Ethylene Plantwide Control and Optimization

Ethylene is the largest-volume industrial bulk commodity in the world. The majority of ethylene is used in the production of ethylene oxide, ethylene dichloride, ethylbenzene, and a variety of homo- and copolymers (plastics ranging from plastic food wrap to impact-absorbing dashboards inside cars).

Ethylene plants are complex, large-scale, flexible factories that can process a wide variety of feedstocks, ranging from gases (such as ethane, propane, and LPG), to naphthas, to distillates and gas oils. Main products are polymer-grade ethylene and propylene. Operational objectives include yield improvement, production maximization, and energy intensity reduction.

Honeywell's advanced control and optimization technology has been applied to ethylene plants worldwide with substantial economic benefits, including millions of dollars from increased production annually and additional benefits from energy savings.

Process and Operating Characteristics

Universal:

- No product blending
- Stringent product quality requirements
- Slow dynamics from gate to gate
- Gradual furnace and converter coking
- Frequent furnace decoking and switching
- Converter decoking

Site-Specific:

- Feed quality variations
- Product demand changes
- Sensitivity to ambient conditions
- Periodic switching (for example, dryers)

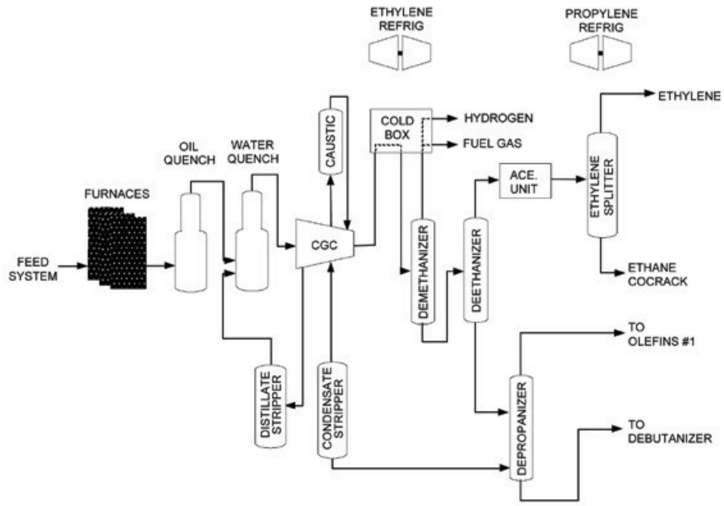
Operating Flexibilities and Solution Goals

The main operating degrees of freedom for ethylene plantwide control and optimization include feed selection, furnace feed rates, cracking severity, dilution steam, cracked gas compressor and refrigeration compressor suction pressures, typical column variables (reflux, reboiler, and pressure), and converter temperature and H_2 ratio. Advanced control and optimization goals include:

- Stabilizing operation
- Minimizing product quality giveaway
- Maximizing selectivity and yield
- Minimizing converter over-hydrogenation
- Minimizing ethylene loss to methane and ethane recycle

Combined Control-Optimization Solution

Unlike optimization approaches based on steady-state models, the solution featured here relies on dynamic models of model predictive controllers (MPCs). There is no need to wait for the plant to reach steady state, and economic optimization is augmented into a standard MPC control formulation known as range control. Nonlinearity of the plant is accounted for with successive linear dynamic models. The use of nonlinear dynamic models is in development and has been demonstrated experimentally.



Ethylene plant schematic

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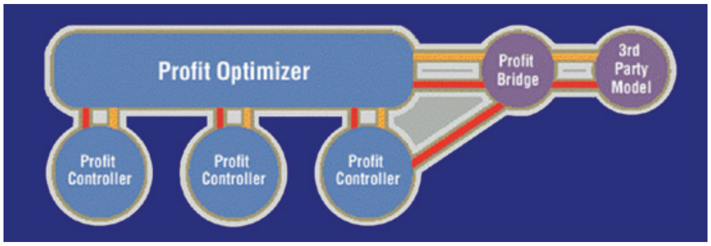
From: ***The Impact of Control Technology,*** **2nd ed., T. Samad and A.M. Annaswamy (eds.), 2014. Available at www.ieeecss.org.**

Overview of an Ethylene Plantwide Control and Optimization Project

A typical advanced control and optimization solution for ethylene plants comprises a global optimizer (Profit Optimizer) that coordinates 15 to 30 model predictive controllers (Profit Controllers) for separation and quench towers, converters, and a fuel-gas system. MPC controllers execute every 30 to 60 seconds and the global optimizer every minute. Technip's SPYRO nonlinear model is used to update the furnace yield gains every 3 to 5 minutes.

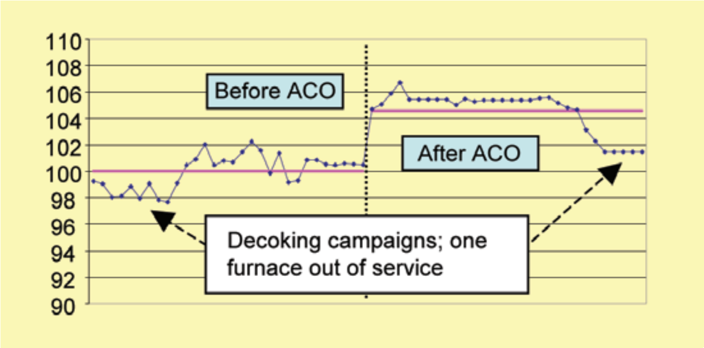


Honeywell's Profit Suite optimization and control products also include Profit Bridge for integrating third-party, nonlinear steady-state models; Profit Stepper for model identification (including closed-loop identification that allows models to be developed while the plant operates); and an advanced single-loop controller, Profit Loop.

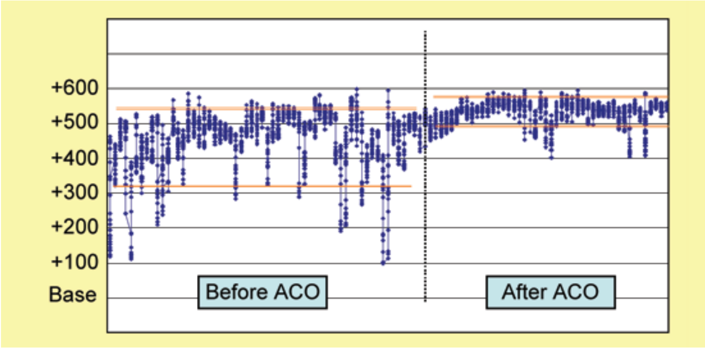
The technology is based heavily on dynamic models. Steady-state nonlinear models are used selectively for calculating critical gains. All Profit Controllers operate off linear dynamical models (usually developed with the Profit Stepper application). The base Profit Optimizer model is automatically aggregated from the Profit Controller models; Bridge Models and source/clone structures are added to define interactions among the controllers.

Once a plant has been commissioned, validated, and put into operation (a process that takes 9 to 12 months), little maintenance is typically required. Clients either dedicate a half-time control engineer to monitor and perform minor services or depend on quarterly visits by Honeywell staff. (In contrast, traditional real-time optimization solutions typically require a full-time modeling person and a half-time control engineer to maintain the solution.)

Normalized olefin production rate before and after advanced control and optimization (ACO):
Production is increased and product variability reduced.



Ethane content (ppm) in product ethylene:
The plantwide optimization and control solution gives tighter control and also reduces quality giveaway; the product purity specification is met without incurring the expense of further reducing ethane content.



Awards

American Automatic Control Council, 2010, Control Engineering Practice Award for "Innovation in advanced control and optimization with sustained impact on the process industries."

***Control Engineering Magazine*, 1999, Editor's Choice Award for RMPCT (now Profit Controller).**

Broad Process Industry Impact

The sequentially linear, dynamical model predictive control and optimization solution showcased here has been applied since 1995 to more than 10 industries, such as refining, petrochemical, oil and gas, coal gasification, LNG and LPG, pulp and paper, polymer, and aluminum.

Production increases valued at $1.5–$3 million annually are typical for ethylene plants. Energy savings are an additional and significant benefit.

For more information, visit www.honeywellprocess.com/software and search for "Advanced Control and Optimization."