

Using Model Predictive Control-Based PAT to Optimize Distillation

At Baxter's anesthetics facility in Guayama, advanced automation is improving process understanding and product quality.

Baxter Healthcare is applying the principles of Lean and Six Sigma to improve efficiencies at its facilities around the world. The company treats each manufacturing plant as if it were an individual small business, responsible for its own profits and losses—an approach that challenges plant leadership to find and implement the best technical solutions, and optimize work processes.

In Puerto Rico, a Baxter team is applying operational excellence tools and advanced control to reaction and distillation operations for Isoflurane and Desflurane anesthetics. The cross-functional team traced production inefficiencies to an acetone recovery column. The column was limiting the facility's capacity to reprocess off-spec acetone, which had to be discarded. In response, the team developed a solution based on statistical process control (SPC) and model predictive control (MPC), installing technology developed by Emerson Process Management (Austin, Texas). MPC is not often applied to pharmaceutical operations, and the team's efforts won an award for innovation from Chemical Processing magazine last Spring. This article, written by Diane Dierking and originally published in that magazine's May 2005 edition, discusses the project in detail.

Last year, engineers at Baxter Healthcare's facility in Guayama, Puerto Rico, improved operation of an acetone recovery column, eliminating failed batches, increasing the throughput and quality of acetone and eliminating the need for lengthy investigations.

The column recovers acetone from the effluent of an upstream column for reuse. The recovered acetone must meet a specification of less than 3 wt % water. During 2003, 615 batches of acetone were processed, 18 of which failed the water specification, leading to significant delays pending the investigation and documentation of each failed batch.

The team used SPC to analyze data from 140 batches, which showed that the acetone had an average water content of 2.3 wt %, a Cp of 1.24 and Cpk of 0.54. The higher the Cpk, the closer the data are to target levels. There was clearly room for improvement.

The first step toward improving column operation was to reconfigure the control scheme and improve the tuning so it could run in automatic mode. Despite the fact that six batches exceeded the 3 wt % water specification, data from 125 batches showed a 35% reduction in average

water content to 1.5 wt %. Although the average water content went down (Cpk = 0.86), the spread in the data increased (Cp = 0.88).

The team decided to implement model predictive control (MPC) on the column, using a module available from Emerson for the DeltaV distributed control system (DCS). The module enables concurrent control of multiple process constraints, rather than managing them as individual loops or variables. The Baxter team uses one

control block to monitor four inputs and two outputs on the acetone column, says site director Francisco Feito.

Once MPC was employed, the average water content of 31 consecutive batches was reduced to 1.2 wt %—none of them failed—and SPC showed a Cp of 8.98 and Cpk of 7.39. There have been no failures since MPC was implemented, says senior principal engineer Diana Santiago. As of last Spring, roughly 600 consecutive batches met specs. 



A winning team. Using model predictive control in conjunction with SPC, Baxter engineers eliminated inefficiencies in the facility's purification operations. The team consisted of (seated, left to right): Diana Rodriguez, Diana Santiago, Geovanna Nazario and Marylin Roque (standing, left to right) Carlos Santiago, Ruben Garcia, Francisco Feito and Adalberto Maldonado.