TECHNICAL BRIEF

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PREDICTIVE PRESSURE CONTROLLER

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Implementation of a Model Predictive Controller in Gas Distribution System Pressure Control

Improving control and minimizing interactions in plantwide gas distribution systems can result in significant improvements in process on-stream time and product quality.

Experitec's Performance Services team recently implemented a Model Predictive Pressure Controller on a Hydrogen Distribution System at a customer site in Illinois. The Model Predictive Controller runs within the existing DeltaV Control System and was designed to improve Hydrogen pressure control as well as eliminate the costly equipment repairs and downtime associated with system pressure upsets and the resulting unit "trips" or "interlocks" from these upsets.

The previously existing Pressure Control System included only a regulator on the main plant hydrogen supply line designed to regulate at 40 psig. There were several problems associated with regulating the pressure of the plantwide Hydrogen system in this fashion:

1. The regulator could not successfully maintain proper Hydrogen System pressure during upset conditions. When one of the downstream operating units would "trip out" or "interlock," the Hydrogen pressure would spike to 15-20 psig beyond normal operating levels causing potential equipment damage and temporary loss of process control in the other areas of the plant. The plant consists of six operating units requiring Hydrogen, with three of these units accounting for over 90% of the total hydrogen usage, thus when one of these three "heavy" users would trip, typically all of the other units would also trip or interlock due to the resulting pressure excursion. The resulting downtime and loss of production from this upset was very costly. It would typically take the operating units 4 hours to restart after the shutdown, due to potential repairs and required cleaning prior to starting back up. The lost production reaches an estimated $25,000 of revenue for each 4-hour unplanned shutdown, not to mention the loss of shipments during "sold out" conditions.

2. During normal operation, the pressure in the Hydrogen system would drift causing downstream process control problems and ultimately product quality issues. Some of the material produced at the plant has very tight quality specifications, and thus require very tight process control. The cost of a rejected lot of material produced in a shift from these units is estimated at $30,000.

3. The process dynamics associated with this Hydrogen pressure control system are "very fast," or in other words, an almost immediate pressure reaction (less than 1.5 sec.) to any upset in the system. For example, if Unit-A has a Burner problem, the resulting hydrogen pressure upset will be seen throughout the system in less than 2 sec. Emerson's DeltaV Process Control System controls four of the six units in the plant, while the other two units are controlled by Emerson's Provox Control System. This makes high-speed communications between the different control sys-

tems very difficult, and eliminates the possibility of any feed forward controls from these areas due to the “fast” dynamics of the system.

Experitec’s Performance Services team was brought in to provide recommendations to improve the Hydrogen process control system and implement the appropriate solution in the DeltaV System. The recommendations included:

- Implementation of a Model Predictive Controller with special safety interlock configurations for the Hydrogen System.
- Proper sizing and location of the instrumentation for optimal Hydrogen pressure control.
- Optimization of Downstream Hydrogen pressure and flow controllers to reduce variability.

The Model predictive controller was implemented in parallel with a PID controller giving the customer significant on-stream flexibility. The Process Model for the controller is developed using the “Predict” application, which is fully embedded in the DeltaV System. Pre-engineered components and function blocks allow the user to quickly develop, test and implement single or multivariable control strategies. In this case, a single MPC block was used with one Manipulated Variable (MV) and one Controlled Variable (CV) for Hydrogen pressure. It was initially determined that several Disturbance Variables (DV) on downstream Hydrogen flows to the three “heavy” users would be configured and tested to determine their effectiveness as feed forward signals to the Model Predictive Controller. Due to the process dynamics associated with the Hydrogen pressure noted above, these Disturbance Variables did not have enough “lead” action to prove effective as disturbance variables and thus were removed from the configuration. The configuration was implemented during the annual outage and the process model was created and deployed during the startup “heat load” operations for each unit. “Heat Load” is typically a requirement for these units prior to the loading of the raw materials into the burners. The burners are brought online with Hydrogen, Natural Gas, Air and other required gases, but the actual product or “feedstock” is not introduced. The testing/modeling phase only required several hours to complete and the Model Predictive Controller was ready to go. The automated identification and testing procedure embedded into the Predict application simplified the modeling process. The DeltaV Historian automatically collects data on the inputs and outputs used by the MPC function block. The data collected can be easily viewed and edited using simple graphical tools. The MPC controller is automatically generated from the process model and subsequently downloaded to the DeltaV Controller.

Shown in Figure 1 is a screen shot of the DeltaV Configuration for this loop. Note how the MPC function block “piggy backs” onto the PID function block. This allows for easy configuration, testing, and commissioning with proper mode shedding in either case. Also shown are the original Disturbance Variables that were later removed.

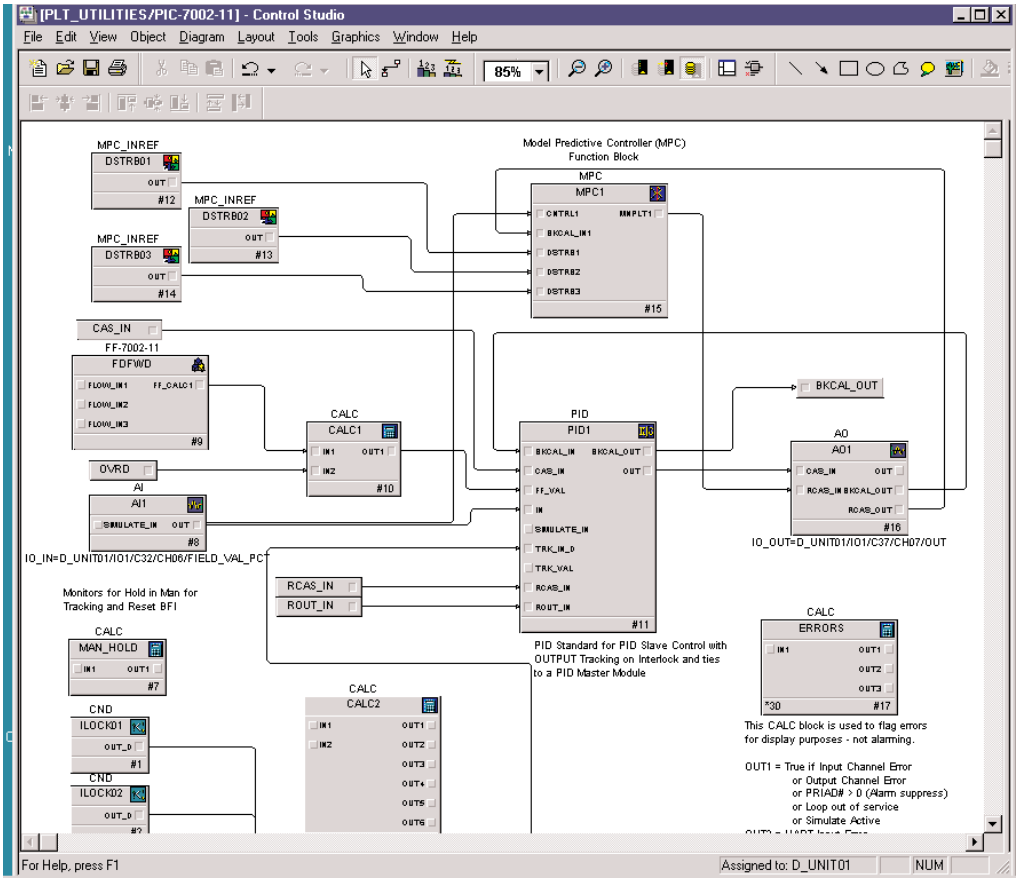

Figure 1

Once in service, the Model Predictive Hydrogen Pressure Controller not only eliminated the severe upset associated with the “trip” or “interlock” condition of the downstream operating units, but also effectively reduced the process variability at normal operating conditions. The reduced Hydrogen system pressure variability also reduced downstream Hydrogen flow variability, which immediately improved product quality. It also allowed for optimized tuning of local Pressure and Flow controllers at each Burner, further reducing process variability at the Burners and further improving product quality.

The savings associated with just the elimination of the plant shutdowns due to Hydrogen Pressure upsets is in the neighborhood of $250,000 per year, not including the maintenance and equipment costs associated with the pressure excursions. The quality improvements have reduced the amount of “off-spec” material, and improved customer satisfaction.

For more information check out this link:
http://www.easydeltav.com/pd/PDS_DeltaV_Predict.pdf

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