

AUTOMATION KPIs CRITICAL FOR IMPROVEMENT OF ENTERPRISE KPIs

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Abstract – Enterprise Key Performance Indicators, or KPIs, measure the goals of business and help management to steer the business efficiently and effectively. Process & Control KPIs measure the effectiveness of the process and the control system, and help plant-floor personnel to allocate their resources to get the most benefits. When the process is running better, Control System KPIs improve, and finally also enterprise KPIs improve. Driving Automation KPIs to their optimum in turn drives Enterprise KPIs toward management goals without adding additional assets. Results in the field have proven this.

Enterprise KPIs, while highly meaningful, reflect longer-term results, and can not be manipulated directly. Control system KPIs are shorter term indices that can be directly managed on a daily basis. Maintain a smooth-running process by managing Control System KPIs, and you will drive unit-operation, plant, and enterprise KPIs to new highs.

Maintaining short-term KPIs is very similar to maintaining performance of an automobile or an airplane. What you desire is high fuel efficiency and high reliability. But you can not easily make direct adjustments to these KPIs. Instead, you can make adjustments to compression, fuel mix, operating procedures, and tire pressure to ensure that short-term process performance will be optimized. Managing these factors ensures better performance of the long-term measures.

Keywords: performance monitoring, process control.

1. INTRODUCTION TO AUTOMATION KPIs

Controller Performance Monitoring (CPM) is the most used technical term for measuring Automation KPIs. T.J. Harris [1] was one of first pioneer in Controller Performance Monitoring [2]. Till the end of the last millennium this topic was almost unknown in Industry and there was little research going on. But in the last years CPM is becoming a buzz word and more and more companies are using CPM as a critical part of their Operational

Excellence Program. Also more research is done by universities and industry in this field.

CPM is much more than the statistics of a control loop such as the mean and variance of manipulated and controlled variables.

The main goal of CPM is to increase the reliability of the plant by discovering hidden fail modes in the process. It also pinpoints opportunities where maximum economic impact to operations can be realized. Control performance can be seen as a “window” to find hidden problems and solve them. Most of those problems are not always tuning, but other causes. Like: hardware (valve, pumps and actuators), operations, design, etc. All those problems will leave a “fingerprint” in your control performance. CPM is able to identify those “fingerprints”. This way your engineers will be more empowered to do their jobs.

2. ENTERPRISE KPIs

The longest term enterprise KPIs drive the long-term success of the company. Most typically, these include:

- Company Reputation
- Customer Satisfaction

While these KPIs are critically important, they face 2 major problems: They are difficult to measure, and they come too late. When a problem is seen, it may take years to address the root cause. For that reason, many companies look at some performance measures with a shorter time-frame. Medium-to-long-term enterprise KPIs may include:

- Profits
- Quality
- Total Costs
- Throughput
- Uptime
- Operating Costs

These KPIs offer some distinct advantages. They are relatively easy to measure, they can be measured at shorter time-scales (typically monthly), and they are scaleable to the entire enterprise. By scaleable, we mean that the same KPIs can be applied to the Corporation, Division, Site, Plant, and even Unit Operation level. Without sustained long term enterprise goals, the longest term goals would not be possible. The company must create good quality products, at

high throughput, in efficient processes, while generating a profit, to have long term happy customers that result in a good reputation for the company.

While these KPIs provide a good measure of progress toward company goals, they are not always directly actionable. If a Plant or Unit Operation is suffering poor performance, what steps can be taken to improve? To answer that, we must look at short-term performance measures.

3. PROCESS & CONTROL SYSTEM KPIs

When the process is running better, Control System KPIs improve, and finally also enterprise KPIs improve (figure 1).

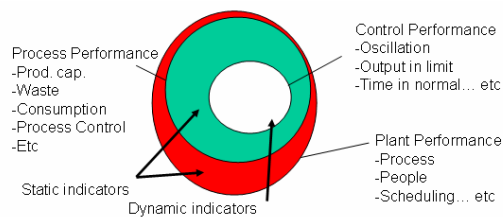


Fig.1. the relationship between Control KPIs and Plant KPIs

To achieve Medium to long term enterprise KPI goals requires achieving short-term Process & Control System KPIs. These KPIs include:

- Efficiency
- Variability
- Reliability
- ExperTune Index
- Harris Index
- Oscillating
- Time in abnormal mode
- Noise
- Output at limit
- Valve travel
- Robustness
- Settling Time

Each of these short-term KPIs is a meter for certain aspects of performance of the plant. Those assessments pinpoint opportunities where maximum economic impact to operations can be realized. This approach uses control performance as a “window” to find hidden problems and solve them. Most of those problems are not always tuning, but other causes. Like: hardware (valve, pumps and actuators), operations, design, etc. All those problems will leave a “fingerprint” in your control performance (figure 2). This approach enables users to identify those “fingerprints”. This way engineers will be more empowered to do their jobs.

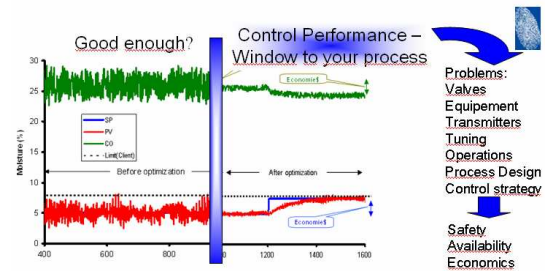


Fig.2. Control performance is THE window to see ALL process problems

In many ways, these assessments are like the gauges on the dashboard of a car, or the heart rate monitor on a patient in a hospital bed. They provide an immediate indication of any problems with process performance. When a problem is noted, there is an immediate action that can be taken to correct it. Modern DCS and PLC systems are collecting the entire base of data needed to complete these assessments. By properly supervising the results, we can quickly optimize the process.

4. UNIVERSAL KPIs FOR PROCESS PLANTS

Of the above KPIs, there are several that have universal appeal. These are KPIs that everyone in the company from operations to plant management can easily understand and interpret. These KPIs can be directly related to Unit and Plant performance KPIs. Three simple KPIs for this purpose are:

- Output at Limit
- Time in abnormal mode
- Oscillating

The reasoning behind choosing these three simple KPIs is this: Everyone can focus on the same easily understandable measures. The measures have direct impact on the corporate KPI goals. Other performance measures may be equally important, but require more process knowledge to interpret. Let’s look at each control system KPI and see how it directly links to corporate KPI goals.

5. THE DIRECT LINKS

In this section, we explore how some short-term KPIs directly drive long-term KPIs, such as throughput, energy cost, and uptime.

5.1 Oscillating

Loops that are oscillating typically result either in a quality problem, high energy costs or an unstable process. In fact no plant should permit any oscillation in their process, but without measuring oscillation this is impossible to achieve.

To solve quality problems, remove the oscillation and you can move closer to quality limits. Improving the control system KPI of oscillation increases the corporate KPI of profitability by allowing you to crowd

specifications.

It is slightly harder to understand how energy consumption is affected by oscillation. Consider what sort of fuel efficiency you would get in your car if you drove the car by oscillating between slow speeds high speeds, or by causing the air/fuel ratio to swing up and down once per minute. It is not hard to see that this would lead to poor performance. The very same thing happens in process plants.

An oscillation in boiler feedwater leads to boiler inefficiency. Furthermore, this oscillation may carry through to steam pressure, and create more expensive downstream process inefficiencies.

For example, oscillating steam pressure can cause pressure oscillations in a distillation column. This oscillation in delta P affects efficiency of separation. Correcting this oscillation lowers the control system oscillation KPI. This results in increases the efficiency of separation which increases the corporate KPIs of throughput and quality.

5.2 Output at Limit

Controllers whose output is at a limit are indicating a bottleneck in the process. The corporate KPI of "throughput" improves when the control system KPI of "output at limit" improves. In fact, even when it is wide open, a control valve can provide a restriction to flow. If the controller is at a limit, one degree of freedom is lost in your process. This can result in a bottleneck for a manufacturing goal.

The root cause of "output at limit" is typically a valve sizing problem or restriction on the operating limits of the valve. This may have been a problem in the original design, or it may have happened after capacity was increased, but this particular valve was not paid attention to.

5.3 Time in Abnormal Mode

Control loops operating in manual or with manual overrides of any sort are loops with "Time in abnormal mode". This is an excellent measure, because a large "Time in abnormal mode" means that the controller is not working as it is supposed to. If it is consistently high then something is wrong: 1) either the controller is unnecessary, 2) or the design of the control system is incorrect with the controller in the wrong place. For example, if the loop is designed with a valve that is too large or too small, operators may not put it in auto. Since there is a work-around, the control engineer may not notice.

Another example is a valve or measurement at the wrong location and better be placed somewhere else. This could be a temperature control of a distillation column where a non-sensitive

temperature measurement is used for control. This loop would probably not be in AUTO, as it could not react to disturbances. Another example is controlling a pressure with a valve where it would be better to control it with cooling media flow. This loop would not be in auto because it is not using the correct pairing of manipulated variable and controlled variable, in this case pressure.

Our experience shows operators usually inform maintenance about troublesome loops.

However if after a certain time it does not get fixed, the work-around is to just keep it in manual. Under normal operating conditions the plant will run fine, but in an upset condition this work-around can cause problems. In essence by tracking this metric you are uncovering hidden issues. Repairing these issues may have a direct effect of increasing the corporate KPI of "Uptime".

6. SHORT TERM PERFORMANCE MEASURES DELIVER RESULTS FAST

The beauty of short-term KPIs is that they are directly actionable. When loops are oscillating, you can diagnose the problem. Is it interaction with other loops or is it a hardware problem in the loop or is it tuning of the loop and eliminate the oscillation. Focusing on loops in abnormal mode will uncover a host of process, equipment, and control configuration problems, many of which can be resolved in one day. Addressing output at limit usually requires slightly longer time to resolve, since it may involve replacing the valve with a spool piece, adding a bypass, or installing a larger valve or pump.

7. CASE STUDIES

What follows are several case studies where performance supervision software was used to improve the control system KPIs. These improved control system KPIs resulted in measurably improved Enterprise KPIs.

7.1 Chemical Manufacturer Case Study

A large chemical manufacturer in the United Kingdom applied a performance supervision system to oversee the performance of 2000 loops. The system identified interacting loops and many valve problems for the manufacturer. They used Oscillating and Valve-At-Limit KPIs to identify problem areas. After repairing valves and tuning control loops, these short-term KPIs showed results. Oscillation, variability, and valve travel were greatly reduced. This in turn reduced the operating costs by \$300,000 / year. With this kind of return in an enterprise KPI, the payback is very fast.

7.2 Kruger Paper Case Study

Kruger Wayagamack, in Trois-Rivieres, Quebec CANADA applied performance supervision software to

500 loops at the start-up/commissioning of a new paper machine. During the startup, many stability problems were uncovered early.

Using a KPI weighted with economic importance, the mill kept a daily focus on problem areas throughout the start-up and commissioning process. For example, high variability in flow loops pointed directly to mechanical issues with a pump.

The result of improving the control system KPIs during start-up reduced the start-up time by 3 months. Kruger Paper estimates that the enterprise cost KPI has been reduced by \$1,000,000 per year as a result of improved control system KPIs.

7.3 Washington State Refinery Case Study

A Refiner in Washington State, USA, applied a performance supervision system to a fluidic catalytic cracker. The performance supervision system was part of a pre-test before applying a model predictive control (MPC) system. The system diagnosed a plant-wide oscillation. Investigation revealed an interaction between control loops as the source of the problem. Through tuning and changes to control strategy, the oscillation was eliminated. With the oscillation removed, the plant could run closer to specification limits. The operating set point was raised, resulting in reduced operating costs. The Total Cost KPI was cut by \$300,000 annually by lowering the control system KPI of oscillation.

8. CONCLUSIONS

Long-term enterprise KPI goals are directly correlated to short-term process & control system KPI goals. These case studies clearly demonstrate that improved control system KPIs directly drive improved corporate KPIs. Managing process & control system KPIs has the advantage that they respond immediately to problems, and they are actionable.

Measure	Typical Improvement
Efficiency	+ 1 to 5%
Energy Usage	-1 to -5%
Variability	-50%
Quality	+30%
Cycling	Removed
Valve Wear	-50%
Robustness	X 2
Performance	X 2

Fig.4. expected results within 1 or 2 years

This means that problems are identified and solved quickly, at the plant floor level, without waiting for monthly management reports to drive action. A performance supervision system like PlantTriage from ExperTune Inc. is essential for

tracking, analyzing, prioritizing, and improving the control system KPIs.

For more information about the use of KPIs, or to discuss the content of this white paper, please contact George Buckbee, Director of Product Development at ExperTune, Inc. at (262)369-7711 or email george.buckbee@expertune.com or Jan Zevenbergen, Business Development Manager at IPCOS B.V. at +31 6 23533259 or email jan.zevenbergen@ipcoss.com.

8.1 About the Authors

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Jan Zevenbergen is graduated in 1998 at Technical University of Delft as Mechanical Engineer at the Department of Measurement and Control. He has worked for several companies in the field of process automation. In 2004 he has started his own company in Process Control and was certified service provider for Expertune in Europe. In 2005 he joined IPCOS as business development manager.

NOTATION

CPM = Controller Performance Monitoring

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