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Drive and Control Technology for Self-Propelled Harvesters

Harvesting technology has undergone powerful changes in the last 50 years. Due to structural changes in agriculture the trend is toward ever bigger and more powerful machines. Self-propelled machines have prevailed and have almost replaced tractor-pulled machines. Hydrostatic drives are already state of the art in many harvesters. For operation and steering drives the throughput capacity and the ergonomics of the vehicle are the focal points. The change to electro-proportional control valve technology in combination with closed loop sensing is already standard equipment for many manufacturers.

While the tractors can now reach speeds of 50 km/h and more, self-propelled agricultural machines are advancing toward the 40 km/h mark. The resulting increased demands on the machines require new drive and braking concepts.

Implement Drives: CAN communications instead of pipelines

The Control Block

The new compact SB12LS-EHR 5 control block permits flows of < 1 to 60 l/min and was developed especially for use in self-propelled harvesters.

Integration of the electronics for the header control directly in the valve, on-board electronics, and a priority valve for the steering hydraulics results in a central modular control block: essential functions, such as complete header control, including a transverse slope control function, are all provided for here. Moreover, it also comes with optimally adapted and flexible software, robust hardware with flash memory and CAN, as well as a built-in steering priority valve.

The control block is based on Rexroth mobile valves that have been used and proven in agricultural machines, combined with Bosch electronics from the automotive sector. Due to the modular design with extensive additional functions, the control blocks can be adapted optimally to various requirements.

The SB12LS system permits a wide variety of variants - from simple switching functions to load sensing proportional controls. The integration of hydraulically unlockable check valves in the case permits additional uses. Various valves are available for the header control, from plain, unregulated switching versions to ones with electronic controls. In the "high-end" version, differential controls ensure optimal adaptation to varying harvesting conditions. Transverse slope control of the header is also integrated, as is damping of header vibration while driving. Electronics are available as on-board electronics or as a separate control unit.

The product range is supplemented by a selection of pressure, position, and angle sensors suitable for use under tough agricultural conditions. Many harvesters with large

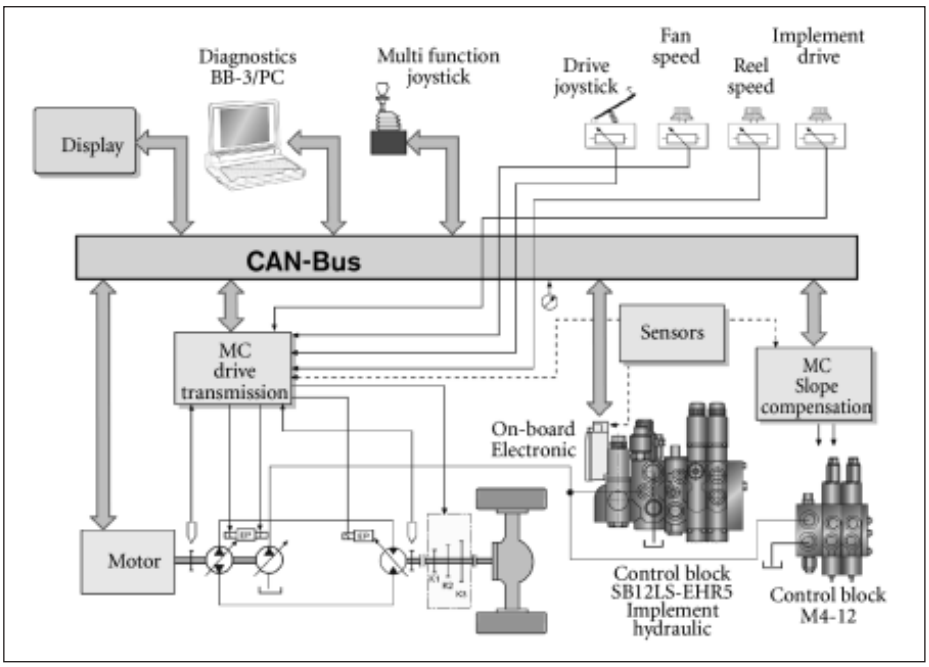

Fig. 1: With CAN, all stations are interconnected via a serial data bus

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headers are designed only for use on flat ground. Any unevenness on the ground could lead to expensive damage. The control system for programmable header control always keeps the header parallel to the ground without driver intervention.

Sensors ensure that the header is kept at stubble height in all phases of work without touching the ground. Model M4-12LS valves are used for the levelling mechanism; in addition to the characteristics already described, they also permit secondary pressure backup for the LS signal.

Electronic Management
Using a serial data bus simplifies cabling and reduces the number of plugtype connectors. The Controller Area Network (CAN) constitutes a suitable bus system - stations with equivalent rights are interconnected via a serial data bus.

This permits linkage and simultaneous communication between multiple sensors, control devices, and instruments. Another advantage of CAN over conventional cabling is that transmission errors that occasionally occur due to electromagnetic interference are detected and automatically corrected by repeat transmission.

Drive Transmissions 40 km/h - the challenge for self-propelled harvesters

Hydrostatic drive transmission
There are three drive concepts for hydrostatic drive transmissions used in harvesters:
- Central drive at the transfer gear, which drives the axles via cardan shafts
- Axle drive with one hydromotor each on the drive axle
- Single-wheel drive with axial-piston motors and planetary gears

Until now, central drives enjoyed nearly 100 % market share in those applications that account for the highest numbers of units used, namely in corn foragers and combines. This is swinging toward axle drives at present.

Each of these drive solutions has advantages and disadvantages that must be weighed during project planning for the corresponding application. All of these concepts have already been realised. The following is a brief list of the most important decision-making criteria:

Central drive
Advantages:
- The differential lock is easy to realise mechanically
- The full propulsive power is available on each wheel
- A larger transformation range can be realised by using shift gearboxes

Disadvantages:
- Mechanically complicated design and concomitant increased space requirements

Axle drive
Advantages:
- Saves space because no propeller shafts are required
- It is possible to distribute the propulsive power between the front and rear axles
- Smaller hydraulic pumps are sufficient, since the Rexroth hydraulic motors can be switched off to zero displacement through swivelling. With a given oil flow from the pump, this results in a higher flow for the other hydraulic motors in the circuit and thus a higher speed and travel velocity

Disadvantages:
- On each axle, only the respective propulsive power for this axle is available, not the total propulsive power
- Additional outlay is required in order to realise a differential lock

Single-wheel drive
Advantages:
- Free space between the wheels and thus improved adaptability to terrain
- Saves space because no propeller shafts are required

Disadvantages:
- Only the respective propulsive power is available on each wheel
- Increased cost for piping and individual actuation of the motors
- Additional outlay is required in order to realise a differential lock

Gearboxes with dynamic brakes

Gearboxes with dynamic brakes are a new development in self-propelled harvesters. When combined with hydraulic dual displacement motors, this can be used to realise very compact drive solutions.

When developing the braking function, there were various requirements that had be to be fulfilled and were accordingly implemented in the Rexroth solution:
- The frictional surfaces must be protected from fouling and moisture. Thus the friction elements are disks that run in gear oil.
- To minimise the installation space required, the number of components was minimised. The parking brake and the main brake, for example, use the same disk packet for this reason.
- The friction brake must be capable of absorbing the necessary braking energy even if the hydrostatic braking effect fails. In order to fulfil this requirement, the disks have been designed for the dynamic case with regard to their friction area and their volume, which must store the heat generated
- Because spring brakes are not permitted at the present time, a combination of two pistons (one inside the other) was chosen. This makes it possible to realise a spring parking brake as well as a pressure-actuated service brake.

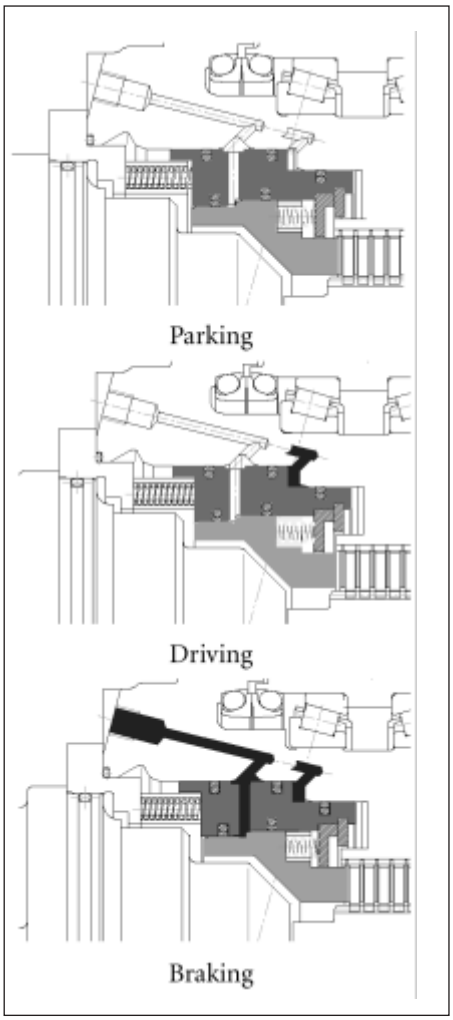

Fig. 2: Parking, driving, braking
Bilder BoschRexroth