PACE Magazine Zenith Award 2007 Submission

Condensate Stabiliser MPC Revamp

Woodside Energy Ltd and ProSys Engineering Pty Ltd

Introduction

Woodside Energy Limited (WEL) is an early adopter of Advanced Process Control (APC) techniques, and specifically Multivariable Predictive Control (MPC) technology at the Burrup Peninsula site in Western Australia. Five MPC applications were commissioned in 1998 on the five Condensate stabiliser trains at the Karratha Gas Plant (KGP).

Karratha Gas Plant at the Burrup Peninsula in Western Australia

Most MPC technologies use dynamic process models coupled with embedded optimisers to control multiple input – multiple output systems. Dynamic process model accuracy is the proverbial Achilles' heel of any MPC application, as model mismatch is the main cause for MPC application performance degradation. The challenge, however, is often to determine the causes of the model mismatch.

The Stabiliser MPC applications at the KGP suffered similar performance degradation problems and the performance of the applications has gradually degraded over the last few years to the point where the service factor of the applications had dropped significantly. This was particularly evident during the summer months when the applications were not maximising feed rates.

ProSys Engineering Pty Ltd (PSE) was contracted by WEL, in the third quarter of 2006, to assist with review and revamp the MPC applications on the Stabiliser trains. Although PSE was not involved with the design of the original applications, their track record of success in the revamping of other MPC applications and designing new applications at the KGP endorsed this approach.

Project Phases

The project started out with a 'Review Phase'. Data was collected for analysis and interviews were conducted with operations personnel and KGP control engineers. The data was analysed to quantify any model errors, caused by equipment fouling and changes over the years. A good understanding of the MPC applications performance and deficiencies was gained from interviewing the operators and engineers. This information was used to plan and execute the other project phases.

The next 'Testing and Design Phase' in the project was to perform plant tests (step testing). The data collected during the step testing was used to develop new dynamic process models. New dynamic models were required as result of a re-design of the MPC applications, which meant that the existing models could not be re-used. This re-design of the applications was necessitated by the plant operations and conditions that have changed from the time that the applications were originally designed.

The final phase was the implementation and commissioning of the newly developed MPC applications. This time was also used to provide training to the control room operators on the differences between the old and new applications.

Each phase started with a week long site visit by the PSE consultant, with three to four weeks between each visit. The periods between the site visits were used to complete data analysis, documentation, instrumentation and control loop analysis, and model development. These tasks were shared amongst the hybrid PSE/WEL project team to improve efficiency and foster technology transfer.

Project Challenges

A number of challenges had to be overcome in order to ensure a successful project outcome and ultimately customer satisfaction. Some of these challenges were:

- an important customer requirement to have the revamped MPC applications commissioned before the start of the warm (summer) season;
- minimising any activities during planned maintenance work on the Stabiliser trains;
- to review the MPC applications design (from a computational view) as the DCS node hosting the applications was at capacity,
- to ensure effective operator training and operator acceptance of the revamped applications.

These challenges forced the project team to be creative in order to streamline the project process without compromising the end result.

Time constraints
One of these challenges was the customer requirement to have the revamped MPC applications commissioned before the start of the warm (summer) season. This left only three months to complete the project successfully.

Some maintenance work was also planned on one of the stabiliser trains. The process plant was not accessible during this period to conduct any test work. However, this provided the project team an opportunity to have some faulty instrumentation and control valves thoroughly checked and fixed.

Design constraints
The DCS node hosting the MPC applications was running at full capacity. The design of the MPC applications required close review and careful consideration to alleviate the load on the DCS node (to prevent MPC failures).

Operator training and acceptance
Good training, application design and performance are crucial elements in ensuring operator acceptance. In this instance the operators had sufficient experience with MPC applications, but their confidence in the MPC performance and therefore acceptance had dwindled over time. Therefore operator training was less of a challenge compared to providing applications that would bolster the operators' confidence. This meant that the operators needed to be confident that the new MPCs were pushing plant constraints in a stable fashion.

Central Control Room operations of the Condensate Stabiliser Units

Project Details

Review Phase

During the Review Phase it became evident that the plant was operating somewhat differently from the time that the MPC applications were originally designed and implemented. Although the models were still fairly accurate some key submodels were missing, due to the changes in plant operation. This required a re-design of the MPC applications.

Another activity during the Review Phase was to review the performance of the base level controls. Some control valves were identified that required maintenance, due to hysteresis and stiction problems. Although the planned maintenance on one of the stabiliser trains reduced the time available to complete the project, it did provide the opportunity to perform the required instrument maintenance.

The re-design effectively reduced the controller matrix size by removing some manipulated variables (MVs) that served no purpose, as well as removing and replacing some redundant controlled variables (CVs). By reducing the controller size the computational requirements would also be reduced, which met the requirement to reduce the load on the DCS node. However, the re-design was more of 'pruning' exercise than a complete rebuild.

One of the biggest uncertainties of any MPC project, whether it is a new or a revamped application, is whether the application will be able to push plant constraints whilst maintaining stable operation. By not changing the controller structure too drastically, it was possible to trial the new design to see if there would be an improvement in performance. One of the existing MPC applications was configured to represent the new design as closely as possible, at the end of the Trial Phase. This provided the project team with the opportunity to verify the new design and to start to involve the operators early on in the project.

Testing and Design Phase

Some plant testing was required as a result of the re-design of the MPC applications. Some key submodels, not present in the existing applications, need to be identified as well as models for the new CVs added. The plant testing was conducted during another week long site visit, after the planned maintenance was completed on one of the stabiliser trains. It was decided to test two stabiliser trains, one on each of the two ends of the 'fouling spectrum'.

Planning for the implementation of the new applications was started during this phase, to ensure that no time would be wasted to commission the MPC applications. During the planning exercise it came to light that a new DCS node was available to host the MPC applications and that an upgrade of the MPC runtime software was planned to utilise the capabilities of the new DCS node. It made sense to combine the implementation of the new MPC applications with the migration to the replacement DCS node, as the migration from one DCS node to another would entail deleting and rebuilding the applications.

Implementation and Commissioning Phase

The last phase in the project was to implement and commission the new MPC applications. The existing MPC applications were deleted from the system and the new DCS node was configured with the upgraded MPC runtime software. Once this was completed, the new MPC applications were installed and the preparations for commissioning were finalised.

The first step was to confirm that the controller models were accurate enough to be used, and this was done by comparing the controller predictions with actual plant measurements. The predictions were acceptable and the new MPC applications were turned on one by one while the controller actions were monitored very closely. The commissioning period was at the start of the warm season and this provided the opportunity to gauge how the revamped applications would perform during the summer months.

It was evident, within the first two days of commissioning, that the MPC applications were able to maximise the stabiliser feed rates up to the plant and product quality constraints. Minimal additional tuning was required after the first two to three days of commissioning. Remote support was provided by the PSE consultant in the following weeks to iron out some fine tuning, but all five revamped MPC applications were effectively commissioned and operational at the end of the week spent on site.

Project Highlights
The decision to trial the intended design using an existing application proved to be pivotal to the success of the whole project for a number of reasons. Some of these are briefly discussed below.

Design Verification
The project team was able to test and verify the new design. This gave the team the confidence to proceed with the project and that the goals set it would be achievable.

Operator Involvement
The operators were involved with the project from very early on by trialling the new design. It provided them the opportunity to understand the different operating philosophies of the two designs and to provide feedback to the project team. By the time the new applications were commissioned the operators already knew what to expect and their acceptance was immediate.

Fast Tracking
All of this enabled the project team to fast track the revamping project, without compromising on the quality of the solution. By the time that the Commissioning Phase was started the applications were effectively pre-commissioned and operator training was also virtually completed.

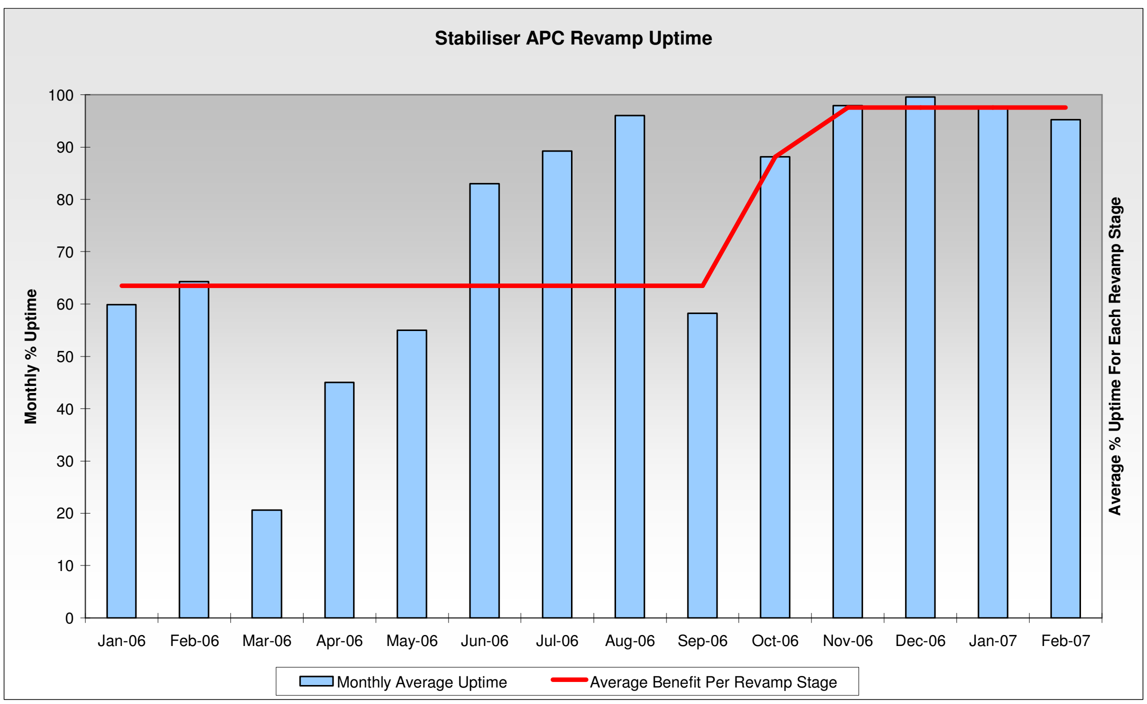
One of the LNG Production Trains at the Karratha Gas Plant

Project Results
The final outcome was a very successful project where all the goals and customer requirements were met.

- The project was completed within the tight schedule by the end of October 2006, in time for the warm season (when maximum stabiliser capacity is crucial for the site profitability). This was mainly due to the fast-tracking of the commissioning phase.

- Not only were five MPC applications commissioned, but the new replacement DCS node was utilised as well. This allowed the use of the latest MPC runtime software and the more computationally powerful DCS node. This addressed the DCS node design loading constraint, by removing it completely from the equation rather than re-design the MPC within this limit. There was also an economic benefit in combining all three activities, as it reduced the total engineering time required and minimised downtime of the applications and therefore potential impact on the process.

- Operator acceptance and confidence in the MPC applications have improved significantly. This is reflected in the increased application service factors. The average service factor has increased from around 65% (before) to 98% (after).



Average MPC utilisation before (pre Sep 06) and after revamp project

- The economic benefits lost by reduced uptime were re-captured and most likely exceeded (this is yet to be quantified). Furthermore, the cost of the revamp project was paid back in less than a month as a result of the re-captured benefits.

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