

KEY PERFORMANCE INDEX

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KEYWORDS

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SUMMARY

A process performance monitoring system must be able to prioritize the loops needing attention. It should also provide historical reports of the plant's status, by areas, by loops, by identified problems.

This information should be provided to a variety of different users in an appropriate format for each category of users:

1. plant management,
2. process engineer, production,
3. technicians and control engineers.

Finally, the system includes the diagnostics and the tools to detect problems.

INTRODUCTION

Different users in process control use key performance index:

- management, ensures that the process control equipment is meeting the objectives of the business
- production, improves planning, benchmark units
- maintenance, identifies poor performers and gives them the tools to fix them

KEY METRICS

One of the keys to make a performance monitor works is to be able to quickly set up the system with metrics that are significant to the plant in question. There must be a template or cookie-cutter approach for setting up your system against a benchmark.

Every assessment interval and metric are calculated, but not all metrics are important to every plant.

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Identifying some of the key metrics is a natural habit for most plants. The plant personnel often know the important factors affecting the product quality and downtime. Once the important key metrics are identified, templates are built around these metrics. The templates are applied to a period of time that you want to use for benchmarks of performance. The optimistic case for this period of time to be settled would be after every loop in the plant has been checked, optimized and tuned. However, the realistic delay for the benchmarks to be settled will represent a portion of time compared with future metrics. Against these benchmarks, there are thresholds to be considered for each important metric in the plant.

These thresholds combined with the benchmarks provide a comparison of this loop with other loops in the plant. They also provide a comparison of the loop, the unit operation or the plant against previous time periods. An economic weight is then applied on each value depending on its economic significance.

Every assessment interval and metric is calculated, but not all metrics are important to every plant.

First the plant picks the metrics that are important. For example, paper mills may want to use variability as a key metric. Variability throughout plant loops affects variability in the final product, whereas chemical plants may consider average error or integrated absolute error more significantly. Most plants will feel oscillation detection is an important metric. Some may want to look at the amount of time the loop is in automatic or normal mode. Loops put in manual mode are probably not working properly.

PLANT BENCHMARK AND THRESHOLD

The templates are applied to a period that you want to use for a benchmark of performance. The optimistic case for this period of time would be after every loop in the plant has been checked, optimized and tuned. However, the realistic case for the benchmark will represent a portion of time to compare future metrics against. Against this benchmark, there are thresholds for each important metric in the plant.

$$\%Towards\ sthreshold = 100 * \frac{(Metric - Baseline)}{(Threshold - Baseline)} \quad \text{Equation 1}$$

These thresholds combined with the benchmarks provide a comparison of this loop to other loops in the plant. They also provide a comparison of the loop, the unit operation or the plant to previous time periods. Since each performance index is converted in a percentage value, it is possible to aggregate all together many performance indices to define a global performance index.

An economic weighing factor is added to compensate for the economic significance for each loop.

$$\%Towards\ threshold\ Economic = 100 * \frac{(Metric - Baseline)}{(Threshold - Baseline)} \div Economic\ Significance \quad \text{Equation 2}$$

PERFORMANCE INDICES

Performance indexes can be divided in categories. Table 1 lists the most common indices used in a performance monitoring. Depending on what someone is looking for, the performance index used will change. Ideally, a global performance index should represent a mixture of these categories.

To define a global performance index, it is essential to determine the goal for each loop, each unit and each plant. Usually each plant should decide which performance indices would be used, then, depending on the loop's goal, the limits for each will be determined.

TABLE 1: COMMON PERFORMANCE INDICES

	Variability	Average error, IAE (integral of absolute error)	Noise band	SP crossings	Number of mode changes	Number of SP changes	Harris Index	Performance Index	Robustness index	Variance	Output standard deviation	Oscillation (strength and period of principal components of power spectral density)	Oscillation from hardware problems	Oscillation from tuning	Oscillation from load	Model parameters	Model quality	Output at limit	Time in normal mode	Valve reversal	valve travel
Multiple values																					
Performance (error)	X	X	X	X			X	X		X		X	X	X	X						
Robustness							X	X	X			X	X	X	X						
Equipment			X	X							X						X		X	X	X
Availability					X	X											X	X			
Process Changes							X	X	X			X			X	X	X	X	X		
Operation				X	X					X				X			X	X			

SELECTING THE BASELINES AND THRESHOLDS

To select baselines and thresholds, the following methods can be used:

- Baselines:
 - Use the average value of current
 - Use a fixed value representing ideal performance
 - Use the limit found (actual minimum or maximum)

- Use the expected value for such a loop
- Thresholds:
 - Use the maximum or minimum value of current
 - Use a statistical value (example, 3 sigmas)
 - Use worst value acceptable.

Generally, the values selected are based on:

- Ideal plant, world class plant
- Actual plant, the actual becoming the benchmark
- Average plant
- Common numbers for all similar loops.

GLOBAL PERFORMANCE INDEX

A browser-based interface would make the reports easily accessible and personally customized for each category and its users. The loop monitoring system should notify, on-demand, the control engineer and the technicians with a list of loops that would make the greatest increase in profits if used optimally. The system should also have the tools imbedded to tune the loops optimally. Management needs to know how the plant is doing on a historical basis.

The metrics of control loops show how well the control loop is performing; the metrics of process control show how well the unit is performing. Diagnostics attempt to identify why a part of the process or the loop performs poorly. Continuous performance monitoring requires benchmarking so you can see the changes that occurred with time. You need a benchmark specified to your plant in order to do comparison.

The global index will be defined by:

$$Global\ Index = \sum_{n=1}^i (\% \text{ Toward } Threshold_i) / n \quad \text{Equation 3}$$

ASSESSING THE DATA

Each loop is assigned to an operation unit, the same way it is assigned to the plant. Each unit operation is assigned to an assessment interval. The assessment interval defines how often that unit operation's performance is assessed. Assessment times can vary between 1 hour and 1 week.

It may be advantageous to set at 8 or 12 hours the assessment times in order to compare how different shifts times in the day may affect the performance. Perhaps 1 assessment every 24 hours is appropriate.

IMPACTS

- Increase process knowledge
- Find problems that are not obvious
- Analyze cross correlation
- Reduce troubleshooting time
- Monitor and benchmark performance over time for continual improvement

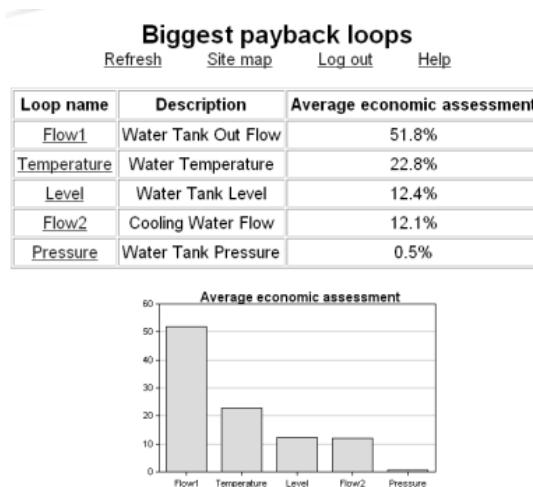
- Encourage communication between engineers, staff engineers, area managers and maintenance forces
- Generate economic gains
- Focus Engineering and Maintenance resources on key problems
- Develop a loop maintenance process
- Determine the economical benefits for advanced control implementation

WHICH LOOPS ARE THE BIGGEST PAYBACK IN YOUR PLANT?

Take the loop Flow1 column as an example in Figure 1. It has bubbled up to the top left-end of the diagram. . It has an Average Economic Assessment of nearly 52% - the largest Average Economic Assessment for all the loops shown.

The higher the Average Economic Assessment is, the greater the negative economic impact the loop is having on the bottom line of the plant.

Figure. 1 Greatest economic impact on the operation



However, this represents an opportunity to engage this loop, find out why it is ill and fix the problem, thus creating the greatest economic impact for the plant. The Biggest Payback Loops automatically set up the triage order of loops to focus attention on.

The system then determines where the problems are coming from; diagnostics are made and possible causes are presented. Figure 2 shows a custom loop list including all the possible causes of oscillation and suggests a diagnosis. This list has been customized to show all the potential suggested causes of oscillation: Hardware, Load upsets or Tuning. The first row shows our loop in question, confirming that the cause of oscillation is from the valve: 100% of the time it will suggest that the cause for the oscillation be from tuning.

Figure. 2 Loop List including possible diagnosis of oscillation.

My Loop List

Refresh Site map Log out
Change rows Change columns Help

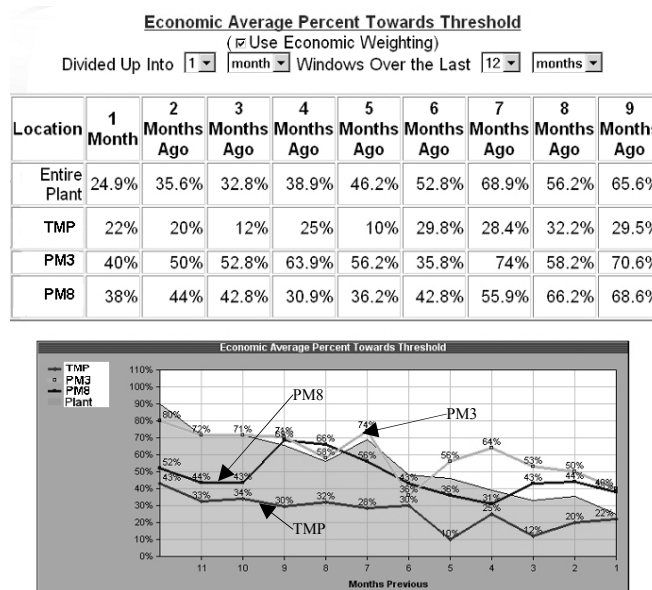
Loop name	Avg % to threshold	Average error	Oscillating	Osc - Hardware	Osc - Tuning	Osc - Load
Flow1	103.6	1.583	100	100	0	0
Flow2	24.4	0.9352	0	0	0	0
Level	24.78	6.762	0	0	0	0
Pressure	1.809	0.6616	0	0	0	0
Temperature	6.258	0.2215	0	0	0	0

PERFORM FURTHER TESTING

Now with the loop identified as having a cycling problem, and probably caused by the valve, you can perform additional tests on the valve to pinpoint and verify the problem. Two of the suggested tests to perform are a stiction test and a hysteresis test.

PLANT PERFORMANCE MONITORING

Figure. 3 Plant monitoring over a year



UNITS AND PLANT PERFORMANCE

$$Unit\ Index = \sum_{n=1}^i (\% \text{ Average Toward Threshold}_i) / n \quad \text{Equation 4}$$

To aggregate performance from many loops, the average of all loops performance (including economic significance) is calculated. This is done for each unit and for the whole plant.

CONCLUSION

It is possible to establish a benchmark of metrics or assessments for an entire plant or a group of loops. Once established, these benchmark and threshold settings are used as a comparison with other loops in the plant. This will direct the efforts of the plant personnel and mostly affect the operation. Being set also allows a comparison with time that shows how the work and money spent by the personnel benefit the operation of the plant from an economic point of view.

The Process Monitoring system should allow plants to prioritize their time to make the biggest economic impact on the company's bottom line.

ACKNOWLEDGEMENTS

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