3*).

Besides weighing the whole bunker hopper, predominantly belt weighing technique is used [19, 20, 21]. But also force/impetus mass flow measurement [22] and optical volume measurement technology [23] have already been investigated successfully. The measurement accuracy is similar to the systems for combinable crops, but varying soiling (stone, clods, soil tare) influences the results and distort the results [23, 24, 25, 26, 27, 28].

Perspective

In the future besides geo-referenced yield measurement online detection of the quality of harvesting products will gain in importance. Only the combination of quantity and quality allows a specific and targeted control of plant production. To measure the moisture content of grain (up to 30 % W.B.) continuously working, competitive capacitive sensors are already in use [29]. For higher moisture levels as well as to detect substances of content (protein, starch, oil, energy), measurement systems based on near infrared spectroscopy (NIR or NIT) are in comprehensive calibration and evaluation tests respectively are offered by one manufacturer [30, 31, 32, 33].

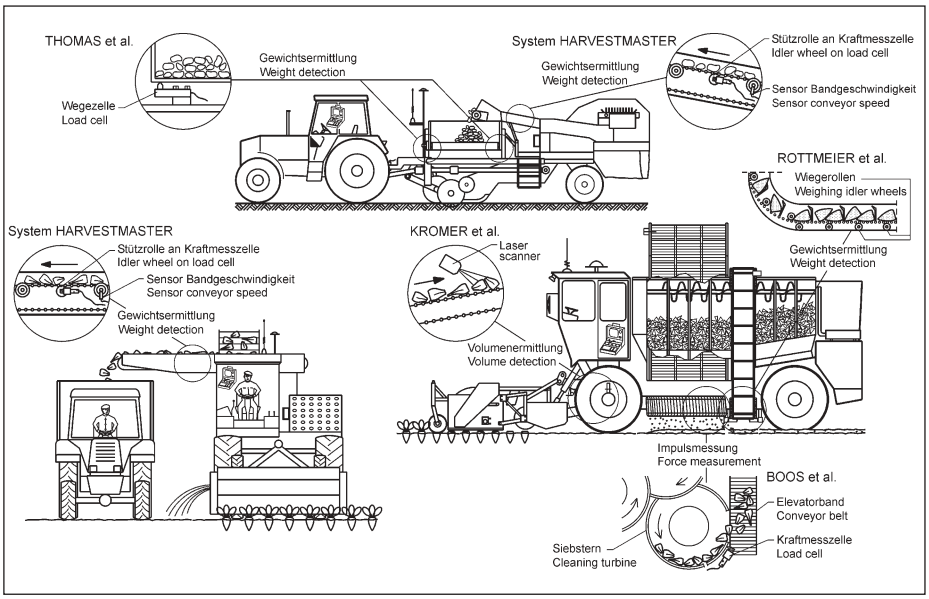

Fig. 3: Systems for mass flow and yield detection in potatoe and sugar beet harvesters