Biological pest control on the corn field

Figure 1: The height and the track width of the stilt tractor can be adapted to the height of growth and row spacing in the corn field (Source: Graf-Syteco)

A working group, in cooperation with a company has developed a special lightweight stilts tractor with hybrid drive for biological pest control on corn fields. For controlling the machine, a CAN-based unit is used.

Agricultural machinery must be optimally adapted to the conditions of use. Since no suitable machine was available for biological pest control on corn fields, a working group of the Institute for Mobile Systems of the Otto von Guericke University, Magdeburg in cooperation with the company Biocare has developed a special lightweight stilts tug. When controlling the machine, the machine builders rely on a control and operating unit from Graf-Syteco.

The European corn borer is a small butterfly that is feared as one of the most important pests in maize farming by farmers. It is estimated that every year it destroys up to 4 % of the corn crop. An environmentally friendly biological method of combating the European corn borer by the parasitic wasp Trichogramma brassicae has proven itself as an alternative to the use of insecticides for many years. The parasitic wasps are parasites that lay their eggs in those of the European corn borer and prevent their development to the caterpillar so effectively.

The company Biocare offers so-called Trichosafe balls for application in the maize field, in which eggs parasitized by the parasitic wasps are contained in different stages of development. After application on the field, the beneficial parasitic wasps that fight the European corn borer develop over a period of up to three weeks. However, the effect of biological pest control depends on the balls being deployed at the right time. And at that time, the corn has already reached a height of about 1,80 m - the application of the balls with a conventional farm tractor is therefore no longer possible without damaging the plants. Since the effective amount of the biological agent is only about 100 global hectare, drones can be used to deploy the balls. For larger acreage Biocare has developed a pneumatic ball-thrower as an attachment that can be mounted on a high-leg self-propelled sprayer. However, these are clearly oversized for the small quantities and therefore too expensive for this application.

The working group of Prof. Stephan Schmidt from the Institute of Mobile Systems of the Otto von Guericke University, Magdeburg, is working on a practicable and cost-effective solution. The machine builders have developed a lightweight vehicle that optimally meets the requirements of the application and at the same time is very cost-effective. Since the required payload of the so-called stilt tractor and thus the required driving performance are very low, instead of a hydraulic an electromechanical drive can be used. Since a purely electric drive cannot cover the requirement for operation of 16 hours per day, a variable concept of backup battery and an internal combustion engine is used as a range extender. The internal combustion engine used in this serial hybrid drive has only a small power, which means an additional weight reduction. "The powertrain is comparatively easy. Overall, we were able to realize a very efficient special machine, " Prof. Schmidt explained.

The geometric requirements on the stilts tractor result from the use in the cornfield with a height of the plants of up to 2 m. The vehicle body with the driver's seat and the other components, such as the pneumatic ball thrower, must be located above the corn rows. The track width of the narrow stilts with the wheels and the drives must be ▷

adjustable so that it can be adapted to different row spacing of the maize rows. In order to prevent the stilts tractor from tipping over hilly terrain, a minimum track width of 4 m is necessary. On the other hand, the vehicle has to collapse to transport dimensions of 3,5 m x 2 m x 3 m. "That's how we make sure," Prof. Schmidt explained, "that the user can easily transport it from one corn field to another on a standard vehicle trailer." The backup battery and the range extender can be removed from the vehicle for transport. With a travel speed of 12 km per hour and a working width of the pneumatic ball thrower of 30 m, the stilt tractor has an area capacity of up to 30 hectare per hour.

Sliding box profiles as a basis

The team around Prof. Schmidt has realized the prototype of the stilt tractor with a classic four-wheeled vehicle concept, with single-wheel steering in front and single-wheel drive in the rear. The drive must have high low-speed torque due to the high road surface resistance and low driving speed. The two rear wheels are each driven by a synchronous machine with two-stage gearbox, which consists of planetary gear and chain drive. Prof. Schmidt explained the advantages of this drive concept: "The speed and torque can be optimally adapted, and we also succeed in constructing the drive very narrowly."

In order to enable the adjustment of the width and the height of the vehicle, a base frame structure based on box profiles is used, which can be pushed together easily. External lifting devices or linear actuators ensure a partially automated adjustment. The driver's cab and the various attachments are mounted on the base frame.

IP65 CAN control unit

The components of the drives, the steering and the power supply are equipped with CAN interfaces. The CAN master is a D1520 control unit from Graf-Syteco. The compact device with a 7-inch touch display with a resolution of 800 pixels x 480 pixels is ideally suited for use in mobile work machines. According to Prof. Schmidt, the main advantage of the D1520 for this project is the high degree of protection: "IP65 is relatively rare in these devices - especially if you want a display." The current speed as well as information about the state of charge of the batteries is monitored. The display shows the essential information needed to operate the vehicle. The horizontal and vertical position of the sliding frame profiles is also displayed.

The bright display is easy to read even in direct sunlight. The D1520 has two CAN interfaces (ISO11898) that can communicate with all components on the vehicle. A USB interface serves as a programming interface, and additional interfaces such as J1939 are used to connect additional peripheral devices. "For example, we connected the analog joystick, which allows the operator to steer, accelerate and decelerate the vehicle," Prof. Schmidt explained. Other functions, such as the choice of direction of travel, are realized via the touch display.

Figure 2: The control of the stilt tractor is realized with an operating and control unit of type D1520, to which an analog joystick is connected (Source: Graf-Syteco)

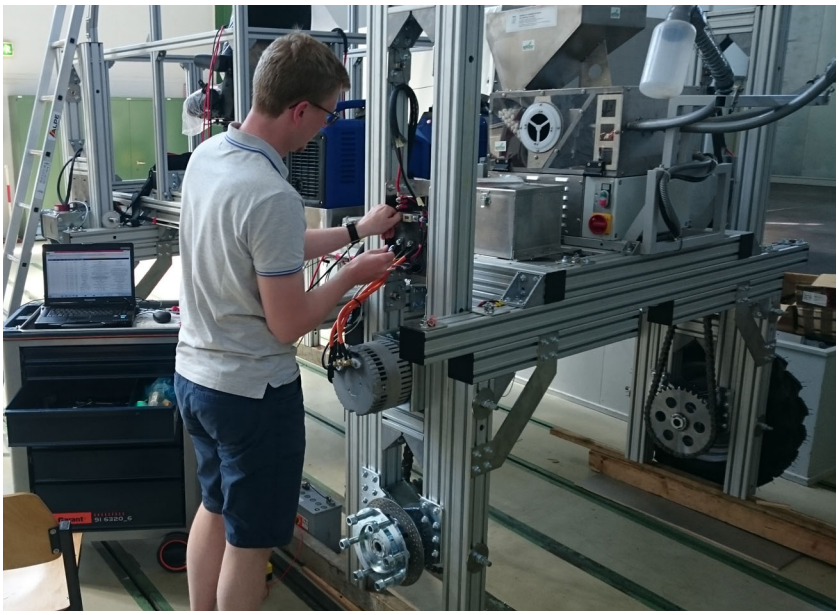

Figure 3: Installation of the drives in the institute workshop (Source: Graf-Syteco)

The ARM9 processor provides enough processing power to perform all the control and visualization tasks for the stilt tractor. In addition to the driving functions, this is above all the energy management. The controller monitors the state of charge of the batteries and the functions of the range extender. In critical conditions, for example, when the battery is discharged, the controller stops the machine. Programming the visualization for the D1520, the students of the Magdeburg working group used the software tool GSe-VISU supplied by Graf-Syteco. The control tasks were programmed in C. "Support from the service team at Graf-Syteco was a great help in software development," Prof. Schmidt recalled.

Fully automatic driving

Currently, still the driver has to control the stilt tractor manually. The working group around Prof. Schmidt is already working on equipping the vehicle with assisted and automatic driving functions. For this, suitable sensors must be able to observe the environment. In particular, the detection of the individual rows is paramount, since then an assisted steering assistance for tracking can be realized. This should allow the fatigue-free operation of the machine. In the next step, a function for automatic turning in the headland is planned, for which, however, an exact location of the stilt tractor within the corn field is necessary. The long-term future project of the mechanical engineers from Magdeburg is the fully automatic driving with automatic sequence tracking, reversing function as well as mechanisms for avoiding obstacles in the field. ◀

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