Performance Monitor Raises Service Factor Of MPC

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Performance Monitor, Real Time, Oscillation, Interaction, Advanced Control, Optimization

ABSTRACT

The benefit of model predictive control or MPC can only be achieved if the regulatory layer is responsive and optimized. This paper will discuss the application of a Performance Monitor in a unit operation where the objective of optimization against constraints is the job of an MPC controller. The responsibility of the Performance Monitor is to keep the regulatory loops optimized so the MPC controller can do its job of optimization against the constraints.

It was decided by the plant that prior to installation of the MPC controller, the loop performance monitoring system should be installed. This would allow for all loops to be optimized and performing with the best response possible so that subsequent step testing and modeling for the MPC controller would be as accurate as possible.

PERFORMANCE MONITOR FUNCTIONS

The purpose of the performance monitor is to keep the plant optimized by identifying areas that could be improved and providing the advanced tools to further diagnose and optimize those areas.

Most of the features of the performance monitor are available real-time through a web-based interface. The performance monitor installs a web server that serves up in real-time most of the information mentioned below.

Here is a brief overview of some of the functions performed by the performance monitor:

- Evaluates loop health for all loops in real-time
- Lists in order of importance the loops that need attention
- Highlights loops that are oscillating and gives a suggested diagnosis

- Sorts and groups categories of loops based on any of the performance criteria over any time period
- Groups all oscillating loops by period of oscillation
- Provides quantitative evaluation of valve stiction and hysteresis from detailed test data
- Provides optimal PID tuning, simulation and robustness analysis
- Provides for a health history for the entire plant, unit operation, or individual loop viewable for any time window

PERFORMANCE MONITORING OF UNIT OPERATIONS

The unit operation that is the target of the MPC controller is a catalytic cracker. However, in the plant there are several unit operations that support the catalytic cracker: a fractionater, reactor regenerator, compressor and gas concentration unit.

The performance monitor was installed first. The performance monitor continually monitors the performance of all the loops in the catalytic cracker and supporting unit operations.

WORK PROCESS - SETUP OF LOOP HEALTH IN THE PERFORMANCE MONITOR

The performance monitor was installed first. The performance monitor continually monitors the performance of all the loops in the catalytic cracker and supporting unit operations.

The performance monitor was installed and let run for roughly 4 weeks. During this time the performance monitor assessed every loop in the Catalytic cracker and supporting unit operations every 12 hours.

After 4 weeks of continual running, an engineer selected and configured the loop health assessments. This was accomplished over the span of about a day.

Nine key assessments were chosen - each one contributing to loop health
variability
average absolute error
set point crossings
normalized harris index
oscillating
time in normal
valve reversals
valve travel
output at limit

Setpoint crossing, average absolute error and variability are inferential quality control loops. How close the plant can push constraints of the MPC controller is tied to these three indexes.

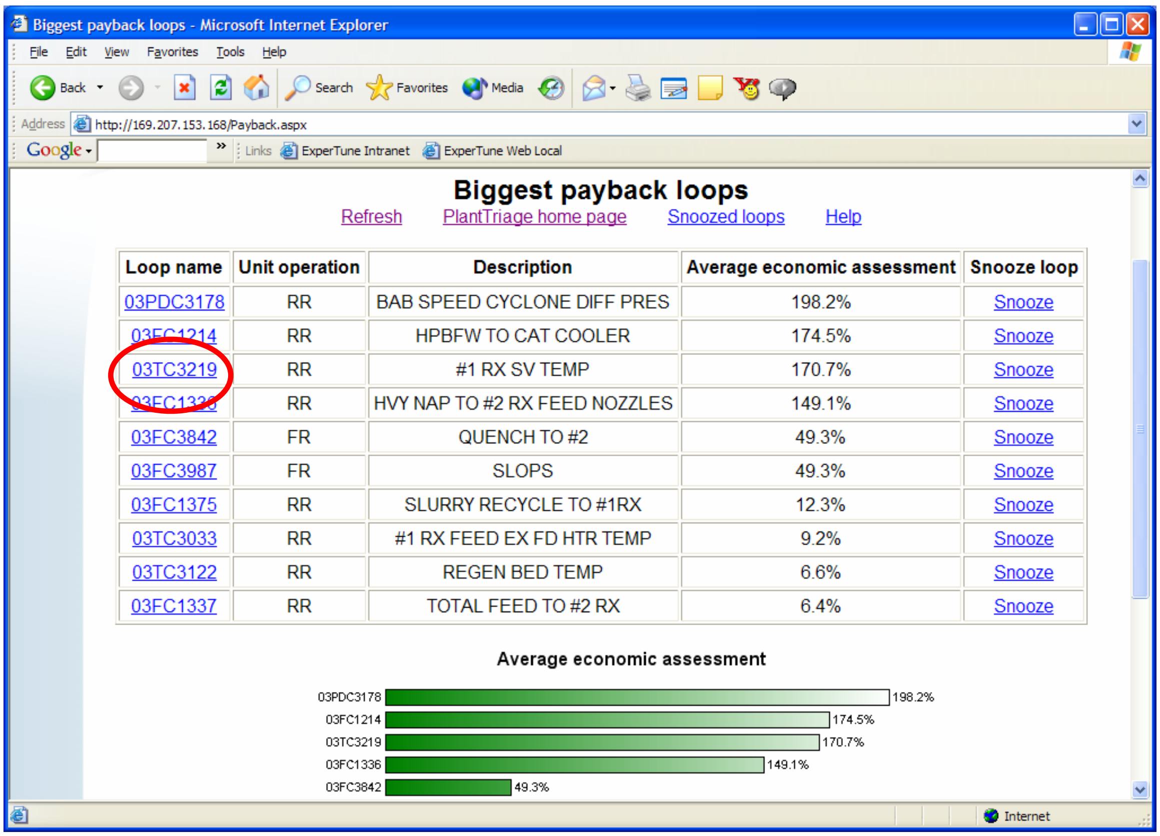
Time in normal and output at a limit were chosen again to reinforce the objectives of the MPC controller. The loops need to be in automatic or a normal mode and not at a limit for the MPC controller to work.

Valve reversals and travels were chosen because in a fluid catalytic cracker requires very high cost valves. A single slide valve can cost upwards of a hundred thousand dollars each and the entire unit must be shutdown to service a valve.

The baselines and thresholds for these 9 assessments were set for all loops using the template function of the performance monitor.

WORK PROCESS AND UNIT OPERATION IMPROVEMENT

By looking at the Biggest Payback loops list, Figure 1, one of the controllers that appeared in the list was the main reactor temperature controller.



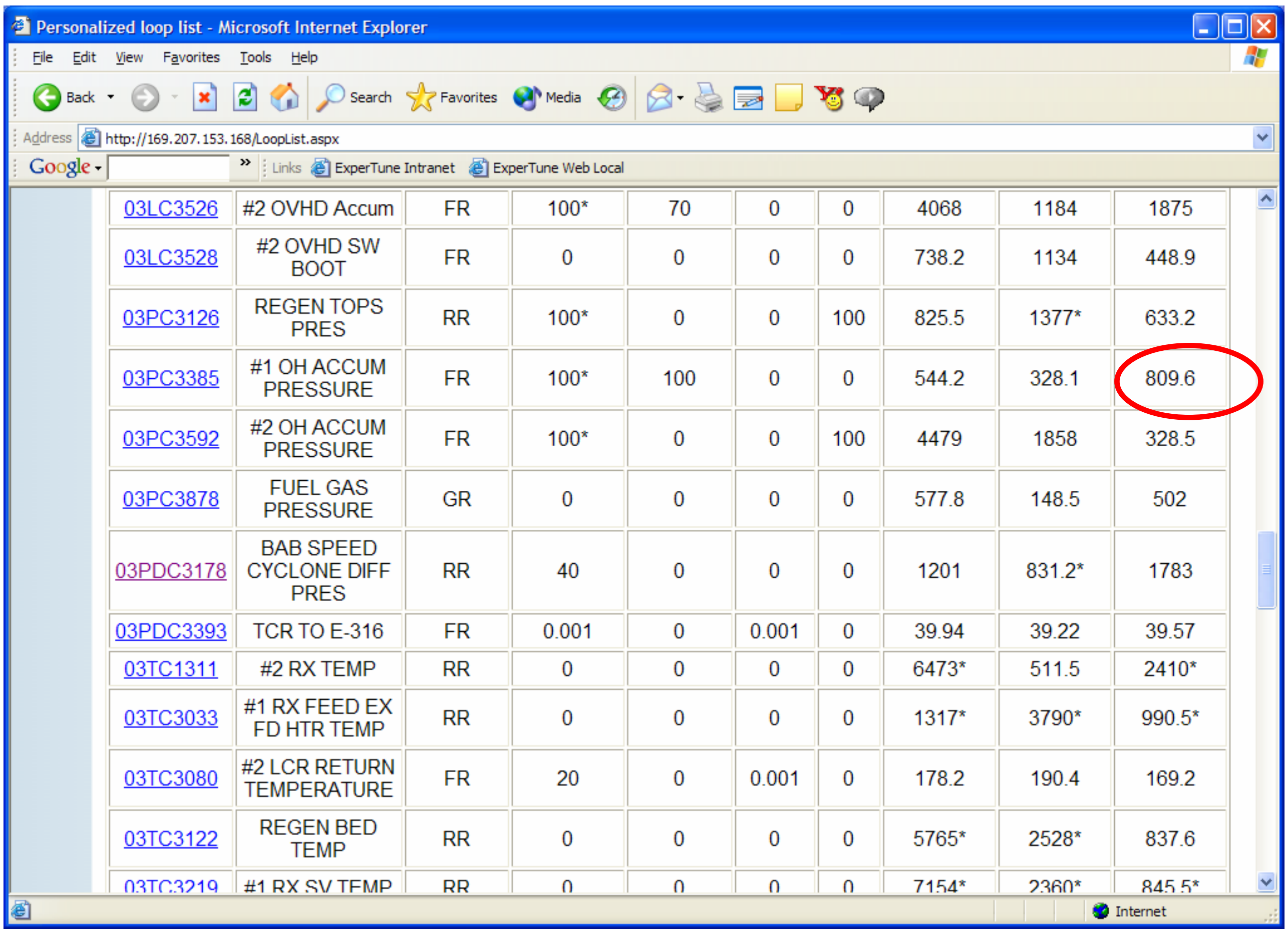
Loop name	Unit operation	Description	Average economic assessment	Snooze loop
03PDC3178	RR	BAB SPEED CYCLONE DIFF PRES	198.2%	Snooze
03FC1214	RR	HPBFW TO CAT COOLER	174.5%	Snooze
03TC3219	RR	#1 RX SV TEMP	170.7%	Snooze
03FC1336	RR	HVY NAP TO #2 RX FEED NOZZLES	149.1%	Snooze
03FC3842	FR	QUENCH TO #2	49.3%	Snooze
03FC3987	FR	SLOPS	49.3%	Snooze
03FC1375	RR	SLURRY RECYCLE TO #1RX	12.3%	Snooze
03TC3033	RR	#1 RX FEED EX FD HTR TEMP	9.2%	Snooze
03TC3122	RR	REGEN BED TEMP	6.6%	Snooze
03FC1337	RR	TOTAL FEED TO #2 RX	6.4%	Snooze

FIGURE 1

Further investigation by drilling down from here resulted in no diagnosis from tuning, hardware problems or from load disturbances. It was, however, noticed that the frequency of oscillation from the main fractionator's overhead was very similar to that of the reactor temperature controller. The pressure controller was put into manual for a short period of time to determine the effect on the reactor temperature controller. The highlights on the screen shots below show the frequencies that led to determination of the cause of the cycling. A hysteresis test was performed on the pressure valve and it was determined that it required service to correct the temperature oscillations on the unit.

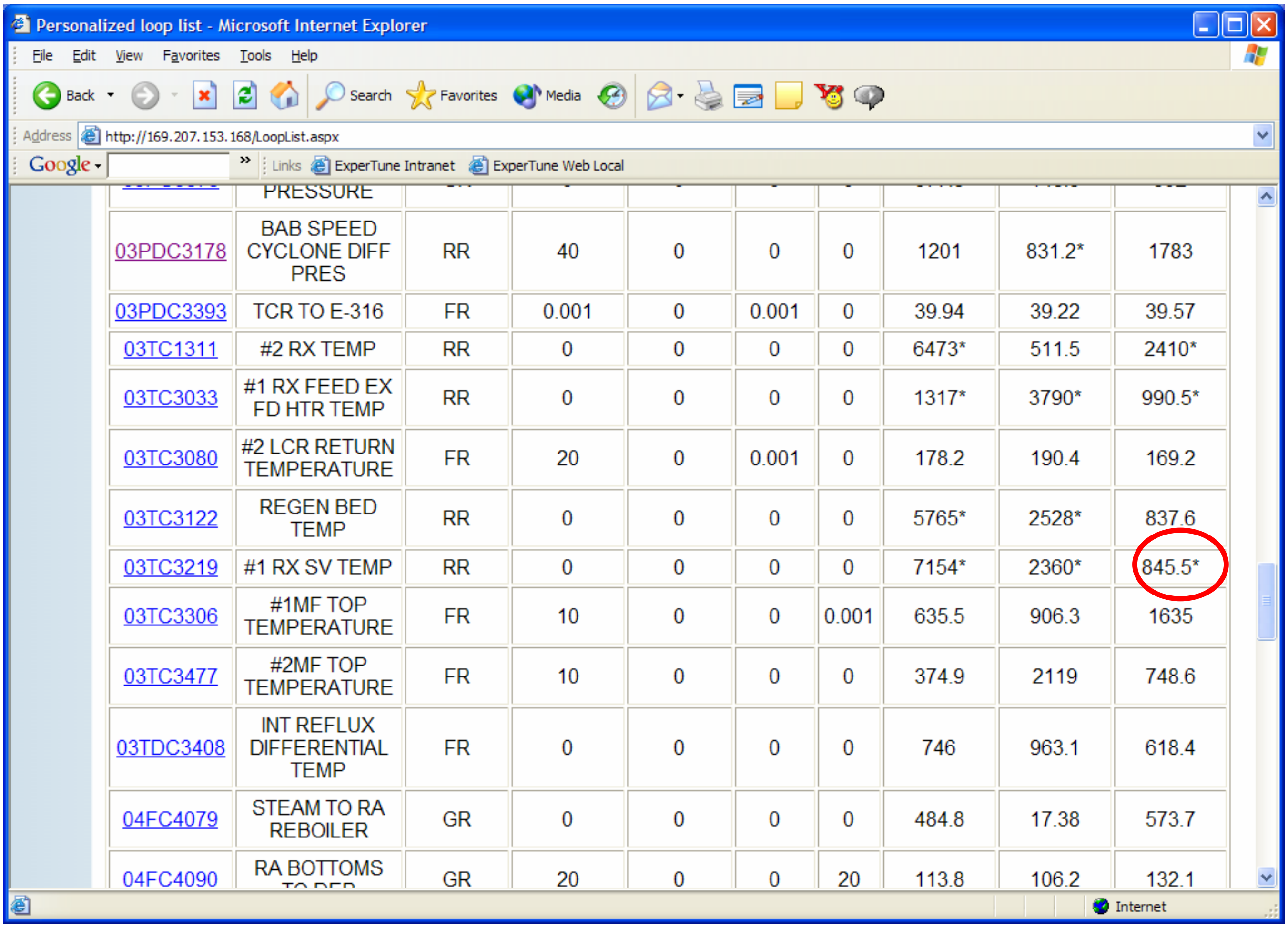
The Catalytic cracking unit had been experiencing an oscillation with amplitude of 6 deg F (degrees Fahrenheit) and with a 25 minute period. Removing this oscillation had a big impact in the performance of the catalytic cracker. For each degree F in the amplitude of the oscillation, the setpoint must be kept away from the optimal value for at least 1/2 of that amplitude. This is so that metallurgical and safety constraints are not violated. Each degree F closer to the optimal value that the catalytic cracker can run results in over $100,000.00 in benefit per year. The importance of removing this oscillation cannot be understated.

Loops that have the same frequency are highlighted on the next two screen shots, Figure 1 and 2.



03LC3526	#2 OVHD Accum	FR	100*	70	0	0	4068	1184	1875
03LC3528	#2 OVHD SW BOOT	FR	0	0	0	0	738.2	1134	448.9
03PC3126	REGEN TOPS PRES	RR	100*	0	0	100	825.5	1377*	633.2
03PC3385	#1 OH ACCUM PRESSURE	FR	100*	100	0	0	544.2	328.1	809.6
03PC3592	#2 OH ACCUM PRESSURE	FR	100*	0	0	100	4479	1858	328.5
03PC3878	FUEL GAS PRESSURE	GR	0	0	0	0	577.8	148.5	502
03PDC3178	BAB SPEED CYCLONE DIFF PRES	RR	40	0	0	0	1201	831.2*	1783
03PDC3393	TCR TO E-316	FR	0.001	0	0.001	0	39.94	39.22	39.57
03TC1311	#2 RX TEMP	RR	0	0	0	0	6473*	511.5	2410*
03TC3033	#1 RX FEED EX FD HTR TEMP	RR	0	0	0	0	1317*	3790*	990.5*
03TC3080	#2 LCR RETURN TEMPERATURE	FR	20	0	0.001	0	178.2	190.4	169.2
03TC3122	REGEN BED TEMP	RR	0	0	0	0	5765*	2528*	837.6
03TC3219	#1 RX SV TEMP	RR	0	0	0	0	7154*	2360*	845.5*

FIGURE 2



[illegible]	PRESSURE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
03PDC3178	BAB SPEED CYCLONE DIFF PRES	RR	40	0	0	0	1201	831.2*	1783
03PDC3393	TCR TO E-316	FR	0.001	0	0.001	0	39.94	39.22	39.57
03TC1311	#2 RX TEMP	RR	0	0	0	0	6473*	511.5	2410*
03TC3033	#1 RX FEED EX FD HTR TEMP	RR	0	0	0	0	1317*	3790*	990.5*
03TC3080	#2 LCR RETURN TEMPERATURE	FR	20	0	0.001	0	178.2	190.4	169.2
03TC3122	REGEN BED TEMP	RR	0	0	0	0	5765*	2528*	837.6
03TC3219	#1 RX SV TEMP	RR	0	0	0	0	7154*	2360*	845.5*
03TC3306	#1MF TOP TEMPERATURE	FR	10	0	0	0.001	635.5	906.3	1635
03TC3477	#2MF TOP TEMPERATURE	FR	10	0	0	0	374.9	2119	748.6
03TDC3408	INT REFLUX DIFFERENTIAL TEMP	FR	0	0	0	0	746	963.1	618.4
04FC4079	STEAM TO RA REBOILER	GR	0	0	0	0	484.8	17.38	573.7
04FC4090	RA BOTTOMS [illegible]	GR	20	0	0	20	113.8	106.2	132.1

FIGURE 3

The main fractionater is downstream of the catalytic cracker. So this is a counter-intuitive and difficult diagnosis. Using advanced analysis and diagnostic tool, the quantitative amount of valve hysteresis in this valve was determined.

CONCLUSION

The performance monitor has given personnel in the refinery the tools to ensure regulatory loops are operating optimally. This performance monitor package has resulted in significant savings when applied to the catalytic cracking unit. The savings amount to circa $500,000/year.

The performance monitor achieved much of the optimization possible on the catalytic cracking unit. This will enable the MPC controller to get the potential gain from the unit and more importantly will allow that benefit to be sustained over time.

REFERENCES

"Stiction: The Hidden Menace", *Control Magazine*, November 2000 Michel Ruel