PACE Magazine Zenith Award 2014 Submission

Hot Oil Process Control Improvement Project

Esso Australia Pty Ltd. and Apex Optimisation

Background

Recent years have seen an increased focus on energy efficiency improvements at most operating plants. One of the most cost effective ways of achieving these objectives is to optimise the operation of existing equipment, by means of better process control and online optimisation.

In late 2010, Esso Australia Pty Ltd commissioned Apex Optimisation (Apex) to assess opportunities for improvement of the Hot Oil system process control configuration at the Long Island Point (LIP) LPG Fractionation Plant.

A number of improvements to the DCS control configuration, as well as a new multivariable predictive controller (MPC) were recommended to reduce Hot Oil temperature variance (primarily via better rejection of disturbances such as changes in Hot Oil demand and fuel gas calorific value) and improve overall efficiency of the two hot oil circuits onsite. Reduced hot oil temperature variance leads to improved benefits on the process side where product yields are affected by the quality of this utility stream.

Figure 1 Long Island Point (LIP) LPG Fractionation Plant

Project Information

The project was kicked off March 2012, and Apex Optimisation conducted plant testing to determine the process dynamics required for the redesign of the DCS control schemes for the five Hot Oil heaters at the site. The existing control scheme designs were inconsistent, so a key objective was providing a uniform approach for the operators to deal with.

The detailed design of the process control schemes was presented to the Esso engineering team, following an analysis of collected performance data and plant personnel interviews. The next step was to configure control schemes in the DCS and complete functional testing prior to commissioning them. The changes to the DCS control schemes were a pre-requisite for the development of the MPC application.

The proposed solution consisted of well accepted approaches to furnace control and optimisation.

- An advanced regulatory control scheme for each furnace consisted of a combination of feedforward and feedback controllers, providing improved hot oil temperature control during furnace load changes and fuel gas quality changes.
- The new MPC application provided further feedforward and feedback control and optimisation of the hot oil circuits, to minimise fuel gas consumption and reject disturbances, such as those caused by changes in the overall plant load.

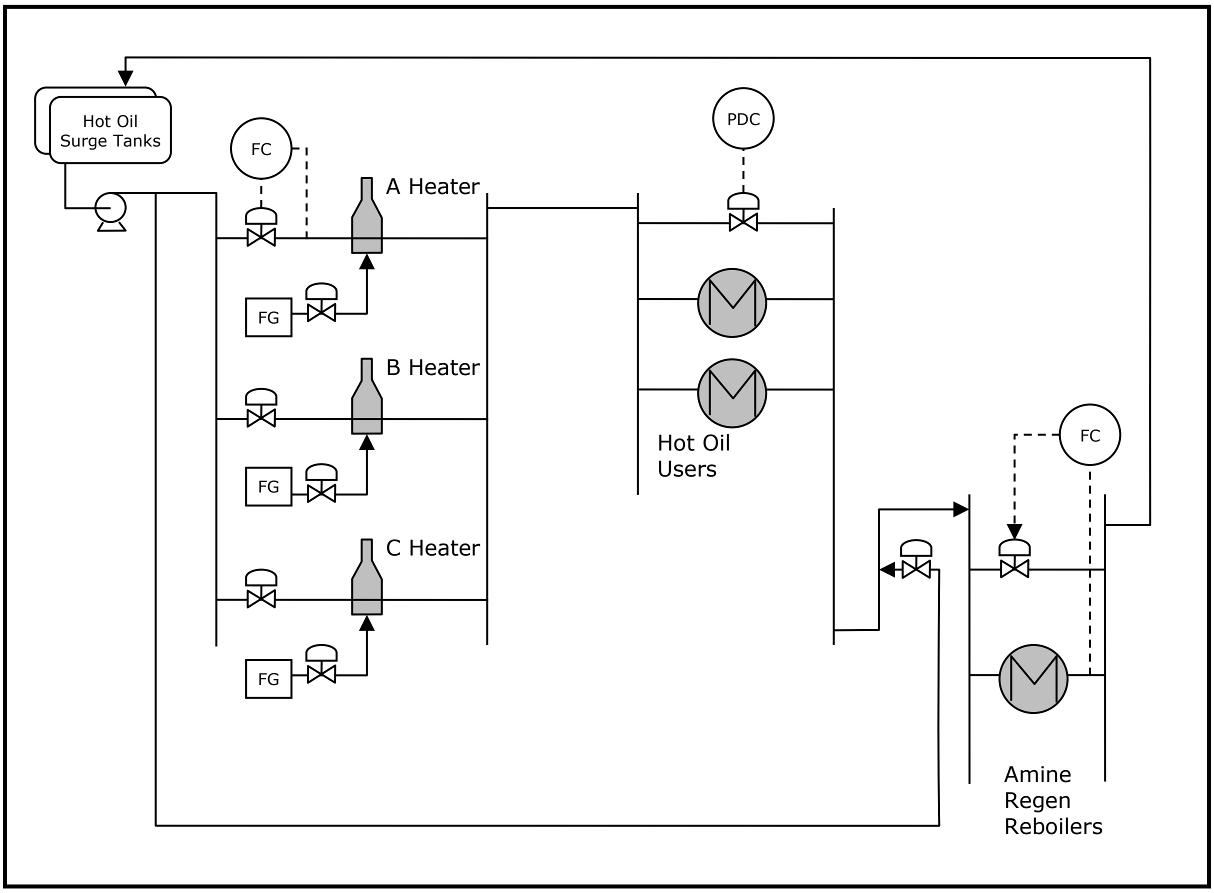

Figure 2 Simplified flow diagram of A/B Train Hot Oil circuit

Technical Challenges

One of the key requirements of the project was to implement the changes to the process control schemes, without impact on the process or plant operations.

- The process control schemes and implementation procedures were developed utilising the Apex team's expert knowledge of the client's DCS and experience in similar significant control system changes.
- Part of this process was to conduct offline simulation and testing of the process control schemes to ensure proper initialisation and bumpless transfer of the entire integrated control scheme – it's important to provide a robust solution that operators will love to use, as well as minimal impact on the process when the changes are commissioned.
- It was decided to make the highest impact changes during a plant shutdown in order to minimise the overall risk of the implementation phase. However, some changes were still required whilst plant was running, and this is where Apex's combined process and systems experience was valuable.

Some of the other technical challenges that were faced, were:

- The various fuel gas meters did not reconcile, and these were important to be correct as they were required inputs in the various furnace duty calculations.
- The fuel gas used in the furnaces is a blend of two sources with very different calorific values, and the occasional addition of ethane to the fuel gas would cause a significant load disturbance to the furnace operation.
- It was indicated early on in the project that it was important to retain individual fuel gas pressure control for each furnace although the target design required flow control was used.

The benefit of having a client engineer assigned to the project was illustrated by the engineer's knowledge of the process and understanding of the first two challenges listed above. The engineer developed an approach where the flow meter reading were corrected and reconciled before being used in the duty calculations. This resulted in another windfall, where the calorific value of the blended fuel gas could be calculated, negating any requirement for an online analyser.

The last challenge was addressed in the design of the process control scheme, by including a fuel gas pressure override during normal operation, which could optionally be used during the start-up of a furnace.

Implementation

The modifications to the first set of three heaters were implemented and commissioned in October 2012, following extensive and successful off-line functional testing. This was followed by a plant test campaign to collect the data required to develop the dynamic models for the MPC application. The first version of the MPC application was commissioned in December 2012.

Following the commissioning of the MPC applications and reassessment of the process context, it was apparent that there is another opportunity for efficiency improvement in one of the major Hot Oil users – the Amine Regeneration section. The same process was followed, in close consultation with the client engineer, to define modifications to control scheme and MPC application. The DCS changes were tested offline, before implementation whilst the plant was running (a strategy adopted as a result of the successful and uneventful changes earlier in the project).

The DCS control modifications for the last set of two heaters were commissioned in April 2013, followed by the inclusion of these heaters and the amine regeneration section in the MPC application.

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

- the DCS control schemes were now consistent across all five hot oil furnaces;
- the MPC application is continually minimising excess hot oil circulation, as well as distributing the load between the furnaces in each circuit to preference the most efficient furnace;
- the operations group were trained in the use of the new systems and were able to run the hot oil circuits in a consistent and sustained manner day in and day out.

The project was successfully completed in June 2013, with the final outcome delivering DCS control schemes and a MPC application that:

- were successfully implemented and commissioned with no impact on the process;
- were well received and accepted by the plant operators;
- improved hot oil temperature control (standard deviation reduced by 30% on some of the furnaces) which facilitated potential fractionation process yield benefits;
- reduced energy consumption of 10.7% and 8.5% for the two hot oil circuits (this included a 33% reduction in the specific duty consumption of the amine regeneration section);
- MPC controller uptimes of 88% and 94% for the two hot circuits;
- resulted in a project payback period of less than 6 months.

Below is an example of the process improvements in Amine Regeneration control, as an example:

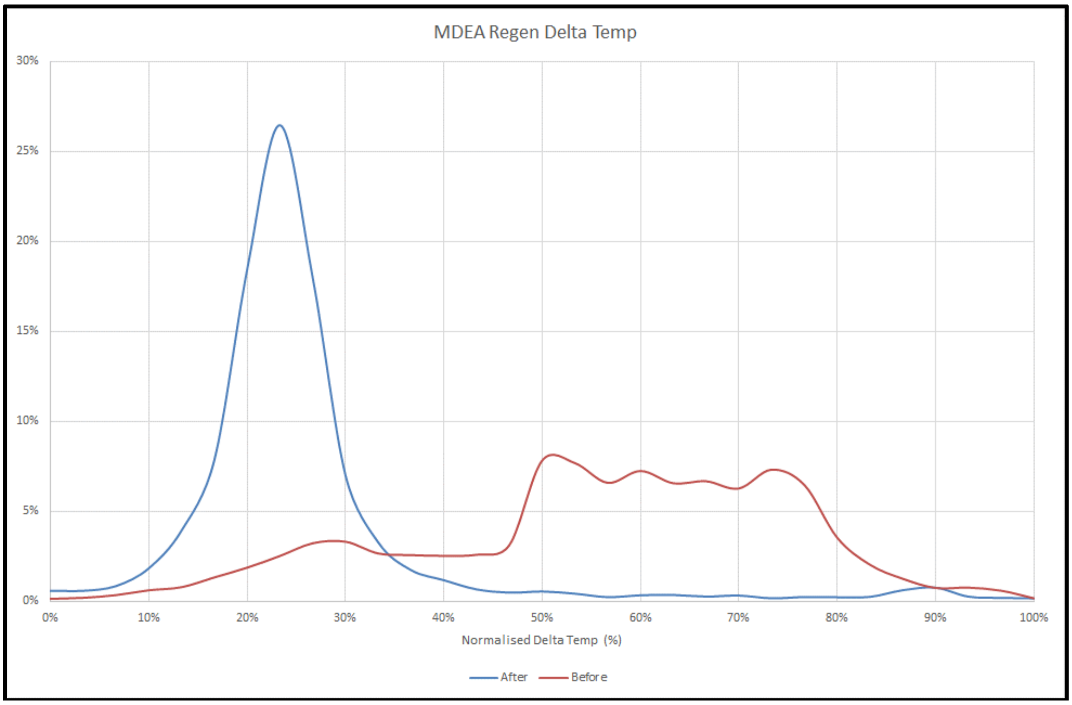

Figure 3 Distribution of the MDEA Regen Column Delta Temperature (Key Controlled Variable)

The post audit benefits were calculated using before/after project performance data extracted from the plant historian. During this process, an observation based upon previous furnace control experience led to a basis for justifying some additional furnace instrumentation which has the potential to further improve heater efficiency, reduce specific fuel gas consumption and improve safety metrics for the site.

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