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Trends of Tractors and Transport Vehicles

In this contribution, important trends in the development of tractors and transport are presented which will characterize the Agritechnica 2003. This preview only provides pre-information and cannot replace a trade fair visit. Completeness is not aimed for.

As a result of the greater technical demands, the increasing complexity of the products, and the continous tightening of the legal conditions, the development requirements for tractors have grown immensely. Only sufficiently large unit numbers enable the manufacturer to recover these expenses. Therefore, it seems appropriate to meet the demand of different markets through equipment- and model variation based on a development platform. One example is the new TS-A series from New Holland, which is produced at two locations in different variants and marketed separately as a Steyr and a Case model even though it is based on one development platform. In the large tractor segment, where a clearly differentiated product for the two brands Case and New Holland has been developed even though largely identical functional units have been used, the group is taking a similar route.

Brand-independent platform strategies can generally only be realized within a group. Mergers and cooperation also serve to retain sales structures or to take over others on markets which have not yet been opened up. Ultimately, they pursue the goal of increasing the unit numbers of a company's own product and achieving economies of scale. This might also have been the main reason for the recent takeover of Renault tractors by Claas. Just recently, the AGCO group has taken over the Finnish company Valtra with its tractor- and engine departments. In the past, Valtra had already supplied engines to MF.

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Mechatronics and Networked Systems Also in Agricultural Engineering

In order to optimize processes in agricultural engineering, electronic systems are integrated into the machines for them to work more effciently and to increase both the quality and the amount of work done. In the past, the application of electronics was generally limited to individual components, such as power lift control, driver information, injection pump control, or transmission control. System networking began with the logically based automatic changing of certain clutches as the precursor of current headland management, which includes the following components:

- power lift control with vibration damping in the front and in the rear
- switching of differential locks, all-wheel drive, PTOs
- vehicle transmission
- engine
- hydraulic control valves with hydraulic pumps
- automatic steering (Challenger)
- cooling system (Steyr)

These components are a virtually complete reflection of all functional units, and it will not take long until front axle- and cab suspension or other comfort elements will be integrated into the comprehensive management system. In the future, the ISO-bus will allow automatic processes on the mounted implement to be included.

As an island solution, electronic component control already provided enough advantages for the user to become part of series equipment. „Shift by wire", for example, enables a reversing system for steering to be realized even though the cab does not offer enough space for the classic solution with a conventional steering wheel (Fendt). Meanwhile, this technology no longer excludes steering during road rides, as a solution from Claas in the redesigned system vehicle XERION shows. The networking of these systems requires only slightly more hardware, but it provides decisive additional advantages.

For automatic functions in the transmission, which make a decisive contribution to the success of continuously variable transmissions, the load status of the engine can be considered. This information was also used for powershift transmissions. Conversely, the transmission can also influence the engine if required in order to adapt the engine speed to the load, for example. As a new feature, the transmission automatically „double-declutches" when shifting powershift gears (John Deere 6020), a technology known from shifting in unsynchronized transmissions. When the gear is shifted down, engine speed is increased for a short time, and it is reduced when the gear is shifted up. As a result, the shifting process is always very smooth independent of the load, which has an additional positive effect on the life of powershift clutches. The CAN bus has established itself as a data bus on the tractor, and the new ISO standard is supported by almost all manufacturers for communication with the mounted implement.

At the Agritechnica 2003, simple, satellite-guided systems for automatic steering are offered (John Deere, Challenger, AGChem, AutoFarm, Claas), which do not replace the driver, but reduce his workload significantly. The upgraded automatic steering systems work with a precision in the cm-range, consider slope inclination, and can bridge stretches where the satellite signal is shaded or disturbed in straight lines with the aid of a built-in gyroscope (John Deere AutoTrac). The better utilization of theoretical working width means a significant productivity increase not only for tractors, but also for self-propelled machines. The costs of the total system range between € 15,000 and € 20,000 with tractor hardware accounting for approximately 50 % of the expenses. The current hydrostatic steering must be supple-

Fig. 1: Exact guiding with AutoTrac automatic steering by John Deere (Foto John Deere)

mented with an electrohydraulic control circuit. For tractors which already feature electrohydraulic steering systems (Claas Xerion or Fendt 700/800 with a reversing option), slightly higher prices must likely be expected for automatic steering.

Electronic Injection for Exhaust Gas Values According to EU Phase 2

The development of energy prices in combination with the impending abolition of price reductions for agricultural gas oil has caused particular sensitivity concerning tractor consumption. However, one should not only consider the efficiency of the engine alone, but also the total efficiency of the tractor and the work process carried out by it. Tractors in the very important power class from 75 to 130 kW produced as of 1 July 2003 must meet the strict exhaust gas requirements of EU Phase II or Tier II in the USA. In the next smaller class, these values will take effect on 1 January 2004. The observance of the new limits requires electronically controlled injection pumps and the installation of an intercooler in all cases. However, this equipment alone is not sufficient. Slightly later injection has a positive effect on nitrous oxide concentration. However, it also leads to larger fuel consumption. Efficiency sinks, and more cooling is required. The intercooler needs additional cooling air supply, which again results in greater ventilator power requirements. While in the past only 5% of engine power at rated engine speed was used to drive the ventilator, this value exceeds 10% in some current tractors. John Deere controls the rotational speed of the ventilator (8000 series) and has two liquid circuits in its 6000 series. In order to save drive power, Steyr (optional on the CVX model, supplied by the Hägele company) only alters the angle of the ventilator blades when the radiator temperature increases. Almost all manufacturers thoroughly redesigned the cooling system for phase II, and significantly worse consumption values must be expected in the case of some manufacturers.

Highly modern engines with 4-valve technology and common rail injection (Case-New Holland, John Deere) contribute to the observance of the exhaust gas limits. In contrast to road vehicles, the cooling system of the tractor must function durably without relative wind and with cooling air which is heavily loaded with dirt. Tractors do not provide sufficient space for large-surface radiators because they restrict front vision too much. Staggered radiators cause problems during cleaning and stronger flow resistance. In tractors from some manufacturers, the cooling system with its ventilator, cooling air guiding duct, heat exchangers, and cooling air intake sheets has a greater construction volume than the actual engine. Here, engineering efforts are still required in particular if one must fulfill the new, even stricter exhaust gas limits, which will probably take effect in 2006. Engine power increase for PTO work, which was presented for the first time by Valtra in 1997, is establishing itself more and more. Electronic injection allows the characteristic curve of the engine and, hence, engine power to be varied depending on the work (power boost). In the TM 190 model, Case-New Holland increases engine power during PTO work or fast transport rides by up to 35 kW. For this purpose, both the torque delivered by the engine and the torque branched off by the PTO train are measured and integrated into engine management. During PTO work, the new, smaller TSA models provide up to 17 kW of additional power. John Deere has already introduced this technology in the 6020 series (model S) and now offers the new 7920 model in the 150 kW class, a powerful tractor whose engine output reaches up to 172 kW during fast transport rides. These solutions in particular meet the requirements for the large share of transport work done by tractors.

Continuously Variable Transmissions Supersede Full-Powershift Transmissions

As soon as continuously variable drive is offered for a tractor model, the demand for the full powershift transmission in the same model sinks drastically. In this case, inexpensive partial powershift tends to be discussed instead, which also enables effective automatic functions, such as engine speed reduction during transport rides and adaptation of the powershift gear during gear shifting in the range transmission to be realized. In EU Phase II, the engines now feature electronic control in any case. This electronic control system can be integrated in the transmission management of partial powershift transmissions and could make automatic gear shift in the range transmission without a powershift clutch, which has already been realized by New Holland, even safer and more comfortable, at least during transport.

The available range of continuously variable drives has been significantly extended since the last Agritechnica. MF uses the transmission technology developed by Fendt as a member of the AGCO group and equips the model series 7400 with this system. A special operating concept has been developed. Case-Steyr redesigned the user interface of the CVT/CVX models and adapted these models to EU Phase II, whereas their sister models with four-speed powershift will be superseded by the new CNH platform models. The redesigned Claas Xerion will be equipped with the largest model of the ZF ECCON series. Thus, the currently available continuously variable powersplit transmissions of the different manufacturers range from 66 kW (Fendt 400) to 243 kW (Xerion 3300).

Fig. 2: MF 7840 with Vario-transmission technology

Electronics Make Hydraulics Even More Efficient

For the integration of hydraulics into an efficient headland management system, the control valves must be able to be operated electrically. Digital control via the CAN bus is increasingly establishing itself and provides the following advantages:

- Less wiring is required.
- Valve malfunctions can be fed back via the bus.
- As compared with the mechanical variant, oil flow rate and opening times can be programmed and set spatially independently. The implement-specific setting of the control valves can be stored and taken over when the implement is mounted again (Fendt).

Proportional valves make work with the front loader more sensitive and more efficient. If the quick-lifting switch of the EHC features a proportional intermediate range between the two end positions, the power lift can also be operated very sensitively (John Deere 7020). In the three-point hitch, additional degrees of freedom are striven for in order to make implement coupling simpler and safer. Hydraulically adjustable rams as well as the power-operated (e.g. compressed air) pocket lock which can be opened from the driver's seat (Walterscheid) make a contribution towards the achievement of this goal. The hydraulic upper link can be controlled simultaneously while the implement is being lifted, which allows for clean parallel lifting or steep lifting of the plough.

Through control valve programming and with the aid of additional sensors (position transmitters), more and more repeating processes during front loading are partially automated. These processes include the returning of the bucket into its initial position, controlled hydraulic parallel guidance of the tool, automatic shaking-out systems, and automatic bucket crowding after bulk material intake, for example. The restricted view of the tool of the lowered tractor front loader increases the demand for an automatic bucket return system.

At the touch of a button, New Holland's steering system changes from normal operation into the quick-steering mode. In this mode, the turning speed changes in proportion to the steering wheel angle (maximum 8°). On the headland and during front loader work, the driver's workload is reduced significantly. In the past decade, hydraulic pressure in the tractor was raised from ~ 175 bar to up to 210 bar. Telescopic loaders and other loaders even work with up to 250 bar.

The Market Demands Comfort, and the Legislator Requires It

In addition to reliability, the expenses for operating resources as well as comfort range at the top of the customer's list of requirements. Comfort is considered a decisive element for the enhancement of the driver's performance and health protection. With front axle-, cab-, and seat suspension, a high standard of vibration insulation has already been reached. Nevertheless, development is continuing. MF is introducing two-step cab suspension which can be operated from the driver's seat. Grammer is optimizing the entire seat including operation and seat surface temperature control. Challenger concentrates all operating- and display units, which are otherwise arranged on the right mudguard, in an armrest terminal which completely swings up and down with the seat and can also be turned. The actively suspended seat, which was already awarded a prize at the last Agritechnica, is built into several tractor brands.

Of course, large tractor models cause louder passing noise, for which the cooling air ventilator is largely responsible. In the future, development is also going to focus on this aspect of the cooling system. For the protection of the employees' health, the EU requires that maximum physical impacts on humans may not range above certain limits. The Vibration Directive, for example, stipulates that machines sold as of 2007 may not exceed the daily limit (8 h) of 1.15 m/s^2. The employer is obliged to prove that these values are not exceeded. Given these requirements, the customer will demand more and more ride comfort.

Efficient Transport Using Large Units

Especially in Central Europe, the largest part of agricultural transport was carried out using tractors and high-capacity transport trailers in the past. Here, no trend reversal can be discerned. Extremely efficient harvesting machines need sophisticated transport logistics, which are organized at very short notice due to weather influences. This generally excludes the use of the non-agricultural transport capacities of forwarders. In addition, the use of the tractor for transport generally leads to a significantly better utilization of its annual capacity, which provides economic advantages. For slurry transport, more and more large tankers are used which have volumes of 25 m^3. Only light construction allows the payload to be increased further like in the aluminium tanker from the Kotte company. In this size class, this enables approximately 2 t of empty weight to be saved and the payload to be increased by ~8%. In these vehicles, hitch-type coupling is a significant safety element. On the road, the 80 mm trailer hitch ball provides a tongue load of 3 t. On the field, even 4 t are permitted, which increases the tractive force of the tractor. The deep hitch close to the axle cannot be seen by the tractor driver during coupling, which often makes the coupling process very difficult. The Scharmüller company promises improvement thanks to a larger catching area and automatic locking. For force-steered multiple axle units, an additional master cylinder must be mounted to the tractor, which makes coupling even more difficult. The ADR company presents a solution which simplifies cylinder coupling and increases the reliability of this system. John Deere integrates the 80 mm hitch ball coupling into the existing hitch.

Large dumping trucks have their own onboard hydraulics because the required oil quantities cannot be taken from the tractor. The Krampe company solves this problem very efficiently with an additional compensation cylinder. During crowding, oil is fed into the tractor hydraulics, and during lowering the intermediate storage container on the trailer is refilled.

Fig. 3: A well-known machine in a new livery - Claas Ares