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Agricultural engineering – energized

A considerable aspect of sustainable agricultural engineering is the farm's balance of incoming and outcoming energy. This balance has to incorporate the amount of energy required to produce of operating goods, e.g. mineral fertilizers. A prime example are nitrogenous fertilizers, whose production induces high energy costs. Intending to apply such expensive supplies yield-efficiently, they should be metered and precisely distributed into the field. The challenge is to discover and exploit the potential advantages of new technologies alongside with the continuous refinement of proven fertilizer spreader designs. Applying electrical drive systems in tractor-implement-combinations offers such an interesting potential.

Keywords

Twindisc-fertilizerspreader, fertilizer massflow, electric drive, overlapping

Abstract

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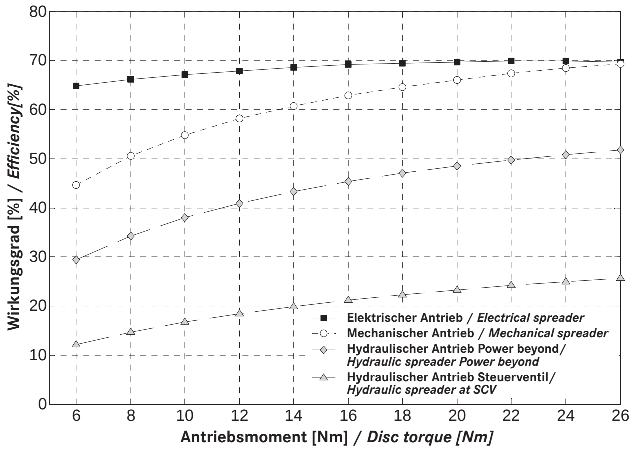
To distribute mineral nitrogenous fertilizers in a highly accurate way, the plants' need of nitrogen is determined by different methods. Today the defined nitrogen rate is distributed with the proven technology of twin-disc fertilizer spreaders. To avoid over-/under fertilization in the field and at the field borders, hydraulically driven twin-disc fertilizer spreaders are applied besides the conventional mechanic versions. Their specific advantage is, that the rotation speed of each disc is adjusted independently of the other. Furthermore, the measured torque of the hydraulic motor metered, it leads to the determination and recording of the actual fertilizer application. Unfortunately hydraulic drives have limited efficiency, require extensive sensor technologies to measure the torque and have the latent potential for oil leaks and the respective environment pollution.

Potentials of electric agricultural machinery

Since years electric drives have become common in the industrial automation and today also vehicle applications.They facilitate the precise drive control and the efficient distribution to various loads. For fertilizer spreaders different disc drives' properties are shown in **figure 1**. Obviously the high efficiency of an electric three-phase drive comes with an excellent controllability of the disc's revs. The potentials of electric drives in agricultural machinery are:

- High power density with optimum controllability
- Feedback of discs' speed and torque
- Simple power distribution also across complex agricultural machines
- Reliability in agricultural applications
- Combination with navigation and automation systems

Fig. 1



Efficiency of various spreading disc drive systems of fertilizer spreaders [1]

Fig. 2 a

Rauch fertilizer spreader AXIS EDR mounted on a JD 7530 E-Premium

Fig. 2 b

Clearance between tractor and fertilizer spreader

At the Agritechnica 2007 John Deere has shown the first standard tractor with a high-voltage system on board, the 6030 E-Premium. These tractors have an integrated system for the generation and distribution of 20 kW electric power. Electric drives are applied for

- reversible main radiator fan
- A/C compressor and
- air break compressor

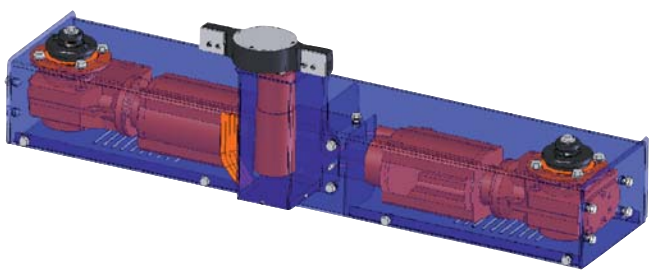
and substitute the legacy alternator by highly efficient DC/DC converter.

Indipendent studies have shown that this technology allows to save a significant amount of fuel.

In a cooperation project Rauch and John Deere have also presented a prototype of a twin-disc fertilizer spreader with electric drives at the 2007 Agritechnica (**figure 2a, 2b, 3a** and **3b**). This machine has three-phase electric drives (480 V A/C) and the respective metering and control components.

The electric drive of both spreading discs facilitates the control of their revolutions with high dynamics and stability as well as a quick change of the distribution characteristics of the spreading pattern. The fertilizer distribution is also adapted to complex distribution duties, e.g. GPS-controled optimization of overlapping on irregular field shapes. Further criteria for twin-disc fertilizer spreaders with different drive systems are shown in **table 1**.

Fig. 3 a



Transparent view of the electrical disc/agitator drive of a fertilizer spreader

Fig. 3 b

External view on the drive from bottom up

Table 1

Comparison of the different drive systems of twin-disc fertilizer spreaders

Kriterium *Criteria*	**Kundenvorteil** *Customers advantage*	**Mechanisch** *Mechanic*	**Hydraulisch** *Hydraulic*	**Elektrisch** *Electric*
		Ausführungsform aktueller Zweischeibendüngerstreuer *Systems on current twin-disc fertilizer spreaders*		
Trennung Scheiben-Rührwerksantrieb *Separation of disc/agitator drive*	Arbeitssicherheit *Operational safety*	nicht *no*	einfach *simple*	einfach *simple*
Stufenlosigkeit des beidseit. Scheibenantriebs *Stepless speed of disc drive on both sides*	Arbeitsbreitenregelung *Adjustment of working width*	nicht *no*	gut *good*	sehr gut *very good*
Unterschiedl.Drehzahlen re./li. Scheibenantrieb *Various right/left revs of disc drive*	Grenz-Randstreuen *Limited and full border spreading*	nicht *no*	gut *good*	sehr gut *very good*
Stufenlosigkeit re./li. einseitiger Scheibenantrieb *Stepless speed of disc drive on one side*	Keilstreuen *Edge spreading*	nicht *no*	gut *good*	sehr gut *very good*
Kontrollierte Regelbarkeit des Scheibenantrieb *Controled adjustment of disc*	Arbeitssicherheit/Keilstr. *Operational safety/edge spreading*	nicht *no*	träge *inert*	sehr gut *very good*
Drehmomenterfassung re./li. Scheibenantrieb *Information about torque to drive right/ left disc drive*	Automatische Düngerstromregelung *Automatic fertilizer flow adjustment*	mit Sensoren *with sensors*	mit Sensoren *with sensors*	ohne Sensoren *without sensors*
Antriebskoppelung zum Traktor *Drive coupling to the tractor*	Komfortable Ankoppelung *Convenient coupling*	Telespace Gelenkwelle *Telespace drive shaft*	Hydraulischer Stecker *Hydraulic plug*	Elektrischer Stecker *Electric plug*
Informationskoppelung zum Traktor *Information data link to tractor*	Geräte-Erkennung *Identification of machine*	nicht *no*	nicht *no*	einfach *simple*
System-Wirkungsgrad *System efficiency factor*	Effizienz des Antriebes *Efficiency of drive*	hoch *high*	gering *low*	sehr hoch *very high*
Ölverbrauch – fossiler Ressourcenverbrauch *Consumption of oil/fossil resources*	Kosten/Nachhaltigkeit *Costs/sustainability*	gering *low*	mittel *mean*	kein *none*
Umweltgefährdung durch Ölverluste *Environmental hazard by oil losses*	Ölverlust/Kosten *Oil losses/costs*	gering *low*	hoch *high*	keine *none*
Herstellungskosten *Production costs*	Anschaffungspreis *Purchase price*	niedrig *low*	hoch *high*	hoch *high*
Kompatibilität mit älteren Traktoren *Compatibility with older tractors*	Flexibilität *Flexibility*	vorhanden *yes*	vorhanden *yes*	nicht vorhanden *no*

To determine the fertilizer mass flow the electric motor current is used as base to calculate the disc drives' torque.

Expected synergetic effects

The successful integration into the overall spreader design is particularly new and defines key parameters for the interaction between tractor and attached machine. A sophisticated design of the electric interface will allow simple connection of power and controls.

The adjustment of the operation parameters of disc fertilizer spreaders are integrated to the tractor operation to a greater extent compared to conventional mechanically or hydraulically driven machines. This allows a high degree of automation and an optimized management of applied functions on the attached machine and the tractor. Like conventional systems the tractor provides the necessary power and control elements. Power electronics represent analogies to the hydraulic control valves. They can be used for a multitude of attached machines. The target of the machine specific optimization is, e.g. to minimize fuel consumption and to maximize the efficiency of the overall system efficiency. The aim is to get an optimum result with minimized effort, considering material, machinery and labour related costs.

A further analogy (all-electric farm machinery) in comparison to conventional drive configurations is the possibility to locate the control elements on board the attachment. The drivers could be an excessive number of the separately controled drives or the requirement to be compatible to tractors with integrated power generators.

A current aproach is to install two universal inverters onto tractors. If more than two independent control functions are needed, a fixed voltage is supplied and several inverters are situated on the implement. The same applies, if the tractor is not able to supply high voltage: a PTO-shaft drives the machine's generator. This could be a transition scenario until all tractors have an electric power interface. The upcoming years will show how rapidly and to what extent the established power interfaces will be replaced by electric ones.

Conclusions

On a twin-disc fertiliser spreader the potentials for optimized metering and distribution of mineral fertilizer with electric drive systems has been shown. They also open up interesting perspectives for a multitude of other agricultural machines e.g. seed drills and pesticide sprayers. High voltage will make sense due to actual power requirements. In modern hybrid-technology vehicles 480 VAC are state of the art.High voltage is leading to interfaces with high power density. Modern power electronics allow the precise control of the drives and become more competitive cost-wise. The integration of a communication interface will not only facilitate the identification of the attached machine and its parameters. It will also offer to identify the individual machine's electric drive and allow a real plug-and-play-design.

In the near future users and experts will be surprised by the possibilities new machine concepts will offer towards efficient and sustainable agricultural processes. The machine concepts are not limited by geometrical or control related limits of mechanical or hydraulical drive. The following visions could become true in future machine generations:

- The self-sustaining, renewable power generation for every farmer by wind generators, photovoltaics, biomass etc. will be common.
- The electric energy storage by batteries and/or intelligent memory systems is simple, reliable and cost-efficient.
- The all-electrification of all agricultural machines and tractors ensures a reasonable load for the sustainable power supplies and disburdens the agricultural holdings from the extremely cost-intensive fossil resources.
- Agriculture is the pioneer in production and use of renewable energies with parallel protection of all not renewable raw materials by modern, foresighted maintenance, long life-time of the machine by updates and complete recycling.
- By modern electronic information-, sensor- and control systems agriculture demonstrates a highly efficient and sustainable production of raw materials.

Electric drives in agricultural applications will become reality, the only question is the time they need to succeed. Agriculture will become even more exciting.

Literature

[1] Hahn, K.: High Voltage Tractor-Implement Interface, SAE Commercial Vehicle Engineering Congress, 2008

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Note

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