CAN-based distributed control of a breakstone cleaner

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Company background
Bosch Rexroth, a part of the Bosch Group, is a specialist in the field of drive and control technologies and is a partner for mobile applications, machinery applications and engineering, factory automation and renewable energies. It develops, produces, and sells components and systems in over 80 countries.

The OT-84 breakstone cleaner with the train set

Consistently growing demand for transportation services and increasing requirements to travel speed and comfort entail the need to improve quality of railway tracks. To meet these demands it is necessary to design machinery that is able to perform their tasks with the top efficiency with consideration to enhanced quality standards. The example of such a machine is the OT84 breakstone cleaner designed and constructed by ZPS from Stargard Szczeciński (Poland) in collaboration with Bosch Rexroth (Poland).

The breakstone cleaner is a vehicle (railroad machine) that is provided with hydraulic drives and dedicated to perform operations including picking up, cleaning and initial spreading of the breakstone located beneath the machine. The surveying facilities make it possible to lay the track subgrade with required slopes.

The machine subassemblies enable to carry out the full operation cycle: the hoist lifts the track and the chain drags the breakstone out from beneath. Upon having the breakstone cleaned it is transferred and spread on the track subgrade by means of dedicated conveyers. The machine is also provided with a traction drive. When the machine is running the lifting and shifting mechanisms raise the entire track up together with sleepers. Next the chain is attached and the moving chain pulls breakstone away from below the track and transfers it to the cleaning screen. After cleaning the dedicated conveyers transfer already treated breakstone back to the space below the track, whilst contaminations are disposed to dedicated cars pulled behind the machine.

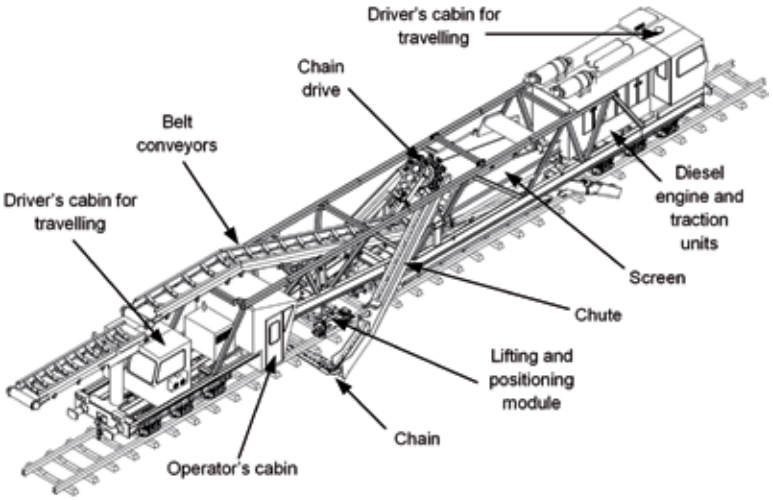

Figure 1: The OT84 breakstone cleaner scheme (Source: ZPS Sp. z o.o.)

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The OT84 breakstone cleaner in figures

Machine length: 27 m
Machine weight: 105 t
Power: 900 HP
Maximum speed: 80 km/h
Number of handled inputs: 243 of that 36 proportional inputs
Number of handled outputs: 111 of that 51 proportional outputs
Number of controllers: 5
Number of hydraulic pilot valves with CAN interface (EPM2): 39
Number of independent CAN paths: 7
Number of displays: 5
Number of CAN I/O modules: 5
Number of inclinometers wit the CAN ports: 5
Number of measurement lines with CAN interfaces: 4
Modules of RF remote control: 2 (few dozens of binary inputs per each)

Figure 2: Applied DI3 display

Figure 3: The 36-20/30 master controller

Figure 4: Pilot valve with CAN interface

Figure 5: Joysticks with CAN ports

The control system

To enable smooth and reliable execution of these operations the machine is provided with the Bodas distributed control system. Each of aforementioned subassemblies has its separated controller that handles associated components of the control system (sensors, actuators, output signals and solenoid hydraulic valves). The machine comprises four controllers of the RC8-8/22 type (for traction units, conveyers, chain and screen) as well as the RC36-20/30 controller. All controllers communicate with each other via the CAN network and exchange the most important data, including values of process and control variables as well as information about disturbances. The RC36-20/30 controller acts as the network master unit to monitor and supervise operation of other slave controllers. It is also responsible for the tasks related to handling communication interfaces (displays, joysticks, actuators, output signals and RF controllers). In addition, it controls auxiliary hydraulic functions, such as air conditioning, lighting and others. Nevertheless the control system acts as the whole integrity of five controllers, each individual unit has been designed to perform its functions independently as an autonomous device, even if installed on another machine.

The control system supervises and manages operation of the entire machine and helps the operator out in performing many jobs. Its advanced feature is automated control of the chain slope and depth to achieve proper embankment shape (see Figure 7). Owing to automation of the basic tasks the operator is capable to focus his attention on the process of the breakstone collection and final spreading. Operation of the belt conveyors and the screen as well as traveling of the machine is partly automated. The conveyors and the screen start automatically with speed control. Also the slope angle of the screen can be positioned to achieve the most efficient operation of that unit. The traveling speed during the machine operation is automatically adjusted to the chain resistance. ▷

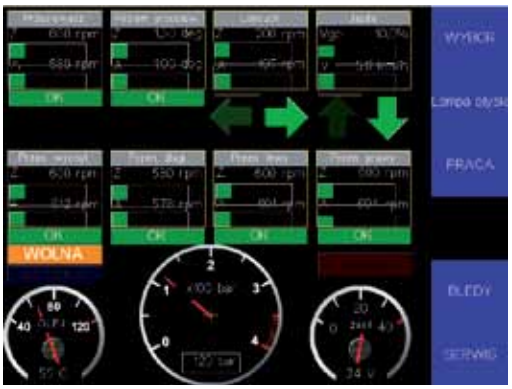

Figure 6: Display in the operator's cabin (basic screen)

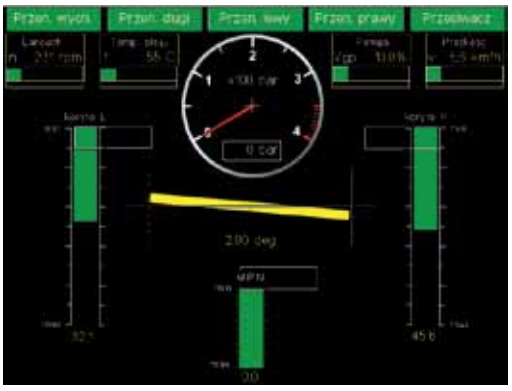

Figure 7: Display in the operator's cabin (screen for chain leveling)

At any moment the operator is capable, if needed, to switch the machine over to the manual mode of operation. The electronic control system enables to monitor operation of the driving and traveling systems as well as to react to disturbances and errors. All the foregoing features guarantee the most efficient working conditions as well as safe operation of the machine over a prolonged lifetime.

CAN interconnection

Another crucial component within the control system is the CAN network that enables transmission of digital information between individual controllers as well as between controllers and peripheral devices. The breakstone cleaner incorporates as many as 69 devices with the CAN ports, including controllers, 58 I/O modules and five displays. Application of the CAN system was imposed by the need to fulfill requirements of the manufacturer with the aim to reduce cable interconnections between huge number of measuring devices and actuators. The control system based on the CAN architecture proved more compact in size and transparent in design. The next requirement was elimination of control reliability by elimination of interferences on long electric lines running down the machine.

The CAN network usage makes the system scaleable as it can be enhanced with additional components such as sensors, actuators, recorders, communication modules, and GSM/GPS units. It also enables distributed control (field-bus controllers are located close to measuring instruments and controlled devices). In order to handle all the system devices, seven separate communication paths were set up and routed in such a way that even in case of a fault on a single line the machine is kept operable.

Conclusion

Application of the control system from Bosch Rexroth substantially simplified and accelerated operation of the breakstone cleaner machine (with simultaneous prolongation of its lifetime). It also improved safety of the machine operation and saved space that is occupied by drives and control units.