Upgrade of power station instrumentation

SSE, the operators of the The Keadby power station, needed to address the obsolescence of its existing DCS and to provide an expandable solution to extend the working service life of the power station. The vendor needed to deliver the total upgrade solution in time for a planned major shutdown and in parallel with other plant projects, with minimal commissioning time.

The River Trent has a history of changing course over the ages, with mention of its meanderings even in the works of William Shakespeare. Once a major commercial waterway marking the traditional boundary between Northern and Southern England, the river is relatively stable today and is the source of recreation and drinking water, as well as cooling water for a large number of coal and gas fired electrical power plants along its route. One of those plants, Keadby Power Station at Scunthorpe in North Lincolnshire, is operated by SSE, one of the largest energy companies in the United Kingdom. The Keadby plant, which began commercial operation in 1996, is a 720 MW combined-cycle gas turbine generating facility.

The plant includes two General Electric frame 9FA gas turbines, one Alstom steam turbine, two Babcock three-pressure waste heat recovery boilers and a Siemens GT10B auxiliary gas turbine. It is maintained and operated by a staff of 53 including managers, engineers and technicians. When SSE management realised the facility’s distributed control system was approaching plant-wide obsolescence, the company chose Invensys operations management to upgrade the plant to a more flexible, scalable and supportable solution.

**Solutions and products**

Solutions included:

- InFusion Enterprise control system (the first major InFusion solution in the UK)
- Foxboro I/A series distributed control system
- SimSci-Esscor ROMeo online performance suite
- SimSci-Esscor dynamic simulation suite results

The Invensys solution was delivered on time for the planned outage and within the SSE budget for the project. The upgrade addressed both the obsolescence and expandability issues. Plant personnel realised major benefits of simulation, including improved operator training and familiarisation and the facility now has a rigorous test-bed for process testing.

**Challenges**

These included incomplete loop drawings, faded conductor identification and the risk of human error during I/O change-out, which were considered significant upgrade obstacles. Limited documentation available on existing software applications presented software migration and testing dilemmas for the project team.

**Shining the light on a new infrastructure approach**

Before the upgrade, the majority of the plant was operated by a site-wide Emerson WDPF (Westinghouse distributed process family) DCS system. A moderate-sized control system, this included 26 fault-tolerant controllers, 12 HMI workstations, including one historian and comprising 6046 hardwired I/O, eight control level data links (Modbus, Allen-Bradley DH+, GE-GSM); three supervisory level data links (Modbus-TCP, ODBC, OSI-PI); and 190 process screens, including approximately 130 overlays and 48 sequences.

SSE engineers initially identified 7 key criteria for the DCS upgrade project. Top of the list was that the upgrade had to be completed in time for a scheduled major plant outage and the system migrated with minimal site commissioning time. In addition, the new DCS system had to address the pressing obsolescence issues and remain current for the remainder of the plant’s expected service life. Sufficient expandability in terms of controller memory, I/O capacity and network bandwidth together with simplified online configuration was also considered a key requirement. Because of the potential impact on operating procedures and other human factors, engineers also specified that the new plant solution should maintain the existing control strategies and HMI interface standards.

**Upgrading systems in harmony with existing operations and upgrades**

As planning progressed, it became clear that the DCS upgrade had to be conducted in parallel with essential major maintenance activities as well as other expansion projects. Furthermore, site works needed to take place with minimal disruption to the outage programme. A risk assessment of the project requirement identified two key areas of concern: the I/O upgrade and application software migration. For the I/O upgrade, plant engineers at Keadby cited challenges such as faded conductor identification labels, incomplete loop drawings, human error risks and the potential impact on the outage programme associated with on-site rewiring and testing of approximately 6000 loops.

Although the existing system had been reliable in the past, problems were emerging. According to Hugh Ferguson, C&I engineer at Keadby Power Station and project manager for the DCS upgrade project. An increasing number of components were either no longer available or no longer repairable. Plus, controller memory was near capacity and most of the data highway bandwidth was already utilised.

Migration of the application software was also considered a potential problem area. Documentation was limited and there were no control narratives available. This meant that the application software itself had to be used as the source for the migration process raising concerns over the potential for human error, the skill-sets required and the functional acceptability test criteria.

Based on the potential obstacles, it was not clear whether there was an alternative to upgrading to Ovation, the next generation of the WDPF platform. However, because of concerns over software acceptance testing and continued support for the existing I/O hardware, SSE decided to go out to Tender for the project. Six DCS vendors pre-qualified for the proposed migration project, with four vendors asked to present formal technical evaluations of their proposed solutions.

Invensys operations management was ultimately selected by SSE because of their proven plug-in I/O card migration solution for WDPF, WDPF migration expertise, in-house simulation capabilities and the
incorporation of a model-based plant simulator for application software testing and operator training.

**Mastery of the migration process**

Invensys WDPF migration-style FBMs are a plug-in replacement for WDPF Q-Line I/O cards which allow the existing WDPF I/O racks, power-supplies and field wiring to be retained and re-used by the new Foxboro I/A system. From an IA system perspective, these modules appear identical to standard Foxboro 200-series FBMs.

Semi-automated tools were offered to migrate the Westinghouse application to the InFusion environment. InFusion is the Invensys delivery mechanism for enterprise control and consists of the hardware and software components necessary to provide a true aggregated view of information across an organisation, enabling a robust foundation for collaboration between people, processes and systems.

The SimSci-Esscor dynamic simulation suite provides both model-based plant simulation and a platform for enabling a complete operator training simulator (OTS) solution comprising virtualised DCS control processors, interfaces to third-party virtual controllers and a feature-rich training environment. This solution provides the full power of rigorous dynamic simulation and control system emulation for process engineers, plant engineers, operators and managers to improve plant design, check out controls, train operators and improve plant performance. It also offers a modern alternative to dated, fragmented, empirical and hard-to-use products with which many engineering firms and plants currently struggle.

Invensys also demonstrated an extensive track record for supporting the Foxboro I/A series distributed control system, a key component of the enterprise control system and were able to offer a number of products to further enhance this system including sequential function charts for DCS sequences and the ROMeo online performance suite for plant performance metrics.

This is an advanced, unified modelling environment delivering online optimisation applications to help users obtain peak performance from their operating units. The suite offers process optimisation across an entire enterprise with online modelling and equation-based optimisation capabilities providing more accurate, current operating information to better manage changing market pressures, product values, energy costs and equipment performance.

The migration approach showed that an alternative to the existing system was a viable option. Simulation is also proving particularly useful at resolving hard-to-replicate problems and was invaluable in leveraging the experience of plant operators during migration of the application software.

Initially, migration of the DCS application software and development of the OTS plant model were undertaken as separate, parallel activities by separate project teams. Once completed, these two elements were then combined to allow functional testing in the factory, prior to installation at site.

Once the system architecture and hardware and been specified, the DCS team began by developing migration tools and carrying out code analyses; breaking the application down into HMI components, interlock/protection logic, sequences, unique strategies and typicals. Migrated DCS components were then tested on a modular basis via a combination of code reviews and basic I/A series functional testing.

The OTS team's first task was to mark up plant piping and instrumentation diagrams (P&IDs) in order to clarify the required scope and topology of the processing model. Once the model had been constructed, this was followed by model acceptance testing to demonstrate the validity of the resulting process simulation.

The DCS and OTS teams joined together for the integration and testing phase. The DCS controls and third-party gas turbine controls (GE-Mark-Vie) were loaded and I/O cross-references between these and the process model were built and verified.

Plant simulation greatly assisted the software migration process and allowed us to catch a number of software integration issues before the system was accepted for installation on site. Without it, the plant would not have returned to service as smoothly as it did and would certainly have required much more commissioning time. If a simulator is used for software acceptance testing, it is necessary to avoid integrating DCS code too early since (just like on the real plant), control updates often take time, particularly if they require additional (virtual) plant run-ups to install or test.

Virtual plant commissioning was implemented on a plant area-by-area basis; balance of plant 1, balance of plant 2, gas turbines, waste heat recovery boilers and the steam turbine. Virtual plant commissioning on the simulator mimicked that which would have occurred on the real plant and included plant pre-start, start-up, steady-state operation and shutdown by an experienced Keadby operator. Once it had been demonstrated that it was possible to operate the plant in accordance with existing operating procedures, SSE gave the "green light" to proceed with the site installation phase of the DCS upgrade.

**A plan well-devised is a plan well-executed**

The project was delivered in time for Keadby's planned shutdown and within SSE budget parameters. The equipment upgrade was completed in less than 13 days, compared with the 18 days that were scheduled. There was only one minor two-hour delay to the return-to-service programme attributable to the migration to the new DCS. The unique Invensys migration solution with plug-in I/O modules allowed for unparalleled minimal plant downtime for the project.

In addition, the expandability issue has been resolved as the new DCS now supports up to 2000 nodes and the central processor loading is less than 25% of capacity. Keadby also enjoys simplified on-line configuration.

Invensys also successfully delivered a model-based OTS system, DCS sequence enhancements, process interlock diagnostics/overides, an on-line heat balance reconciled performance package via the automated rigorous performance monitoring product that is part of the ROMeo suite and alarm performance analysis via the third-party PAS PlantState suite.

The project has satisfied all of the technical objectives and we now have a supportable system with the capacity we need to proceed with a number of control improvements which were being held-up by the limitations of the previous system" said Hugh Ferguson. "Not only was the migration completed with minimal impact on routine plant operations, it has been possible to retain much of the look and feel of the previous system but at the same time making improvements to consistency, operability and system configurability. Furthermore, we now have a number of new tools in our toolbox. For example not only did the simulator play an important role in the migration project, is it now proving particularly beneficial both for staff training and as a rigorous test-bed for control and process changes."

The extensive migration upgrade at the Keadby Power Station resulted in several gains for the plant and SSE acknowledged Invensys for providing a standardised and successful migration solution.

Contact Jaco Markwat, Invensys, Tel 011 607-8100, jaco.markwat@invensys.co.za