Reconstruction of the Electrical Equipment of the Dragline Esh 15/90 in Narva, Estonia (2003)

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Many of the draglines, which are in operation today, were built in the 70ies and 80ies. Although they are very robust and have been serviced by preventive maintenance these machines reach a “natural” limit caused by wear after about 15 to 20 years of operation.

Besides the mechanical engineering, this applies most of all to the electrical engineering. Decreasing availability, morally worn equipment, increasing difficulties in getting spare parts and clear conceptual disadvantages compared with modern equipment, cause many operators to look for alternatives.

In any case the decision has to be made between new construction and reconstruction. The electrical reconstruction offers an alternative which is being used increasingly.

History

In 2002, ABB acquired a new order in the discontinuous opencast mining technology, which was a challenge for the dedicated team of engineers in Cottbus. It was aimed at modernizing a dragline Esh 15/90 in the Estonian oil shale mine of Narva Karjäär together with the Russian firm United Heavy Machinery (Uralmasch/UHM) from Yekaterinburg and our ABB colleagues in Estonia.

The major task was the change-over to three-phase AC drives instead of the combination of Ward-Leonard converter/DC drives and an intelligent control including visualisation. The mechanical adaptation of the motors to the existing mechanical construction of the gears etc. was also included.

For this project, ABB delivered the digital control for the excavator technology and the drive control, main drives, frequency converter with IGBT technology, control programmes for safety requirements and for the partial automation of the excavator operations and the visualisation.

Technical Data of the Dragline

- Volume of dragline bucket: 15.0 m^3
- Boom length: 90.0 m
- Max. load of loaded dragline bucket:: ca. 42 t
- Max. emptying height: 38.5 m
- Max. emptying range: 83.0 m
- Max. dragging depth: 42.5 m
- Calculated cycle time for slewing by 120 °, dragging depth up to 25 m in soils of category 1: 60 s
- Walking speed on horizontal path: 0.08 km/h
- Mean specific soil pressure when walking: 0.240 Mpa
- Mean specific soil pressure when operating: 0.115 Mpa
- Supply voltage (50 Hz): 6000 V
- Working weight of excavator incl. counterweight 1,740 t

Specific of the Project

The specific of this joint project was that three-phase AC drives in IGBT technology (insulated gate bipolar transistor) were used for this type of excavator for the first time.

The Drives-Group of ABB Cottbus, being the Center of Excellence of Open Pit Mining, gained comprehensive wide in projects for retrofitting BE295 shovels in Mexico and Brazil. The selection of the technology for the Esh offer in Estonia was based on this knowledge.

A specification prepared by UHM provided all technical preconditions for the use of the electrical components as for temperature, vibrations, shock load and performance parameters.

The incoming supply is 6 KV and the voltage level for the motors of the main drives for hoist, drag and swing is 0.69 KV

Motor check at the ABB manufacturer's in Finland

The maximum available motor output of the three-phase AC drives (2 x 710 kW hoist, 2 x 710 kW drag, 4 x 210 kW swing, 2 x 260 kW walking mechanism) without auxiliary and secondary drives is ca. 4.2 MW.

The frequency converters are installed in totally air-conditioned containers for outdoor installation, which correspond to the high requirement group requested, on the left- and right-hand sides of the machine room each on specifically constructed platforms. Thus a large part of the environmental impacts is kept away from the components

Reconstructed Esh 15/90 with FC container solution

Project course

Based on the Russian specification, the first offers containing the technical components were submitted to UHM, Russia, in May 2002.

Frequency converters
Braking choppers
Motors
Transformer
Container with air-conditioning
PLC for technological and drive control
Visualisation with touch TFT display and conventional text displays
Control chair with master switches

It was planned that UHM, Electric Drive & Automation Department would deliver, install and commission the low-voltage and medium-voltage equipment.

After successful technical discussions and commercial negotiations the contract was signed in July 2002 between UHM as the major responsible party and the customer Eesti Polevkivi.

ABB Estonia and ABB Germany were commissioned to provide dismantling, delivery, installation and commissioning of the electrical equipment. The technical concept, the acceptance test, the technical coordination with UHM and the entire technical responsibility were provided by ABB Cottbus as the CoE Open Pit Mining.

The installation started in May 2003, and the commissioning in June.

From 1st to 12th July 2003 the test run was prepared in which specialist of UHM and ABB took part in close cooperation with the customer Eesti Polevkivi in order to check the necessary adjustments and safety parameters and to minimise the load onto the mechanics of the ropes, the supporting frame and other mechanical components.

During this time the excavator operators worked at full output – in particular during the night shift – which demonstrated already the efficiency of the new plant and the acceptance by the excavator operators without being included into the test period.

The test run was carried out from 12.07.2003 to 17.07.2003 under the most severe load of solid rock overburden. A criterion of the successful test run was to excavate at least 22 hours of normal output every day. A standstill caused by a failure of the electrical installation of more than 2 hours would have resulted in a new commencement of the 5-day test run (requested availability: more than 92 %).

The output is 420 – 450 buckets per shift which corresponds to an output of about 8000 m^3 of solid rock.

The test run of the dragline was successfully finished on 17.07.2003 at 10 pm and it was handed over to the customer on 22.07.2003 after the necessary safety adjustments had been carried out. Thus the regular three shift operation could be started and the commencement of the warranty period was stated.

Reliability and Availability

Reliability, availability and efficiency of the equipment used are the central quantities influencing the customer satisfaction.

Three-phase installations equipped with frequency converters and squirrel-cage motors are increasingly used because they are more efficient than the conventional systems. Compared with DC solutions there are less investments for the drive system of motor and power converter – in particular in case of large performance (above 500 kW). The operation, maintenance and repair costs are considerably less. The high system efficiency factor of the whole drive (motor and converter) of up to 93.5% results in considerable savings of energy costs.

The fully digitalised frequency converter and its drive control provide high functional safety and reduce – amongst other things by torque monitoring – stress factors for the machine during the excavator operation.

PLC AC80 with I/O S800

Based on the modular design the drive components can be easily exchanged. The expenses for preventive maintenance are reduced.

The equipment which includes an efficient drive control (AC80 together with remote I/O-modules S800) allows a minimisation of the numerous interfaces.

An extensive visualisation concentrates on fault indication, status indications using graphic elements and a clearly structured layout of the display hierarchy and the display of system components.

Interview with Mr. Belgorai, senior mechanic, Narva Karjäär mine, company Eesti Polevkivi

ABB:

How would you describe the state of the excavator before the reconstruction?

Belgorai:

The excavator Esch 15/90 has been in operation in the Narva mine since 1970. The control system of the main drives corresponds to the traditional URALMASCH control system “G-G“ (Generator-DC motor).
The main equipment has not been replaced since the erection. The automatic switching devices, lighting equipment and parts of the cables were replaced during the general repairs (once in 5 years). Damaged motors and generators were replaced during the operation.

Based on the operational conditions and the decline in demand for oil shale the excavator was out of operation in the last 5 years. The environmental conditions have adversely affected the idle excavator. Owing to the very high humidity and the temperature drop the insulation in particular was heavily loaded. In our country such excavators have to work 24 hours a day without any days of rest or holidays (except for

the New Year's holiday) because long standstills deteriorate the insulation resistance rapidly and cause a malfunction or breakdown of the electrical equipment.

ABB:

Which operational and ambient conditions prevail in the opencast mine and how do they influence the excavator?

Belgorai:

The weather conditions in our region include high humidity, rainfall (even in winter), low temperatures in winter (up to -30 °C) and high ones in summer (up to +30 °C). Dust is another factor that influences the machines. An enormous dust volume is generated during the mining works and in particular when boring. The interaction of humidity and dust causes a rapid deterioration of the insulation and the electrical equipment.

ABB:

What does the use of a new electrical equipment mean for the customer?

Belgorai:

The decision for using the AC drive on the excavator Esch 15/90 is based on the following:

- It is now possible to use serial frequency converters made by Western manufacturers which have not been available in Russia yet.
- Examples of excavators made by American manufacturers where such drives are in use were convincing.
- The more cost-effective variant using AC motors was essential for decision-making.
- The maintenance times for electric motors were considerably reduced.
- Up-to-date information, control and diagnosis systems are used.
- The electric power consumption is minimised.

Technical Solution and their Advantages at a Glance

- Digital control
- Frequency converter with IGBT-technology (insulated gate bipolar transistor)
- Three-phase AC drives
- Visualisation by means of touch LCD display
- Container design with air-conditioner
- Closed system
- The fully digitalised frequency converter and its drive control provide high functional safety
- The operation can be implemented without sensors as the essential parameters, torque and speed, are provided in the drive control.
- Based on the modular design and the IGBT power semiconductors the components can be exchanged easily.
- The efficient drive control (AC80 together with remote I/O S800) allows a minimisation of the numerous interfaces.
- The reconstruction time of the entire machine is shortened.
- Higher resistance towards the rough application conditions in mining.
- Three-phase systems with frequency converters and squirrel-cage motors are more efficient than the conventional systems. Compared with DC solutions there are less investments for the drive system of motor and power converter in case of a large performance (above 500 kW). The operation, maintenance and repair costs are considerably less.
- AC motors are almost maintenance-free.
- A mains failure can be managed taking the technological and safety aspects into account.
- Emergency operation with a reduced number of motors (in particular for slewing gear) is monitored and controlled.

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