With an eye on uptime manufacturers are now investing in solutions that analyze the performance of their regulatory control systems. The control loop remains a building block for manufacturers across the process industries and it is intimately connected to innumerable production assets. Data from the common control loop offers a wealth of information and insight into mechanical issues. Still, knowing how to use that data effectively often presents a challenge.
Simply put, downtime of any variety is expensive. When the typical manufacturer generates annual Net Income in the single digits, it’s painful knowing that an average of 5% of production and 30-40% of profits are lost to events that are in large part avoidable. Monitoring and diagnostic tools have been accepted as a means for both anticipating equipment failure and avoiding unplanned downtime. Those monitoring technologies are no longer focused narrowly on the analysis of rotating equipment. Available solutions now leverage insight from a readily available source – the PID control loop.
In SmartSignal's early analysis of the financial impact of downtime, the company's David Bell gave names to three culprits: Lost Revenue, Carrying Excess Capacity, and Disruption & Recovery Costs. Collectively these three set a glass ceiling for a given production facility's availability at between 85% and 95%. Viewed only in terms of Revenue the impact of downtime can amount to $1 million per day for an average power utility or offshore oil rig.

Time certainly is money. That expression applies directly to the consequences of downtime and it is underscored by the associated bottom-line impact. According to General Electric lost production time can be exceptionally costly for process manufacturers. Take for instance a power plant with 170 megawatts of capacity. GE calculated losses to operational profit of nearly $45,000 with each day of downtime. How about a refinery that processes an average of 200,000 barrels per day? The losses to profit jump to $800,000 per day. Indeed, downtime discriminates against no industry in particular as its impact hurts all manufacturers from Food & Beverage and Pharmaceuticals to Basic Materials and Oil & Gas – each in equal measure.

The business case for proactive equipment maintenance is established and it is linked increasingly to plant-wide monitoring and diagnostic solutions. It’s generally accepted that dynamics leading to equipment failure occur on their own time. Those events are not often in synch with a maintenance schedule. Technologies that vigilantly keep watch on production assets both around the clock and in near real-time provide manufacturers with the benefit of identifying issues before they become costly problems. A production loss of 5% is sizeable for any manufacturer and recapturing any portion of that amount is usually easily cost justified.

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In its recent study of production and reliability related technologies the US Department of Energy confirmed significant benefits, specifying areas of financial gain for manufacturers. Among the highlights were documented reductions to downtime ranging from 35% to 45% and increases to production on the order of 20%-25%. These results apply equally to improvements in the performance of large rotating equipment as well as the decidedly more prevalent process equipment.

In terms of control loop monitoring technologies there is a select group of five (5) metrics that help process manufacturers to realize those gains.

**Stiction**

This metric identifies a form of nonlinear behavior that commonly affects valves and other final control elements (FCEs). A combination of the words ‘sticky’ and ‘friction’, Stiction prevents a FCE from responding on a direct and apportioned basis to changes in Controller Output (CO). Rather, the FCE requires the application of excess force by the associated actuator in order to enact the desired change, resulting in persistent overshooting of Set Point and oscillation within the process. Failure is precipitated by the constant back and forth of the FCE – a behavior which is revealed in either saw-toothed or square-wave data trends.

**Output Travel**

Understanding the relationship between a control loop’s FCE and its ability to track Set Point is key to maintaining effective control as well as essential to avoiding mechanical issues and potential failure. Output Travel in particular accounts for the work of a loop’s FCE relative to Set Point tracking. As a normalized value of all movement made by a given valve, damper, or other FCE, the Output Travel metric provides a number that can be easily trended for analysis. When the Output Travel value rises while Set Point tracking remains relatively constant, the FCE is working harder and is at increased risk.
Oscillation

Variability in a process hampers control and it unnecessarily accelerates the mean time to failure (MTTF) of the associated process instrumentation. Loops that oscillate force the FCE in particular to exert greater effort than necessary – a behavior that can often be attributable to an oversized FCE, poor controller tuning, or process interactions. As a metric, Oscillation identifies loops with significant oscillations as well as loops that exhibit other issues resulting from variable behavior upstream in the process. Increased Oscillation points to these changing dynamics and provides advance warning of potential negative consequences.

Output Distribution

Processes are designed to operate in the middle of a range and not at the extremes. In that same context a PID loop’s Controller Output (CO) seeks to maintain operation within that middle range. Where the CO actually spends its time offers valuable insight into the amount of resource needed to maintain effective control as well as advance warning of a possible failure. Operating at the extremes often corresponds with a FCE sizing issue. For properly sized FCEs, however, a decreasing Output Distribution value generally points to maintenance-related issues such as an eroding valve seat.

Output Reversals

More often than not wear and tear and MTTF go hand in hand. Process dynamics that cause a valve, a damper, or other FCE to reverse direction with increased frequency serve both to accelerate the instrumentation’s need for replacement and to increase the potential for unplanned failure. Such dynamics are generally driven by process variability, instrument noise, and other changes in FCE behavior. What’s more, large reversals suggest instability in the process as the CO hunts for a stable condition. Each of these potential sources of variability are captured by the Output Reversals metric and can be examined using a data trend.
Planned vs. Unplanned: The Financial Side of Downtime

Further in its analysis the Department of Energy estimated cost savings of 90% by minimizing unplanned downtime primarily through the use of advanced monitoring and diagnostic technologies. The savings were notably higher in comparison to those achieved through the use of more traditional preventive maintenance approaches. At a more granular level the findings identified several key factors that made the savings possible, including:

- Reduction in maintenance costs of 25% to 30%
- Elimination of 70% to 75% of equipment breakdowns
- Return on technology investment of up to 1,000%

Like other studies, the analysis conducted by the Department of Energy focused heavily on condition-based monitoring solutions used primarily in the analysis of costly rotating equipment. Beyond these assets, however, is an abundance of other process equipment. Mechanical equipment including valves, dampers, motors, and actuators represent the majority of a typical manufacturer’s productions assets. This equipment is critical to maintaining control over production processes, and it is equally relevant in the pursuit of zero unplanned downtime.

Control loop performance monitoring solutions utilize a facility’s existing process data to first identify then isolate issues affecting production. A core function of these technologies is the identification of mechanical issues. Metrics such as Stiction, Output Travel, Oscillation, Output Distribution, and Output Travel have become standard KPIs that facilitate early detection of mechanical issues. These monitoring solutions help to optimize controller performance as well as avoid costly mechanical failure and unplanned downtime.
Most production processes are highly dynamic and constantly changing, so much so that it’s not hard to stumble upon issues that hamper performance. The real challenge for practitioners is prioritizing limited time around their facility’s most pressing issues. To optimize their effectiveness practitioners need access to information that is both accurate and insightful. That applies equally to their facility’s PID controllers as it does to process instrumentation. If you require improved awareness of your facility's production performance issues, look no further than PlantESP!

- Plant-Wide Control Loop Monitoring
- Timely Alerts and Detailed Reports
- Targeted KPIs and Advanced Forensic Tools
- Actionable Recommendations for Corrective Action

Contact us today to learn how PlantESP is enabling manufacturers across the process industries to accurately diagnose complex control loop performance issues and to quickly correct them for increased production and enhanced efficiency.