Process Performance through Critical Control Loop Optimization

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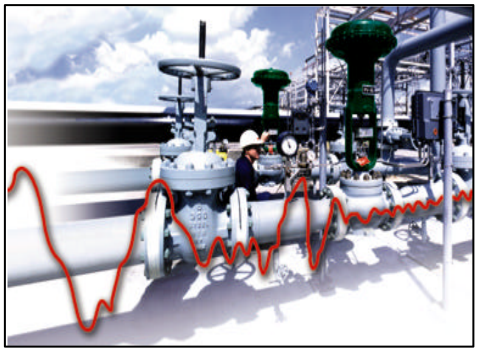
Tim Olsen and Neal Rinehart, Emerson Process Management

Abstract:
In the refining industry, process optimization typically begins with a process engineer collecting operation data to perform a heat and weight balance and to evaluate the catalyst activity. Based on the current trends and operating conditions, the setpoint(s) on critical process control loops (loops that affect unit stability and bottom line economic benefits) may need to be adjusted manually or with the use of an advanced control system to achieve optimal process performance. This is the first step in optimizing the process, provided the field devices perform as well as the software demands it to. Process optimization should always include an evaluation of the field devices and an optimization of their performance. Hardware issues primarily include the control valve performance, but transmitters, pumps, and other field devices can also contribute to poor process performance. With poor performing field devices, the control loop is usually de-tuned to maintain controller stability. The unit is stable, but process performance and potential economic benefits are lost.

Remember to Optimize Field Device Performance



There has been an industry focus to use Advanced Process Control (APC) systems to allow processes the flexibility to operate both optimally for product yield and/or purity and the utility usage required producing the desired products. This practice allows a facility an economic advantage over the competition that does not utilize an APC system themselves due to the benefits of producing the same product more efficiently (less cost). Great efforts and engineering man-hours have assisted facilities to take advantage of APC. Unfortunately, field equipment performance has not been given the same attention that the software has. If field equipment is not optimized, the advantages of an APC system fall short of expectations.

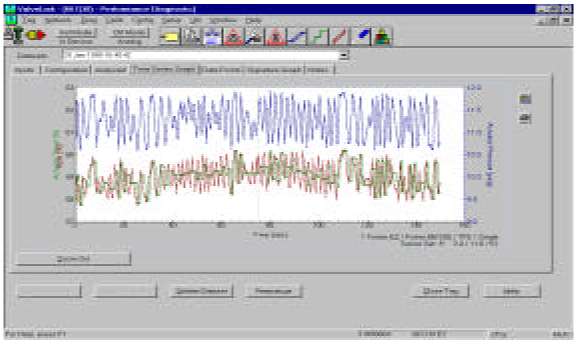
When a refiner decides to invest in an APC system, they invest time and resources in capturing additional economic benefits available through smarter process control. As time progresses, field equipment degrades which reduces the potential economic returns from the APC system. Maintaining the field devices and the tuning for these loops ensures potential economic benefits are realized.

Field device optimization can also be used to see economic improvements in units without APC systems. Critical loops that affect the stability of the unit, the product yield and/or product purity all have economic impact on the bottom line. Optimizing these critical loops will result in achieving desired production levels at competitive costs. Examples of critical loops include reactor inlet temperature, distillation overhead pressure and tray temperature to maintain composition control. Stability is also a major factor in overall process performance for two reasons: 1) avoids unnecessary upsets and unscheduled shutdowns and 2) operators tend to operate where the unit is stable ("comfort zone") which may not be optimal. Board operators also tend to switch poor performing "automatic" control to a more stable "manual" control mode. This same mentality results in APC systems being turned off and the potential advanced control benefits lost.

Measuring Process Performance

A typical refiner measures process performance many different ways. Some of the common measurements used are as follows:

- Actual throughput vs. design capacity
- Efficiency of certain utility usage such as hydrogen consumption for treating and fuel gas usage for fired heaters
- Product purity (minimizing impurities and/or side-reactions)
- Product yield
- Up-time (avoiding unscheduled shutdowns)
- Stability (minimizing upsets which affect the quantity of product produced efficiently for maximum profits)
- Minimizing overall cost to produce (to stay ahead of the competition)
- Cascade control vs. Auto control vs. Manual control

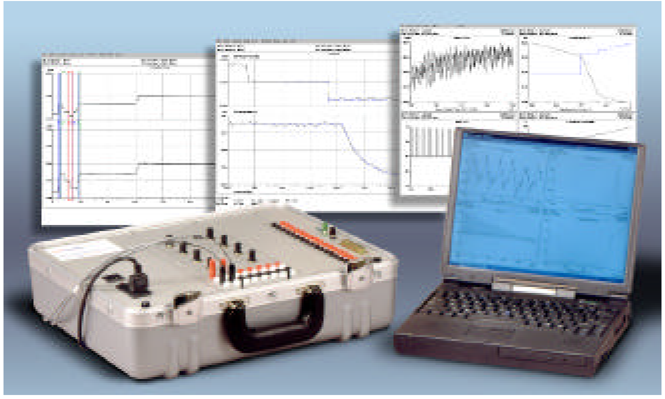


These types of measurement are used to benchmark the process performance and determine if additional benefits are possible with process control optimization. Every facility is unique and some process control optimization strategies result in significant economic benefits. These large-scale benefits are typically when the process control was found to be the process bottleneck. This is not to say that economic benefits are not possible when process control is not the primary bottleneck. Benefits such as stability that eliminates process upsets and unscheduled shutdowns also contribute to significant economic benefits.

Steps to Determine if Process Control Optimization is Required

One should first look for obvious process control problems such as controllers in manual and loops that limit cycle. These problems are obvious, but it is amazing how well these issues are hidden due to talented board operators maintaining the unit (operating in between the ditches).

One would then statistically analyze historical data (long term) and real time data (short term). This is as simple as looking at average process variable (PV) versus average setpoint (SP) and the standard deviation from setpoint. Many factors can play a role in these numbers such as different crude stock composition, so it is important to understand the process and what the statistical analysis actually means. To just look blindly at the data may find



obvious errors, but true optimization opportunities may be overlooked. An example of this is a control valve with greater than 5% deadband that is not responding to the software demands asked of it. Statistically, the standard deviation is very low as a result of no movement in the valve stem travel. The statistical analysis is just a method to scan the surface for potential opportunities requiring optimization. An understanding of the process is essential to focus attention on critical loops that affect the bottom line production and stability of the unit.

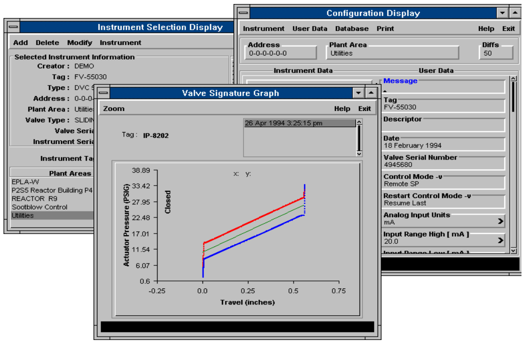
After critical loops have been identified as not operating optimally, one must troubleshoot the problem and determine what is required to optimize the control loop. Typically, there is more than one solution available in optimizing the critical loops. One must evaluate the Return on Investment for each solution to determine the most economic potential for capturing the objectives of the process operation. Field equipment issues should be analyzed first and corrected prior to any DCS or APC optimization.

The steps required for optimization can be summarized in the list below:

- Review process information
- Perform application reviews
- Establish audit plans / coordinate with operations
- Identify/model critical loops, process constraints
- Detailed review of loop equipment: physical condition and performance history
- Process data collection & analysis
- Loop & device troubleshooting
- Establish performance benchmark.

Maintaining Process Performance

A program should be established to maintain the process performance of critical loops. Field equipment degradation over time affects APC and critical loop performance. With new technology advances, many options are available to ensure optimal loop performance for critical loops to sustain potential economic benefits.



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Plant Area : Utilitie
Valve Type : SLIDIN
Valve Seria
Instrument Seria
Instrument Ta
Plant Areas
EPLA-W
P2S5 Reactor Building P4
REACTOR R9
Sootblow Control
Utilities

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Plant Area Utilities
Diffs 50
Instrument Data
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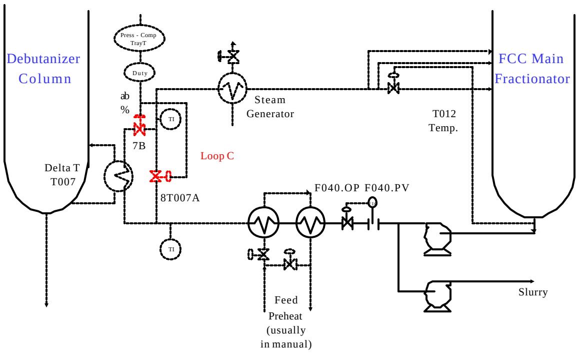
Message
Tag FV-55030
Descriptor
Date 18 February 1994
Valve Serial Number 4945680
Control Mode -v Remote SP
Restart Control Mode -v Resume Last
Analog Input Units mA
Input Range High [mA] 20.0

Tag : IP-8202
26 Apr 1994 3:25:15 pm

Examples of Economic Benefits Realized through Critical Control Loop Optimization

One particular refiner with an advanced control system on their FCC unit was encountering losses in LPG (primarily propane) out the top of their de-ethanizer column. This loss in LPG to fuel gas was due to poor performing temperature control on the debutanizer column that recycled its bottoms flow heat back to the de-ethanizer column. Approximately 1.5% of the total propane was downgraded from LPG to fuel gas as a result of this poor temperature control. One of the temperature control valves had a deadband near 10%, thus not moving when the APC system requested process changes. The valve was repaired and assembled with a new two-stage positioner and then tuned based on the new performance of the valve responsiveness. Based on this hardware fix, the advanced control system was able to recover 1% of the lost 1.5% LPG from the de-ethanizer overhead. Based on the recovered C_3 uplift from fuel gas to LPG, this optimization was worth over $100,000 annually. A poor performing field device added an additional constraint to the APC system which resulted in loss of a secondary product, LPG.



Another refiner was operating their crude unit charge rate less than they had observed in the past. The crude unit was operated in this manner due to a poor performing pressure control loop on the desalter unit that resulted in accidental lifting of the relief valve. To minimize the potential of accidentally lifting relief valve, the pressure controller setpoint was lowered and thus the crude flow rate reduced to ensure proper salt removal. The gain for this particular loop was de-tuned due to an incorrectly sized and selected poor performing control valve with greater than 5% deadband. The oversized butterfly valve was replaced with a correctly sized ball valve and then re-tuned with more aggressive yet robust gain for the loop. The pressure controller improved from +/-12 psi control to +/-1 psi. As a result of this improved loop performance, the pressure was increased closer to the relief valve setting (constraint) and the crude charge increased by an additional 2000 BPD. This particular example demonstrates that process control was the bottleneck, therefore significant economic benefits were realized.

Another refiner was experiencing difficulties in making gasoline on-spec despite having a conservative octane-giveaway target of +0.2. Optimizing the process by walking into the field revealed a cavitating pump due to insufficient NPSH, turbine meters requiring calibration and control valves requiring two-stage positioners. In addition, the DCS sample rate was slow at once per 2 seconds. Field equipment was optimized and the DCS sample rate increased to once per second. Initially, the gasoline blends were worse due to the different behavior of the field equipment (responding actually to the software demands). After the blend engineers re-learned the new system, the number of off-spec blends had been reduced from 1 in 3 to 1 in 15 with a more aggressive octane-giveaway target of +0.1.

Summary

Significant economic benefits can be captured with proper field equipment optimization on critical loops. In addition, APC systems can capture the expected benefits if the field equipment is as responsive as the APC demands it to be. Despite the advanced control and DCS requesting optimal performance, field devices are key to executing the process demands.

> “*No amount of advanced control which relies on the use of poor field instrumentation can be expected to yield worthwhile benefit. Thinking of control as a hierarchy, everything must work well at the lower levels for the higher levels above to work*".
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> M. J. Oglesby
> ICI Engineering Technology

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Contact us at:

email: AAT@emersonprocess.com
phone: +1 512-832-3575

Emerson Process Management
12301 Research Blvd.
Research Park Plaza, Building III
Austin, Texas 78759 USA

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