Combining Migration and Optimization of DCS in an Existing Scheduled Maintenance Simulator ensures faultless commissioning and startup

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Simulator ensures faultless commissioning and startup

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Abstract

Combining migration and optimisation of DCS in an existing scheduled maintenance – Use of simulator for faultless DCS commissioning and startup

During outage for a scheduled maintenance the existing SPPA-T2000 control system of unit K (BoA 1) at RWE Power AG’s Niederaußem power plant was to be replaced by the SPPA T3000 control system. At the same time an increase in the unit’s flexibility with regard to primary and secondary control operation, a reduction of smallest exporting load as well as a reduction of startup time were intended. In order to accomplish these goals, the SPPA-S3000 simulator 1,100 MW block unit G (BoA 3) of RWE Power AG’s Neurath power plant owned by KWS supporting the new DCS was planned to be used for advance-commissioning and subsequent optimisation of the DCS.

This approach was chosen for the benefit of the project’s cost effectiveness. The simulator was used in order to reduce the commissioning time period for the main DCS to just a few hours. Within this time, the unit should reach load operation even during the first startup controlled by the unit master program.

Based on the existing simulator, the process models for BoA1 were developed. With the help of migration tools from Siemens AG the automation code was translated to the new SPPA-T3000 control system.

Thanks to the advanced commissioning of the main DCS independent of the main project, the unit started-up as planned, quickly and efficiently, without any need for further corrections. The operating personnel, which had already been trained on the SPPA-T3000 control system, actively assisted the commissioning of the real unit, successfully safeguarding plant operations.

Project goals

The “DCS migration to SPPA-T3000” project was initiated for Unit K of Niederaußem Power Station (Figure 1) in 2011, in response to the changing energy market and the resulting demand for flexibility, even for lignite-fired power plant units. The project focused on specific key characteristics aimed at increasing flexibility: reducing unit startup times, enhancing primary and secondary control operation and load change gradients, reducing the minimum load point, and fully automating the unit control system and improving its restart capability. Measures of this type can only be applied efficiently if they are implemented.

– without causing any additional non-availability, and
– within the scope and timeframe of a regular scheduled maintenance.

Quality assurance and optimization of the DCS therefore had to be performed in advance. This could only be achieved through virtual commissioning followed by optimization on a simulator model of the plant.

Simulation technology

Simulator configurations like those used in the latest training simulators have proven to be extremely effective for virtual commissioning of main instrumentation and control systems for new unit construction projects and plant modernization projects. Such simulators comprise:

• the virtual control system of the supplier of the main DCS (in this case SPPA-S3000), which replicates the response of the original control system in the power plant and,
• the simulation computer on which all process-engineering and electrical plant sections as well as ancillary I&C systems are simulated.

The HMI of the virtual control system comprises the original operator station components of the SPPA-T3000 control system. It is connected to the server level over the application highway, which is a standard computer network. The original application software of the main DCS executes on the application servers.

A final diagnostics display and the engineering functional scope are available through the operation and monitoring functions, unconstrained in the simulator environment.

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Figure 1: RWE Power’s Niederaußem power plant (source: RWE Power AG).
In the power plant, the automation servers are connected to the server level over the automation highway. In the simulation environment, these are replicated in software on an emulation server. They execute or interpret the automation code loaded from the server level. With this emulation principle, the emulated automation in the simulator environment responds to the process models in exactly the same manner as the original main DCS in the power plant responds to the real processes.

The plant sections of the power plant and the ancillary I&C are simulated on the simulation computer. The sensors, actuators, the interfaces to the ancillary I&C and the blackbox systems are simulated at the interface to the control system in the model. The data interface between the main DCS and simulation models has the same scope as the field interfacing in the power plant, as it is directly wired or implemented over signal buses. In a modern coal-fired power plant, the signal interface typically comprises more than 40,000 signals. In the simulation environment, this signal scope is simulated in full and is exchanged ten times every second between the virtual control system and the simulation models.

This simulation environment provides a test environment which can be used prior to actual commissioning in the power plant for almost complete testing of the instrumentation and control functions of the main DCS. The tests comprise the single-loop, group, and unit control levels and cover the stages from connecting the field to the main DCS, through individual interlocks, to unit startup and shutdown tests. The I&C functions configured in the main DCS can be tested with an appropriately defined test scope and sufficient test time. Corrections to configuration and parameterization of the control system can be implemented directly in the simulator environment and repeatedly checked until they function faultlessly (Figure 2).

### Projects in which virtual commissioning has been used

- RWE Power AG, Siemens AG and KRAFTWERKSSCHULE E.V. (KWS) have already successfully employed virtual commissioning of the DCS in two projects:
  - Neurath Power Station, Unit D, 600 MW, lignite-fired, a main I&C system retrofit project, and
  - Westfalen Power Station, Unit D, 800 MW, anthracite-fired, a new power plant construction project.

The 600-MW Unit D at Neurath Power Station has been in operation since 1975. The main instrumentation and control system was originally implemented with BBC Decontic (open-loop controls) and H&B Contronic 2 (closed-loop controls). In the context of the retrofit project for enhancing the flexibility of the unit, the main I&C system was replaced with the Siemens AG SPPA-T3000 Control System. Key objectives of the modernization project were to increase the flexibility of the unit by: enhancing the primary and secondary control operation and, significantly reducing the minimum load point.

To ensure efficient and successful commissioning of the unit, it was agreed by the contractual partners in March 2010 that virtual commissioning of the DCS would be performed beforehand on a simulator platform from KWS. After a project runtime of just seven months, the main functional complexes were successfully tested (September 2010) in the context of virtual commissioning.

The Westfalen Power Station currently under construction, including Units D and E, is designed as an anthracite-fired twin-unit plant of the latest generation with ultra-critical process values. In 2012, the instrumentation and control system was also tested prior to commissioning in the power plant on the KWS simulator for anthracite-fired power plants, and optimized as needed. The objectives for this project were:

- the early detection and rectifying of problems in the automation code of the DCS,
- to create a ready-to-use simulator environment for initial training of future operating personnel.

Following the successful conclusion of virtual commissioning, training started on the simulator for 800-MW anthracite-fired units at Westfalen Power Station on February 27, 2012.

### Project – Location and team

As in previous I&C projects in which virtual commissioning was used, a core project team was assembled to verify automation, including the open-loop and closed-loop controls on the unit model. It has proved effective in the past for the customer to delegate specialists in both productive operation and process engineering and I&C. The DCS supplier was required to provide specialists with plant know-how and knowledge of the SPPA-T2000 (Teleperm XP) and SPPA-T3000 control systems. Further experts provided support for the fail-safe functions and the turbine governor. In addition, experienced model engineers from KWS and OSE Power Systems Inc., USA, and a KWS simulator trainer were integrated into the project team.

The project locations were the Siemens site in Erlangen for DCS migration, and KWS in Essen for virtual commissioning. The system meetings were held and commissioning was performed on site at Niederaußem Power Station (Figure 3).

### Project progression

The contract was awarded to Siemens AG and KWS eleven months before planned reconnection to the grid following a scheduled maintenance. The time available for modeling the unit, migrating the DCS and performing virtual commissioning followed by an optimization phase for the complex power plant operating sequences was therefore extremely limited. Advance virtual commissioning was divided into two phases:

- In the first phase; migration, the existing I&C functions of SPPA-T2000 were automatically implemented into the SPPA-T3000 environment using software tools. The necessary manual adaptation of logic sequences and plant displays was performed on development servers at Siemens. Function expansions of the main DCS were deliberately not incorporated into the automation code at this point.
In parallel, a simulator environment (SPPA-S3000) was set up at KWS that comprised the virtual control system and the simulation computer for simulation of the process models. The process models for BoA 1 were developed from the existing process models for the KWS training simulator for lignite-fired power plants (variant BoA 3), and therefore did not have to be completely recreated.

The migrated code of the control system was imported into the virtual control system of the simulator environment and connected to the process models at the beginning of 2012. The interfaces for new components were adapted on the simulator. Even at this early stage in the project, it was possible to detect discrepancies in the automation code and to report them to the experts working on the development server in Erlangen. Errors were corrected there, and following the second generation of the code, a quality was achieved that enabled startup sequences to be performed using process models interoperating with the control system. In this project phase, the main focus was on validation of the process models. Further problems that arose due to migration of the code were identified and resolved. The engineering work that resulted was performed directly in the simulator environment which therefore took on the role of “master” for the I&C code from this point in time.

The fail-safe software and the turbine controls could not be automatically migrated, so this had to be configured in Erlangen. The identified programming errors were directly rectified in the simulator environment. At the end of the migration phase, long before post-overhaul commissioning of the power plant unit, a quality-assured automation code (migration code) was available that was suitable for commissioning the unit. A tested model of the simulated unit was also available for a subsequent development stage.

In the second phase, the optimization opportunities identified in the real plant and the I&C expansions resulting from process engineering changes had to be integrated into the automation of the simulator environment. The tests could then be performed immediately afterwards in conjunction with the model. In this project phase, the simulator remained the master for engineering of the automation code. At the end of this phase, complete startup and shutdown procedures were repeatedly performed, whereby the unit control program and the subordinate function groups started up and shut down all power plant components. Selected unit operating personnel were familiarized with the properties of SPPA-T3000. Following this implementation process, it was extremely helpful to be able to check the new automation code on a simulator.

BoA 1, with its innovative technology, is one of the most up-to-date lignite-fired power plants in the world. To meet this challenge, even during initial commissioning, all the possibilities of the SPPA-T2000 Control System had to be exploited in full. The opportunity had therefore been presented to Siemens AG to gain experience from the migration process in large-scale, complex plants.
Insights gained during virtual commissioning were evaluated on the simulator, implemented, categorized and subsequently retested. Due to the intensity and, in particular, the practical nature of the tests, even small problems such as incorrect display links could be detected and rectified in advance.

Another advantage of the two-phase test was validation of the simulation models during the migration phase. By obtaining perfectly functioning migrated software, the model was ideally prepared for the optimization phase. Inaccuracies in the model were detected and rectified to achieve an accurate picture of the plant. This model quality, close to reality, was particularly important for the optimization phase. The behavior of the newly configured enhancements in the real plant could be intensively tested. This guaranteed smooth commissioning in the plant. Finally, all test load cases were initiated and it was checked to ensure that the associated processes were conducted correctly in the plant.

On-site commissioning

After decommissioning the SPPA-T2000 Control System to be replaced, retrofitting of the hardware for conversion to SPPA-T3000 was performed. Following commissioning of the system, selective spot checks were performed on the connections to the instrumentation as well as a 100% check of all protection-relevant signals. Drives that were controlled from the switchgear were subjected to a 100% connection check by operating their remote switches in the plant. Blackboxes and bus-controlled drives were run through all their functions completely in test mode.

On completion of the overhaul, recommissioning of the instrumentation and control of the unit was performed. The remaining outage time was utilized for starting up ancillary plant systems that were ready for operation through the subgroup controls. Also, preheating of the steam generator was activated early following approval of the air and smoke circuit.

On completion of all the overhaul work, the unit control program was commissioned. Due to comprehensive testing during virtual commissioning, hardly any DCS changes were required. Apart from the standardized burner interlock test and the waiting time for steam purity, the unit was operating on the grid within 14 hours.

Goals achieved

At the end of virtual commissioning, fully tested and almost error-free automation code was available that had been qualified in the simulator environment by means of comprehensive tests. Engineering of the main DCS was therefore almost complete. By this point, the operating personnel were already familiar with the control system and the automation functions implemented in the single-loop, group and unit control levels and had already performed the startup procedure several times. They were, therefore, ideally prepared for actively supporting real commissioning in the plant. They were able to detect faults as they arose, quickly and reliably. This starting point led to:

- real commissioning of the DCS in the power plant being reduced to a minimum,
- the power plant unit entering productive operation on time and,
- the project goal being assured.

The first startup procedure was executed without any unit failure.

There was no need to make changes to the DCS in the power plant due to faulty programming. Further time saving was achieved by executing test runs beforehand on the simulator, for example, process enablers, safety interlocks and equipment unit switchovers. In particular, the restart capability of the function groups and unit control program was established for the start of commissioning in the plant.

Extensive testing of fail-safe functions is frequently performed in bypass mode during ignition or main combustion, but before synchronizing the generator with the grid. Because these tests were performed in advance during virtual commissioning, the commissioning time for combustion could be reduced to a minimum. Large quantities of resources such as fuel were saved. The safety-related acceptance tests of the fail-safe systems were conducted in the shortest possible time, because the personnel responsible had already prepared the acceptance tests on the simulator.

Process enabling and the tripping of large components had been tested in advance in the simulator environment to such an extent that only examples needed to be performed during real commissioning. Unnecessary shutdowns could therefore be avoided which, in turn, avoided undesirable stressing of the major components. All of the specified project objectives, such as reducing the unit startup time, enhancing primary and secondary control operation as well as load change gradients and reducing the minimum load point, were achieved.

Conclusion

Recommissioning of the power plant unit following I&C retrofit and DCS migration could be assured, due to advance virtual commissioning, without any unit failures caused by the DCS during the startup process and subsequent commercial operation. It was also repeatedly noted that commissioning of the real plant was much less stressful.

Plant non-availability time was reduced considerably because of faster startup following the I&C retrofit and the reduced test and verification runs on the real plant, as well as to having implemented these measures during a scheduled maintenance. The resulting substantial efficiency potential was due to the virtual commissioning performed in advance. The simulator platform can also be used in future projects in the context of process engineering and I&C optimization. Depending on the degree of expansion, the platform can also be used as a training simulator.