Modernisation of a Bucket-Wheel Excavator
at the Welzow-South lignite mine, Lausitzer Braunkohle AG, Germany (1996)
The task

An SRs 6300.50/15.0+VR bucket-wheel excavator used for overburden removal at the Welzow-South lignite mine in Germany had been in operation since 1981. An electrical rehabilitation became necessary in 1997, due to the long years of operation under extreme mining conditions. The job was given to ABB Cottbus with the target to enable the machine to work, under the geological and operational conditions of the mine, for another fifteen to twenty years and to achieve a marked reduction of electrical maintenance costs.

This paper describes the major elements of that rehabilitation.

Variable-speed drives

The main drives of the conveying system consisted of slipring motors with rheostatic starters that did not allow, because of their fixed speeds, any optimisation by adapting performances to varying operational requirements.

The introduction of variable-speed drives for the 4 belt conveyors, in addition to the main drives and the bucket-wheel drive, laid the basis for a complex automation of material conveying.

The new solution yields essential operational advantages:

- Squirrel-cage motors can be used.
- Starting and slip resistors that caused high losses are no longer needed.
- Performance is adapted by speed reduction (power saving).
- Motors can be run at crawling speed (for removing large rocks in the overburden).
- Starting and stopping torques can be controlled.
- Mechanical maintenance is reduced.
- The noise level decreases.

ABB Cottbus has chosen the reliable ABB frequency converters ACV 700 Multidrive, and for smaller drives the model ACS 600. The incoming supplies of the main drives in the superstructure of the excavator work as self-commutated grid inverters.

The system is characterised by the following features:

- high overall efficiency of >94.5 %
- regenerative braking at minimum system perturbation (distortion factor of <3%)
- improved power factor
- high availability through parallel power supply
- fully digitalised power electronics
- powerful optical-fibre interfaces for diagnostic routines

The control of drive speeds is based on active vector regulation, with the application control (APC) implementing torque setpoints.

Moreover, the application control serves to visualise all inverter signals for each drive on a local display.
Technical Data of the Conveying System

<table>
<thead>
<tr>
<th>Component</th>
<th>Power Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bucket wheel</td>
<td>3 x 700 kW / 690 V</td>
</tr>
<tr>
<td>Bucket-wheel conveyor</td>
<td>2 x 1120 kW / 690 V</td>
</tr>
<tr>
<td>Intermediate conveyor</td>
<td>630 kW / 690 V</td>
</tr>
<tr>
<td>Receiving conveyor</td>
<td>2 x 1120 kW / 690 V</td>
</tr>
<tr>
<td>Loading conveyor</td>
<td>630 kW / 690 V</td>
</tr>
</tbody>
</table>

Technical Data of the Main Drives

<table>
<thead>
<tr>
<th>Component</th>
<th>Power Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bucket-wheel hoist</td>
<td>2 x 620 kW / 690 V</td>
</tr>
<tr>
<td>Slewling</td>
<td>4 x 75 kW / 500 V</td>
</tr>
<tr>
<td>Travelling (excavator)</td>
<td>12 x 132 kW / 500 V</td>
</tr>
<tr>
<td>Travelling (loading section)</td>
<td>6 x 132 kW / 500 V</td>
</tr>
<tr>
<td>Conveyor hoist</td>
<td>1 x 15 kW / 500 V</td>
</tr>
<tr>
<td>Loading-boom hoist</td>
<td>1 x 22 kW / 500 V</td>
</tr>
<tr>
<td>Loading-boom slewing</td>
<td>1 x 15 kW / 500 V</td>
</tr>
<tr>
<td>Cable reel</td>
<td>1 x 4 kW / 500 V</td>
</tr>
<tr>
<td>Cable carriage</td>
<td>1 x 0,15 kW / 500 V</td>
</tr>
</tbody>
</table>

Control System and Process Management

The machine is controlled and supervised from the control room of the excavator that has been designed according to modern ergonomic principles. The installation consists of an OS 520 operator station from the ABB Advant Open Control System and three powerful AdvantController 450 processing stations of the same family. Those controllers have a high processing capacity, a comprehensive process periphery, a wide range of different process input and output devices as well as a large number of communication interfaces. All process data is stored fully configurally in databases.

The Advant process control stations and the controllers are connected to a MasterBus 300 network. The MasterBus 300 is based on the connection-free data circuit service protocol according to IEEE 802.2, class 1, and the access protocol as to IEEE 802.3 CSMA/CD. The process level uses the sensor-actor bus INTERBUS-S specified by the customer.
Communication Infrastructure

Signal transmission within the excavator complex as well as to and from a central control station is based on a powerful communication structure using most modern components, such as optical-fibre connections for data communication and signal exchanges between the individual sections of the system. A wide-band communication system (OTN) makes it possible to print out signalisation, fault and operation records at any point of the excavator. All data can be received at the central control station via Ethernet.

Automation functions

The modernised excavator features a high degree of automation:
- automatic positioning of the loading conveyor over the hopper
- optimisation of starting and stopping the conveyor
  - accelerated start
  - control of belt speed
- operational cycles and programmed control moves for
  - slewing angle limitation
  - cutting depth control
  - slice thickness
  - slice height
  - formation of even surfaces
  - 1/cosϕ control
  - lateral slope formation
  - front slope formation
  - deep cutting
  - performance control
- excavation and transport of rocks
- automatic transmission of specified values (setpoint and limit values)

System diagnosis

For the first time a comprehensive diagnostic programme has been introduced in order to support maintenance and repair measures. All necessary software modules and communication interfaces have been concentrated at a diagnosis desk located in the substructure of the excavator. That desk can be remote-controlled via TCP/IP network connection.

The programme breaks up into “operative diagnosis” and “extended diagnosis”.

“Operative diagnosis” covers the examination of individual system components for faults and maintenance status. That is done by means of the tailor-made diagnostic tools the manufacturers provide for their devices as well as on the basis of the information gathered in the central control system.
“Extended diagnosis” means the longer-term supervision of wear and tear by means of

- relevant control data
- a central data library kept on a database server
- evaluation of specific applications.

New technological possibilities such as client server databases and INTRANET have been utilised to implement that function.

Extended Diagnostic Applications

- Maintenance of basic data in the database
- Supervision of maintenance cycles by
  - elapsed-hour metering at motors and gears
  - counting of switching cycles at breakers
- Analysis of function complex data
  - graphic display of analog and digital process values
- Recording of operational processes with relevant analog values for
  - limit switches, buttons, rip-cord switches etc.
  - repair modes, belt slipping, load per metre etc.
Summary

The project has been implemented in close cooperation with the customer, Lausitzer Braunkohle Aktiengesellschaft. In part, new ways have been opened up, particularly with regard to installing speed control for all main drives, which has made the excavator the only one of its kind with all main drives controlled. Thus it has become clearly more efficient than comparable machines without control, because the innovative design produces savings in the field of variable costs.