Process Monitoring and Loop Prioritization Can Reap Big Payback and Benefit Process Plants

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A process monitoring system should be able to prioritize the loops needing attention. It should also provide historical reports on the status of the plant. i.e. "How am I doing this month compared to last month, last year etc.?" This information should be provided to a variety of different users in the appropriate format for that user: 1) technicians and control engineers, 2) process engineer, 3) plant management. A browser-based interface would make the reports easily accessible and personally customizable for each user type and each user. The loop monitoring system should notify, on-demand, the control engineer and technicians with a list of loops that if made optimal would make the greatest increase in profits. 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.

WHAT IS IMPORTANT?

Each plant has certain metrics that are important to the bottom line. For example, if the error of my loop was continually high, one knows that the product of that loop will not be on specification. So average error or integrated absolute error may be important to your plant. Other metrics like variance, standard deviation, valve travel, time in normal mode, robustness and oscillations may be important. Pick what is most important for your operation.

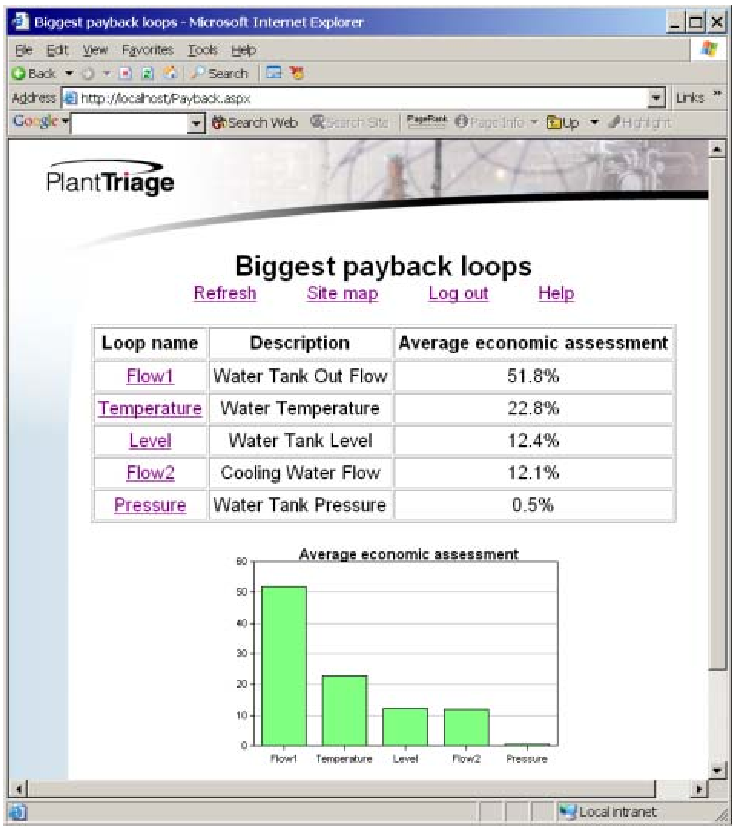
It is important to prioritize loops in the plant so that engineering personnel can make the best use of their time: they will be working on the areas that will give make the greatest economic impact to the plant. For this to happen, there must be continual assessment and analysis of the loops so a system can notify the engineer preferably via a simple list which are loops the ones to work on. Perhaps the name for this is "Biggest Payback Loops".

TECHNICIAN AND CONTROL ENGINEER USAGE

Most engineers and technicians have access to a web browser. This facilitates easy access to a browser interface of plant assessments, answering the question "What is the most significant thing I can do today that will have the most impact on the economic bottom line of my company?" So they will want to view a list something like "Biggest Payback Loops" section using a browser interface.

WHAT IS THE BIGGEST PAYBACK LOOPS IN YOUR PLANT?

For example in Figure 1, the loop Flow1 has bubbled to the top. The name Flow1 is in the top left-hand column. 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, the greater the negative economic impact this loop is having on the bottom line of the plant.



Loop name	Description	Average economic assessment
Flow1	Water Tank Out Flow	51.8%
Temperature	Water Temperature	22.8%
Level	Water Tank Level	12.4%
Flow2	Cooling Water Flow	12.1%
Pressure	Water Tank Pressure	0.5%

FIGURE 1: REPAIRING FLOW1 WILL HAVE THE 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.

HOW CAN I FIND OUT HOW TO MAKE THE LOOP HEALTHY?

Looking at past assessments with a breakdown of the individual assessments making up the overall average assessment shows more details of what is occurring in the loop. Each assessment represents calculations for that time period. In this chart the assessments are spaced by 1 hour, which is the assessment time for this loop. It is assessed every hour.

The key here is to look at the individual assessments over time that have made up the "Avg % to threshold". The components that are large have the biggest effect on the average.

Loop History for Flow1 during the previous 1 Days **of assessments.**

Show assessments as % towards threshold

Site map   Log out   Help

Time	Avg % to threshold	Average error	Harris (normalized)	Oscillating	Osc - Hardware
8:00 AM 6/9/2002	no data	no data	no data	no data	no data
7:00 AM 6/9/2002	179.1%	347.1%	77.6%	125.0%	166.7%
6:00 AM 6/9/2002	97.1%	78.4%	34.9%	125.0%	150.0%
5:00 AM 6/9/2002	100.3%	75.7%	33.9%	125.0%	166.7%
4:00 AM 6/9/2002	99.3%	76.5%	29.1%	125.0%	166.7%
3:00 AM 6/9/2002	96.5%	73.2%	21.2%	125.0%	166.7%

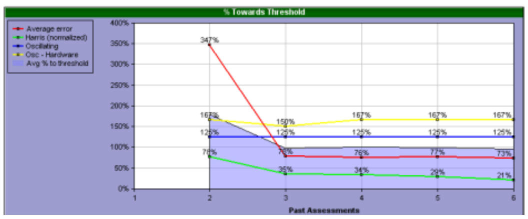


FIGURE 2: LOOP HISTORY SHOWING DETAIL OF WHAT THE PROBLEM IS

IS OSCILLATION THE PROBLEM?

In the fifth and sixth columns there are "Oscillating" and "Osc - Hardware". These are consistently high with values near 125 and 167% respectively. The "Oscillating" column indicates there is a consistent oscillation problem with the loop during each assessment. The "Osc-Hardware" column suggests that the reason for the oscillation is from the hardware or valve.

VERIFY THE CAUSE OF OSCILLATION

Figure 3 shows a list including all the possible causes of oscillation. This confirms the diagnosis. This list shows all the possible potential suggested causes of oscillation: Hardware, Load upsets or Tuning. In the first row is our loop in question, confirming the cause of oscillation is from the valve: 100% of the time it suggests the cause for the oscillation is from valve hardware. This means the valve is probably cycling from either stiction or hysteresis.

My Loop List

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Change rows Change columns Help

Loop name	Avg % to threshold	Average error	Oscillating	Osc - Hardware	Osc - Tuning	Osc - Load	Oscillation period 1
Sort	Sort	Sort	Sort	Sort	Sort	Sort	Sort
Flow1	103.6	1.583	100	100	0	0	512
Flow2	24.4	0.9352	0	0	0	0	8
Level	24.78	6.762	0	0	0	0	512
Pressure	1.809	0.6616	0	0	0	0	512
Temperature	6.258	0.2215	0	0	0	0	256

FIGURE 3: CUSTOMIZED LOOP LIST INCLUDING ALL THE POSSIBLE DIAGNOSIS OF OSCILLATION.

PERFORM FURTHER TESTING

Now with the loop identified as having a cycling problem, and probably caused from the valve, you should 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. Both stiction and hysteresis are problems that often effect valves, and both will cause the loop to cycle. For details of these tests see the attached references in the Bibliography.

Figure 4 shows the report of the hysteresis check done on the valve. This test is done with the valve in service. An in service check is more accurate than testing the hysteresis with the valve out of service. Figure 5 shows the report of the stiction check done on the valve. Again this test is more meaningful done with the valve installed. Both of these tests are documented in Word. Tests were done using the optimization software that is integrated into the Process Monitoring system. However both of these tests could have been done as discussed in the referenced articles.

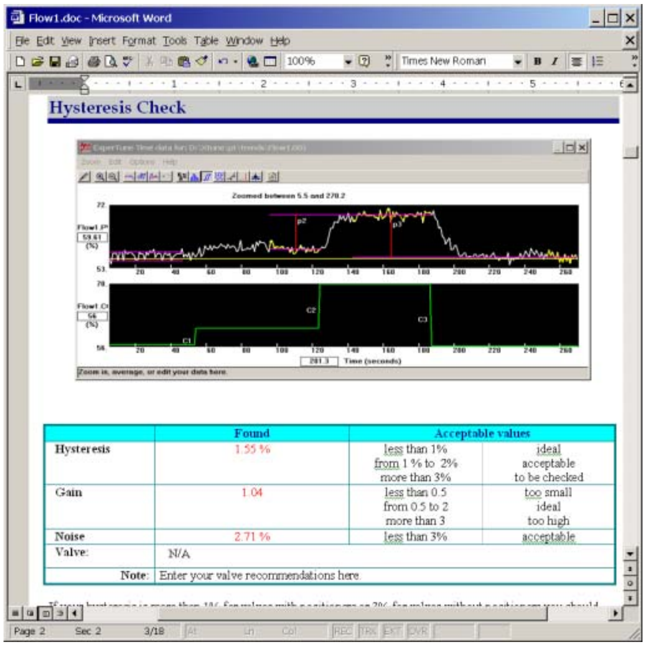

FIGURE 4: REPORT OF THE HYSTERESIS CHECK ON THE VALVE IN SERVICE SHOWS HYSTERESIS OF ABOUT 1.6%

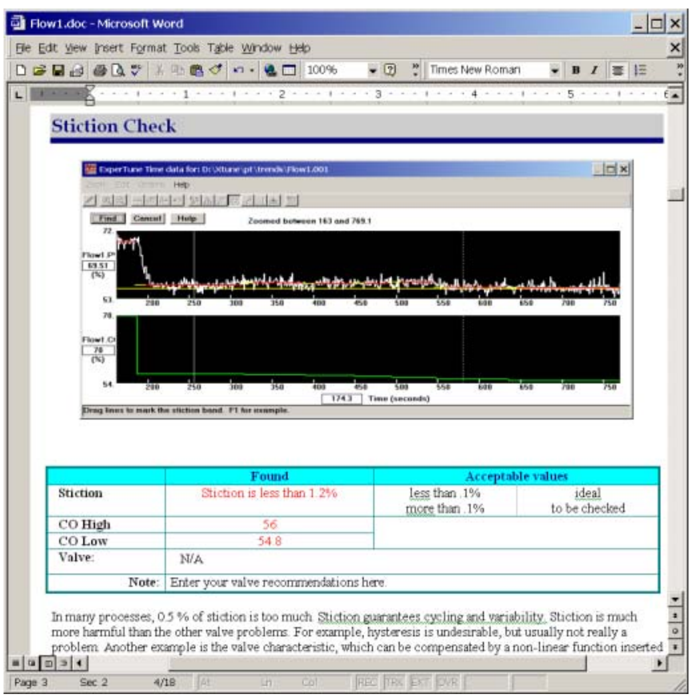

FIGURE 5: REPORT OF THE STICTION CHECK ON THE VALVE WHEN IT IS IN SERVICE SHOWS STICTION OF ABOUT 1.2%

The tests show that hysteresis may not be a problem but that stiction probably is a problem. Stiction of more than .2% will usually cause cycling whereas hysteresis of more than 3% is considered worth repair.

ACTION TAKEN AND REPAIR

Two actions were taken based on the result of examining our Biggest Payback Loops:

1) We repaired the valve, bringing the hysteresis to 1% and stiction to .2%

2) Using the optimization software that is integrated in the process monitor we re-tuned flow1 and the other 2 loops in the unit: a level loop and a pressure loop. Flow1 was the inner loop of a cascade.

The results can be seen after letting the plant for a day after the repair and re-tuning of this unit operation.

RESULTS OF REPAIRING BIGGEST PAYBACK LOOPS

A day after the repair, Figure 6 shows that now Flow1 is among the best performing loops in the plant.

Biggest payback loops

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Loop name	Description	Average economic assessment
Level	Water Tank Level	11.3%
Flow2	Cooling Water Flow	11.3%
Pressure	Water Tank Pressure	7.5%
Flow1	Water Tank Out Flow	5.7%
Temperature	Water Temperature	2.4%

FIGURE 6: BIGGEST PAYBACK LOOPS NOW SHOW FLOW1 HAS BEEN REPAIRED.

Now if we look at a graph of the loop history as shown in Figure 7 we can see how the loop has improved since we made our corrections. This graph shows the previous assessments for Flow1. The lavender shading represents the overall or Average % Towards Threshold for all the assessments that are important to us. This is made up of 4 assessments as show by the additional red, green, blue and yellow lines on the graph. The oldest assessment, from 25 hours ago is on the far left, the latest on the far right of the graph.

At assessment 22 and 21 we were making tests to the loop and the assessments all increased. After this time, we repaired the valve, and re-tuned the loop. This caused the assessments after 21 to steadily decrease. The oscillation measure and oscillation diagnosis are the blue and yellow lines respectively. They are an average of the previous 10 assessments and so take 10 assessments to reach 0. The average error and normalized Harris index dropped immediately after repair.

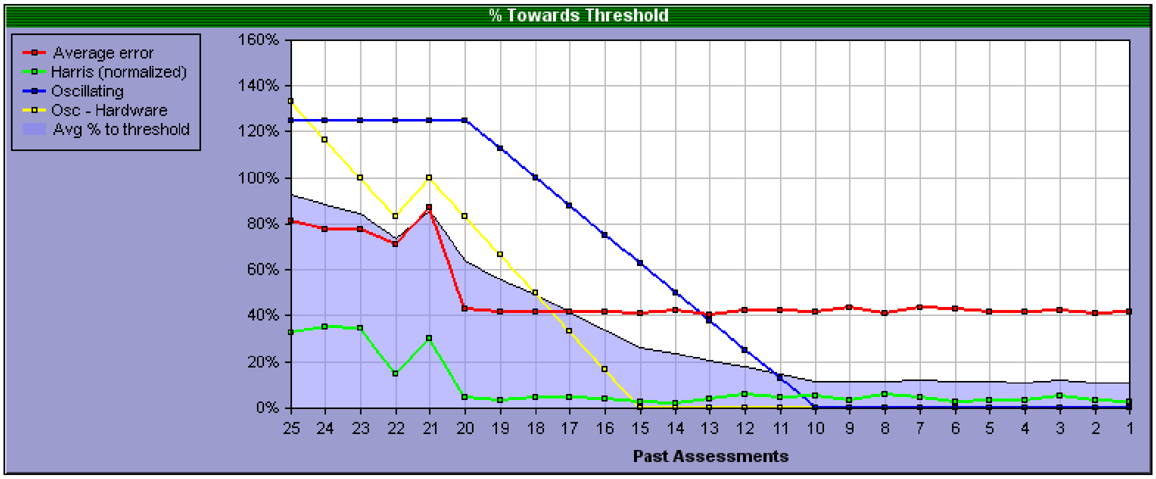

FIGURE 7: LOOP HISTORY GRAPH FOR FLOW1. TESTING AND IMPROVEMENTS DONE DURING ASSESSMENT 22 AND 21. IMPROVEMENTS SEEN STARTING IN ASSESSMENT 20.

The values in Figure 7 represent normalized values.

The average error (red line) is the average value of the absolute value of the difference between SP and PV for every sample.

The Normalized Harris Index (green line) is:
Normalized Harris Index = 1 - 1/(Harris Index)

The oscillation detection (blue line) is a measure of whether the loop is oscillation: 100% indicates oscillation. 0% indicates no oscillation. The oscillation diagnosis of hardware (yellow line) is similar: 100% denotes the oscillation is caused by hardware.

CONCLUSIONS

A Process Monitoring system has been introduced that provides for the user to prioritize his time to make the largest economic impact in his plant. It includes a Triage list of Biggest Payback Loops identifying the loop or loops to give attention to. It also provides the tools for automatic diagnosis of the problem, and detailed analysis to confirm the problem in the system. Optimization software is seamlessly integrated to allow for the complete diagnosis and tuning of the loop once those loops have been identified.

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

CREDITS

All the figures in this article were derived from PlantTriage software from ExperTune Inc.

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