Reliable positioning with CAN encoders

For over 20 years, CVT gearboxes have been an integral part of mobile machinery. Agricultural tractors are forerunners in this area. They benefit from the performance of a power-split gearbox.

Customer-specific encoders optimize continuously variable tractor transmissions (Photo: Kuebler)

Tractors brave adverse weather conditions and plough loamy and stony grounds. They heave, tow, or cut tons of crop. Encoders for such requirements are mostly not listed in the catalog. Reliable positioning is a safety factor that prevents machines from damages and men from injuries. Two of the major tractor manufacturers use Kuebler encoders in their CVT (continuously variable transmission) systems. These encoders, which ensure reliable positioning in modern tractors, are the result of extensive development projects – based on strict customer specifications.

The used encoders contribute significantly to machine performance; they are integrated in the servo actuator, which includes components matched to one another, the electrical gearbox, and encoders. This is where the accuracy and the intelligence of the machine come together: jointly, these three components of the actuator form the communication interface.

Full power under tough conditions

For mobile machinery, the technical goal is to combine an improvement of the efficiency and the energy consumption in combination with maximizing the so-called area performance, that is to say the power at the work systems and longitudinal drive. The real challenge on the way to a suitable encoder consisted in a compromise: the balance between precision – very high accuracy and repeatability – together with total insensitiveness to magnetic fields and resistance against shocks and continuous vibration. Safe operation over a wide temperature range and reliable protection against moisture and humidity were also part of the requirements.

A servo actuator converts the signals of a controller to the required gearbox ratio in the vehicle. Here, the precision gearbox and the servomotor merge with the encoder to form one single unit. Used in tractors, it must master the whole temperature and supply voltage range thanks to its torque and torsional rigidity. This task is made more difficult by the fact that the values must be provided and represented under varying load situations.

A group of specialized companies worked jointly to provide the decisive impetus for this product, from its initiation up to series-production readiness. Besides sensor and electronic suppliers, the project involved electromechanical, software, and motor developers. The result of this joint work is the CVT gearbox, which ensures acceleration and deceleration processes almost without adjustment times.

Singleturn encoder solution

Tough environmental conditions with extreme temperature ranges and strong vibrations place very particular demands on an encoder solution. The accurate optical singleturn encoders specially developed by Kuebler for use in the servo actuators of agricultural machinery are based on the combination of two interfaces: An incremental one with 2000 pulses and parallel 5-bit Grey code scanning. Singleturn resolutions reaching 17 bits are usual: for the desired actuator, a 13-bit resolution was ideal. The customer-specific mounting options for the flange and the shaft complete the encoder construction designed especially for the integration in the actuator.

The cable is flatter than usually. Within the actuator, the encoder converts a CAN instruction into the angular position of the axial piston pump. The instruction is triggered by a joystick in the driver's cabin. The angular position determines the hydraulic oil throughput. This oil quantity finally regulates the speed of the hydraulic motor, and thus the gearbox ratio. In addition, a housing protects the electronics from vibrations, heat, and humidity.

CAN for safety

Within the drive, the actuator, being a monitoring interface, also has a great relevance from a safety point of view. Accidental adjusting movements, which can lead to machine motion from standstill, as well as missing adjusting movements, which in the worst case can result in braking processes not performed, belong to the hazards that can lead to severe damages to men or to the machine. The communication between the gearbox controller and the adjusting unit is based on a safety-oriented CAN protocol. It integrates many diagnostic functions and plausibility checks, such as temperature, voltage, and current monitoring.

Within the servo actuator, Kuebler encoders help the CVT gearboxes to make the defined high-torque motion sequences even smoother. This allows more accurate driving of the tractors. In addition, since no gear change is required, there is no further power loss linked to this gear change, which allows achieving constant engine speeds.

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