

Throughput 101

Improving Throughput by Improving Process Control

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Overview



Plants today can find themselves competing both for market share and for the capital needed to expand or improve. One way to come out ahead is to show a higher return on investment by increasing plant throughput.

For capacity-limited plants, increasing throughput enables you to meet more of the available demand without building new production facilities. That is a great way to increase margins and ROI, or to use your lower cost per unit of output as a competitive weapon.

Market-limited plants should be prepared to improve throughput as well. By increasing throughput, market demand can sometimes be met with fewer operating units. This improvement results in reduced cost and longer equipment life. Furthermore, you will also need that capacity when recovery comes. In the meantime, optimizing the efficiency of your current production equipment can significantly affect profits and shareholder values.

One way to find some of this hidden capacity is by reducing process downtime or outages. When the process stops, so does throughput. Throughput can be affected by unexpected downtime or forced outages caused by equipment failure or process upset. It can also suffer from planned downtime that is longer or more frequent than necessary. You can reduce both types of downtime by shifting maintenance practices more towards predictive maintenance, where equipment monitoring and diagnostic technologies predict when a problem is likely to occur. These issues are discussed in the Availability courses in PlantWeb University.

For many processes the greatest opportunity for increasing throughput comes from improving control, so that you can wring more out of the process while it is running.

In this course, you will learn how to increase throughput with improved control by:

- Eliminating field device problems.
- Improving your regulatory control.
- Applying advanced control techniques.
- Managing your entire process with real time optimization.

Hint

As you go through the topics in this course, watch for answers to these questions:

- How do devices affect throughput?
- What is the role of regulatory control in improving throughput?
- How can you operate closer to constraints?

Basics

Improving throughput begins in the field, not in the control room. The final control elements in the field execute the changes required to control process parameters like flow, temperature, pressure, and level. If the valves do not function as required, you can't expect the overall process control to perform optimally. And advanced control options cannot "fix" the problem.

Similarly, instruments, which measure these parameters, must perform optimally to provide high performance regulatory loop control. Basically, the regulatory loop performance needs to work properly if one expects success at tuning and implementing advanced process controls or optimization software for added throughput.

Examples of field devices that can affect overall process control are:

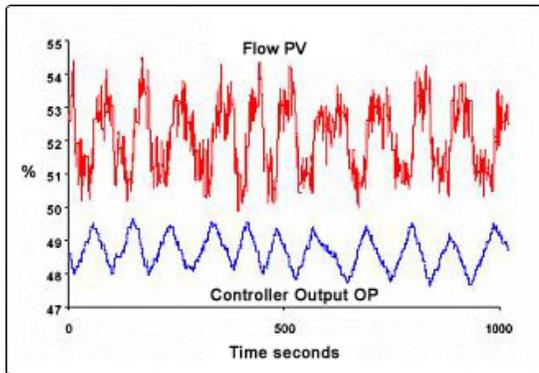
■ Valves

There is a strong tendency for valves to be over-sized due to the natural desire to ensure adequate capacity. The net result of using an over-sized valve is that it will operate in a sub-optimal part of its range, and the control loop will cycle continuously. This increases process variability, making smooth control virtually impossible.

A valve controls optimally when it is 50-85% open, and it is severely oversized if it is 15% open under normal operation. Valve type and trim also affect valve performance, and ultimately control performance. Equipment related constraints like these cannot be tuned out; therefore, bad-acting field equipment affects the overall success in achieving process control tuning that allows maximum throughput.

In addition to being oversized, control valves of any design and manufacturer degrade slowly over time. The key is to know when to repair or replace the valve before poor performance sets in. Worse, the valve may stick and cause an unscheduled shutdown.

The image depicts a sample of a control valve that cannot be tuned out as it is in a limit cycle (oscillating at a constant amplitude). It needs to be serviced or replaced.



Flow process variable and controller output of a valve in a limit cycle

■ Transmitters

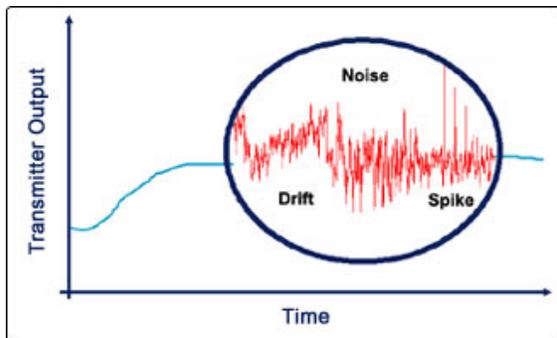
The physical location where field devices are installed can also cause variability problems. For example, transmitters may have been installed at ground level to ease maintenance. Such placement can potentially cause excessive process dead time making control difficult. Excessive process dead time causes loops to resonate, cycle, and amplify certain variability. Extreme excess dead time can actually cause a loop to perform worse under automatic control than in manual mode, impacting throughput more.

Digital Technology

Digital technology can aid in improving throughput. Through digital technology it is possible to access and use new types of information. This information goes far beyond the process-variable signals of traditional automation architectures.

Field devices with digital technology use embedded microprocessors and diagnostic software to monitor their own health, variability and performance. These devices can also monitor the process, and signal when there is a problem or when maintenance is needed.

With the ability to detect and deal with problems before they occur, you can keep instruments and equipment working at their best. Consequently, you not only avoid conditions that could cause downtime, but also reduce opportunities for variability to creep into your process.



Advanced signals from transmitters

A transmitter with digital technology may be able to detect conditions in the process such as drift, before it causes process upsets.

Regulatory Control Loop

After analyzing the field equipment and fixing any deficient acting devices, one can begin understanding the current process dynamics of the system to improve throughput. The word "current" is used as equipment will always degrade over time, and process parameters and raw materials usually change over time. Control loops therefore need to be monitored and tuned on a regular basis.

A strategy for monitoring and enhancing performance of the control system will help loops perform optimally over time; but as is often the case, collecting data is not sufficient. Information must be presented to the user in an intuitive, informative, and effective manner, thereby encouraging its use. To this end, control analysis software must first determine under-performing loops, and then assist in the proper tuning of those loops.

Many controllers are tuned only when the tuning is so bad that the operator notices a problem. Then they may just be put in manual to "line them out."

Example

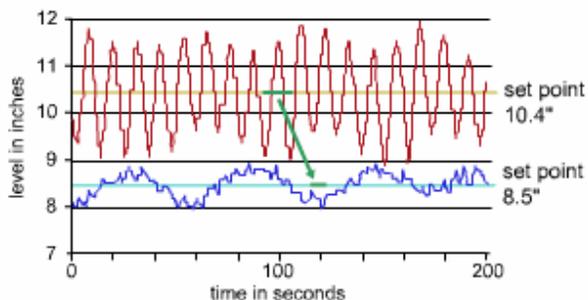
It is common to see default tuning parameters—such as a gain of 1.0 and a reset time of 1.0 minute—installed in each loop ready for startup.

The startup team puts the loops on automatic. If the loops worked without going unstable, they were declared commissioned. Hence, the original tuning after startup is likely to stay in place for years. The startup is officially over when the startup team has demonstrated that the plant actually operates and can make the product to specification. It is then up to plant operations to run the plant, usually with the original variability still present. Therefore, it is common to see several loops in manual at any given time.

Adjusting Setpoints

Each process has an operating objective chosen to achieve a desired outcome (such as maximizing throughput) while staying within process, equipment, or other constraints. The actual loop setpoints, however, are usually set conservatively—primarily to allow process variability and unexpected disturbances.

Proper tuning and advance warning of potential problems can give you the confidence to push setpoints closer to theoretical operating limits, for even greater gains in throughput.



Many loops are left with default tuning parameters after startup, leaving behind high variability.

In this example, correct tuning of upstream level controls reduces the variability in feed water level significantly from the original. With the variability reduced, the setpoint could be lowered, resulting in additional power.

Once all devices are checked, and loops properly tuned, additional throughput can be found by implementing more advanced loop control. The next section covers some choices.

For more information on reducing variability, check out the PlantWeb University course on Quality.

The PlantWeb Advantage

DeltaV Inspect software monitors not only device performance, but also overall loop performance and variability. It automatically flags any degradation or abnormal condition in a measurement, actuator, or control function block. It also tracks how much time each loop that should be in Auto is actually in Manual—pinpointing trouble spots where operators are struggling to control variability.

DeltaV Tune gives you out-of-the-box tuning solutions for your PID and fuzzy logic control loops. Based on a patented, field-proven algorithm for calculating control loop parameters, DeltaV Tune minimizes the time required to establish stable, responsive control loops—including FOUNDATION fieldbus loops.

OvationTune is a system-wide adaptive tuning package for the Ovation system. It quickly and automatically determines optimal tuning parameters for PID and PID feedforward control loops. The user can select whether tuning advice is provided or tuning adjustments occur automatically. And the optimized tuning parameters can be archived and documented for future analysis and comparisons.

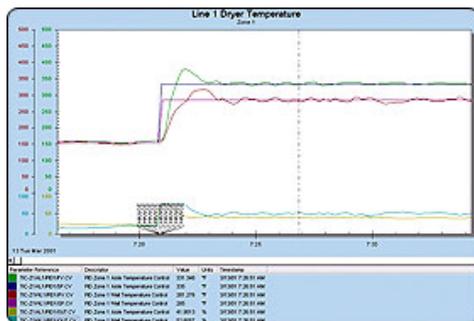
The **EnTech Toolkit** software quantifies the dynamic characteristics of a process and its control system. It also aids in the diagnosis of control loop strategy and tuning problems. Additionally, instrumentation performance can be evaluated while the process is running. The EnTech Toolkit software works with legacy and modern digital architectures.

Fuzzy Logic Control

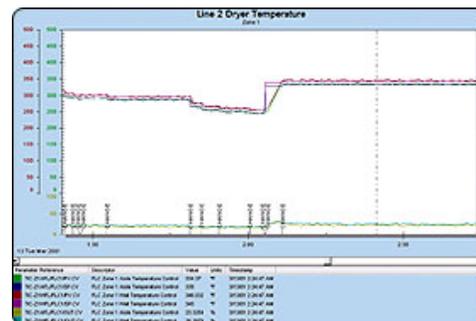
The process design might also be a factor in underperforming loops. Conventional feedforward and feedback controls work well on 90% of control loops. However, the remaining 10% have time delays and/or interactive systems. In these cases, **fuzzy logic** is one way to achieve additional throughput from the process unit.

For slower responding processes, fuzzy logic control may be used to get critical process outputs to setpoint in minimum time without overshoot. For both load disturbances and setpoint changes, fuzzy logic control will typically get the process to setpoint 30% faster than the best-tuned PID control.

Fuzzy logic control returns the process to setpoint faster and with little-to-no overshoot. Therefore, fuzzy control is excellent for loops where the setpoint changes often or for loops that experience frequent process load disturbance. Temperature and composition loops where overshoot can ruin the product also benefit from fuzzy logic control's response curve.



Traditional PID Loop



Fuzzy Logic Control

A traditional PID loop has overshoot and takes too much time to get back to setpoint after a load disturbance. Fuzzy logic loop outperforms traditional PID loop for setpoint and load distributions on a carpet drying application. (Screen captures courtesy of the Dixie group)

The PlantWeb Advantage

The DeltaV and Ovation systems include a Fuzzy PID algorithm that is:

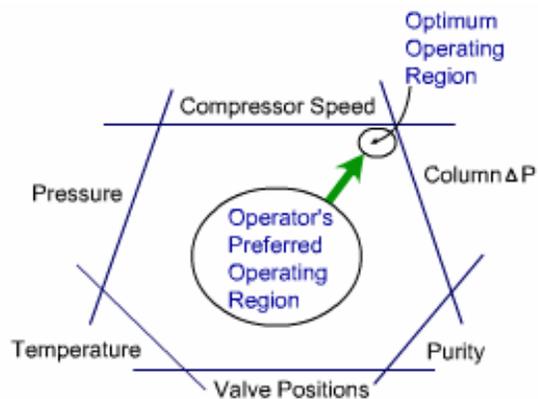
- As easy to use and configure as PID.
- Superior to PID control for setpoint and load changes.
- Highly tolerant of noisy signals and non-linear processes.
- Included in every DeltaV and Ovation system.

Model Predictive Controllers

Most processes have constraints to production: maximum temperature, pressure, or flows that prevent more products from being made. Model Predictive Controllers (MPC) allow operation right up to the constraints, giving maximum throughput.

Examples of process constraints are limits to liquid flows in fixed-sized piping, allowable temperature and pressure in process units, and allowable emissions to atmosphere.

Optimum throughput is often achieved by operating "on the edge"—or at the limits of the process constraints. This type of operation may risk violating limits if a disturbance enters the process—especially if it is not handled properly by the control system. MPC calculates the impact of a disturbance or control action on constraint parameters. It can predict a future path for the constrained variables. It can also determine the control move to explicitly avoid violating these limits. This control allows operation closer to optimum throughput with less risk of going over the edge.



When several constraints are present, operators will operate conservatively (large circle).

MPC allows the operator to confidently move closer to a constraint (smaller circle) for optimum throughput.

The PlantWeb Advantage

Multivariable Model Predictive Software

You can obtain greater process throughput and reduced process variability by using the multivariable model predictive control strategies available in the **Ovation and DeltaV** systems. Using tools like **DeltaV Predict**, users can easily address process interactions and difficult process dynamics. Since these strategies are fully embedded in the Ovation and DeltaV systems, you may use the pre-engineered

components and Function Blocks to easily develop your multivariable control strategies. These can be easily engineered and commissioned without the assistance of costly outside experts.

Model Predictive Controllers, continued...

MPC technology is becoming more commonplace in the process control arena. It involves establishing relationships between control variables and manipulated variables. For example, raising the temperature may also increase pressure and reduce level.

Model Predictive Controllers are designed to solve local, constrained optimization and control problems. These are found on process units such as chemical reactors, distillation columns, furnaces, boilers, compressors, and generators.

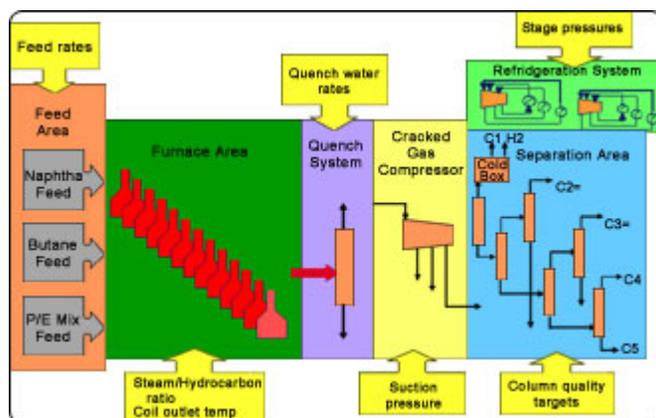
Unfortunately, optimizing each individual unit does not mean that the whole plant is operating at maximum throughput. To optimize the whole plant it is necessary to consider all the parts together. The next section covers how optimization is done with real time optimization.

Optimization

For many processes, conditions change frequently (or even continuously). There can be changes in feedstock and product slates, equipment performance, fuel quality, emissions, ambient conditions, and operating costs. These changes can make the "best" operating point a moving target. You will have to keep up with changing conditions.

For operations like these, real time optimization software can constantly evaluate process, equipment, and economic factors to find the "sweet spot" for maximizing throughput. As conditions change, the optimization software can find the "sweet spot" again.

Real time optimization (RTO) refers to continual evaluation and alteration of operating conditions to maximize the economic productivity of the process. RTO models tie together several processes to establish and set the optimum operating point for whole systems. These models then interact directly with multivariable control systems to move the system to the optimum quickly and automatically. By operating in real time, the models detect and adjust for continual changes in feed and operations to achieve maximum value and throughput.



Typical real time optimization variables in an Olefin plant:

- Feed rate
- Steam/Hydrocarbon ratio
- Coil outlet temp
- Quench water rate
- Suction Pressure
- Stage Pressure
- Column quality targets

RTO Software

The following is a simple explanation of how RTO software works:

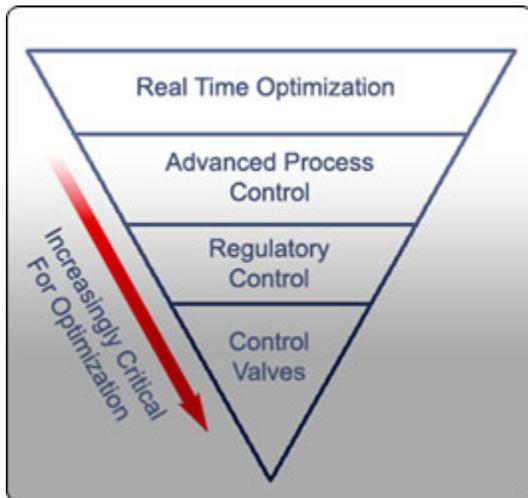
- Reads the current process measurement from the plant.
- Calculates the present throughput value.
- Optimizes the operating variables of the plant to maximize throughput.
- Returns these values to the plant.
- Repeats this process when plant returns to steady state.

The PlantWeb Advantage

AMS Suite: Real-Time Optimizer software is specifically designed for real time on-line applications. An integrated suite of tools, **AMS Optimizer** determines the optimum operating conditions required to maximize margin within the complex constraints. It provides a suite of proven optimization techniques, which have been successfully applied to a wide variety of process simulations. It provides the ability to configure and run optimization systems quickly While working within a uniform product environment.

Back to Basics

Throughput improvements should always begin with basic control. This includes tuning loops and making sure that they are being run under automatic control, and ensuring that field devices such as valves and instruments are delivering the performance needed.



In addition, most processes benefit significantly when appropriate forms of advanced regulatory control are implemented. And, interestingly, applying advanced regulatory control techniques often reveals important process interrelationships that precipitate further improvement of the field instrumentation. This brings us back to the basics once again.

[End of course]