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Information and Control Systems on Combine and Forage Harvesters

Electronic information and control systems have become widespread in agricultural technology. Manufacturers offer further automation of existing functions with new models every year. And through electronics new functions are realised, which were previously impossible. The challenge here is to insure machine operation by avoiding breakdowns caused by electric and electronic failures.

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Dedicated to Prof. Dr.-Ing. Dr. h.c. H. D. Kutzbach on occasion of his 65th anniversary.

Keywords

Combine harvester, forage harvester, information and control systems

Literature

Literature references can be called up under LT 05225 via internet http://www.landwirtschaftsverlag.com/landtech/local/literatur.htm.

Electric and electronic units have become self-evident to inform the driver about the working conditions of his machine. These units are described in [1, 2]. Grain yield measurement, often in combination with a grain moisture measurement, has become very common on big combine harvesters. Together with the amount and the composition of the returns more and more information will be available for a comprehensive assessment and optimization of the threshing and separating processes.

For forage harvesters yield measurement units are getting only slowly acceptance. Under development are several alternatives to the measurement of the displacement of the in-take drums [3, 4, 5]. The demand for yield measurement and mapping is now stimulated by political incentive measures for biogas plants. The yield signal can also be used via an interface for the adapted dosing of silage additives. For the determination of the dry matter content on the forage harvester, a moisture measurement unit is necessary. Actually there is no device available for a reasonable price. For the determination of the protein content the technique of near infrared reflectance is under development as it is also for combine harvesters [6].

Especially on harvesting machines high demands are made on the HMI (human machine interface). These machines are used only in a short time period and the driver should not adapt himself every year newly to the operation of the machine. This could be made easier by an intuitive, logical and general philosophy of operation and be supported by a colour coding of important operational functions, independent of the manufacturer (red: turning off of the engine, orange: changing the forward speed, yellow: activation of working units) [7].

The different manufacturers are having different philosophies about the information and operation systems for the machines. Each philosophy itself is a compromise between the complexity of the machine, the amount of information and the wish for a simple and clear operation [8].

Automation of partial functions

An overview of the status of the automation technique on combine harvesters is given in *Figure 1*.

The extension of the range of steering controllers by GPS based system has to be emphasised. The GPS Pilot of Claas and the Au-

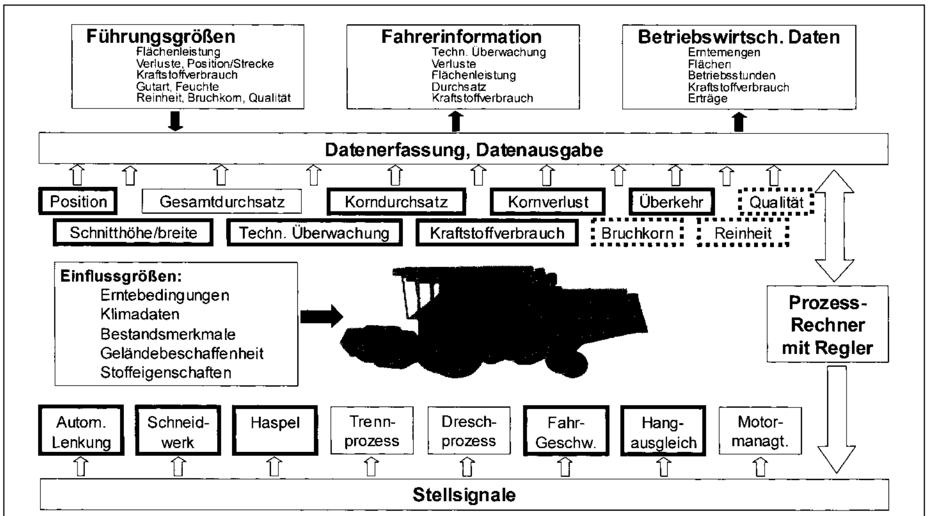

Fig. 1: Control systems on combine harvesters. Bold border: status 2005

	Claas	John Deere	CNH	Krone	Forschungsarbeiten
Antriebsquelle Dieselmotor	Elektronisches Motormanagement				
	Drehzahleinstellung für Ernte Drehzahlregelung bei Straßenfahrt	Drehzahleinstellung für Ernte		Automotives Fahren (Geschwindigkeits- und lastabhängige Drehzahlregelung)	
Einzug und Häckselaggregat	Metalldetektor mit Auto-Stopp des Einzuges Schleifen der Häckselmesser von Kabine aus steuerbar und automatische Gegenschneideneinstellung mit Klopfsensoren Quetschwalzen von Fahrerplatz aus einstellbar				
		Stufenlose Schnittlänge von Kabine aus vorwählbar			
		Positionserkennung des Metalls im Einzug	Drehzahlregelung Häckselaggregat (bei Drehzahlabfall Dieselmotor)		
Auswurfturm	Schwenkautomatik (Seitenwechsel auf Knopfdruck) Zwei Verstellgeschwindigkeiten	Programmierbare Zeit nachdem Turmdrehung schneller wird	Stufenlos einstellbare Drehgeschwindigkeit		TU Braunschweig: Assistenzsystem für Überladevorgang [9]
Fahrantrieb	elektronisch geregelter Fahrantrieb nach erforderlichem Drehmoment	Elektronische, schlupfabhängige Regelung des Ölstroms zwischen beiden Achsen		Parametrierbarer Fahrantrieb mit getrennten Antrieben (vorne/hinten): Beschleunigungsverhalten, Reifengrößen	Uni Hohenheim: Regelung Fahrgeschwindigkeit nach gespeicherter, ortsbezogener Leistung und Geschwindigkeit beim Schwaden
Vorsatzgeräte	Auflagedruckregelung Schnitthöhenregelung Speedstar: Schwingungstilgung	Auflagedruckregelung Schnitthöhenregelung Elektrohydraulische Einstellung von zwei Vorsatzdrehzahlen	Stufenlose Einstellung der Vorsatzdrehzahlen	Stufenlose Einstellung der Vorsatzdrehzahlen Pickup: beim Reversieren geht Niederhalter automatisch hoch	
Lenkung	Maistaster Laserpilot für Schwaderkennung	Maistaster			Uni Hohenheim: GPS-Lenkung mit Leitlinienplanung basierend auf Schwaderfahrkurs [10, 11].
Bedienkonzept	Multifunktionsgriff in der Armlehne integriert				
	Fahrgeschwindigkeitseinstellung über Fahrhebelauslenkung			Fahrbeschleunigung über Fahrhebelauslenkung	
	Claas Informationssystem CIS: Bildschirm für alle Messgrößen, Warnmeldungen, Maschineneinstellungen Separates Communicator-Terminal für Durchsatzmessung	3 Monitore in rechter A-Säule für alle Messgrößen, Warnungen, Maschineneinstellung, Schalter in Armlehne integriert Separater Greenstar-Monitor für Ertragskartierung	InfoView Monitor: Bildschirm für alle Messgrößen, Warnmeldungen, Maschineneinstellungen	Krone Infoterminal Easytouch: Bildschirm für alle Messgrößen, Warnmeldungen, Maschineneinstellungen	
Informationsgewinnung	Durchsatzermittlung durch Messung der Spaltweite im Einzug				ATB, Uni Bonn, TU München (Weihenstephan) [3, 4, 5]: Durchsatz (Auslenkung Vorpresswalze, radiometrisch, Laserscanner mit Radar, Impuls Wurfklappe), Feuchte, Inhaltsstoffe [6]
	Siliermitteldosierung Durchsatzermittlung	Ertragskartierung			

TTable 1: Use of electronics and information and control systems on forage harvesters

toTrac System of John Deere are steering the machines on straight lines or in contour lines over the field.

John Deere is offering for all i-series combines the harvest smart system. Driving speed is controlled in dependence of the engine load and of the load of threshing drum or rotor respectively. Additionally the accepted level of grain losses can be pre-setted. This technique is an additional step towards the control of the whole combine harvester.

For forage harvesters the overview of the use of electronic and information and control systems is given in *Table 1*. The control of the cutting height and / or the bearing pressure on the ground is similar to combine harvesters. Claas offers an active vibration compensation for the header. By this the amplifying of the machine is avoided while driving on the road. Comfort and safety is increased also at speeds up to 40 km/h.

The operation of the outlet is made easier by different semi-automatic systems. Assistance systems for the loading are still under development [8]. Automatic steering systems for forage harvesters on the basis of the mechanical sensors are also offered for row independent maize headers. Steering along swathes by a Laser Pilot, mounted centrally under the cab, is offered by Claas. GPS-based steering systems are not yet available.

Guidance of a forage harvester with satellite navigation

An automatic guidance system for a forage harvester was developed and investigated at the University of Hohenheim [10]. The demanded values for the driving course and the driving speed are integrated in the guidance path. The guidance system compares position, driving direction and driving speed which are measured with RTK GPS with the guidance path and controls the steering angle and the drive train.

The guidance path is calculated for swath harvesting with the recorded swath positions [12]. Different methods to control the machine load were investigated. The pickup power consumption was one indicator for the machine load. The driving speed was used to control the pickup power consumption. The system could react well to varying swath masses. However, very local changes could not be detected in time.

Corresponding to a defined harvester load, the harvester's driving speed was derived by the spatial power consumption and the driving speed of the swather. This speed information was combined with the guidance path and enabled the guidance system to adjust the driving speed in time. The guidance system controlled the driving speed during harvesting according to the guidance path. This procedure depends on the used calibration.

The yield variation can be assumed to be constant in the time between swathing and harvesting. The swath properties can vary according to the weather, so that the speed calculation can deviate. Therefore, the speed plan was calibrated with actual pickup power measurements. Now, a predictive speed control was possible. This system reacted better to the harvesting conditions then it was possible with the single systems.

Outlook

Planning, operating and documenting the work of the machines are getting more important for farmers and contractors. For this the connection of the machine to the information systems in the offices is necessary. The use of a wireless radio depends on the covered area, the additional costs and the monetary advantage by the immediate and secure availability of the data [12].

The future use of electronic systems can be derived from the development in the car industry. Speech recognition and speech output, force feedback operating units and head up displays are already available for cars. How fast these techniques will be used in agriculture machines also depends from the intuitive learnable HMI.