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ISA Management Division

PERFORMANCE AND OPTIMIZATION
AN ECONOMIC POINT OF VIEW

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This is the third in a series of articles that will present numbers and examples to help convince management of the process control opportunities available to improve the bottom line. This article will describe the basics of benchmarking … To be able to improve something, first you have to measure it. To measure performance, you need to benchmark what you plan to improve. Benchmarking will allow comparisons. Benchmarking can be established from historical data or data from another site for example. In this article, we will use an example from day-to-day life: driving a car to illustrate the importance of benchmarking as an important management tool.

Performance, Benchmark, Cars: What is the link?

To illustrate the concept of "process supervision", I will use a day-to-day life example. Every time we talk about performance, we first need to define what performance for a specific situation is.

Let me tell you a short story about my car to illustrate this topic …

What is a performing car?

I asked a few people; this is what I got (in general, they gave two or three characteristics) ..

- powerful engine
- economic
- able to face the worst conditions (SUV)
- able to resist impacts (safety)
- 0-60 mph in less than …sec
- stable in curves

And, many more!

Everybody evaluates a car's performance as a function of meeting their personal needs. When they are looking for a new car, people usually try different cars of a certain price range in order to test their handling. They come up with their own conclusions. They analyse their impressions and the statistics they are given, and a global impression comes up that helps guide their choice. This choice is an amalgam of many performances indexes.

Habits

Once this choice is made, after having bought or rent the car, they become users: Performance criteria are readjusted. After a few months, the seat position, the steering height and the mirrors angles have been chosen carefully. The driver knows his car behaviour better than anyone; they will detect any unusual sound or change.

Hesitating transmission

A few years ago, I had a car that gave me full satisfaction until I started to detect a change in its behaviour. I waited a few days to make sure these changes were not due to other users driving the car; since the automatic transmission was an "auto-adaptative" type (its behaviour adapted itself to the driver's conduct). Considering that my wife's conduct is quite different than mine, I first thought the problem might be there! At that time, I was driving 2,000 miles per month and the car had about 20,000 miles on it.

Suspicion

A week later, I was convinced that the transmission had a problem: I felt a slight hesitation during accelerations. I must admit that the problem was minor, but since I chose the car especially for its powerful engine and acceleration, I was particularly sensitive to the transmission behaviour.

First verdict

I first asked a friend who is a car fan to test my vehicle. Without hesitation, he told me that I was fussy and too demanding! I decided to stop thinking about it for a while.

Second verdict

A few weeks later, as I was visiting my car dealer for an oil change, I asked the mechanic to check the transmission. When I took my car back, he mentioned: "Mr. Ruel, I personally tried your car and I can guarantee you that everything is in order." He also wrote on the bill that the transmission had been check by a road test.

Third verdict

My doubts were persisting … A few months later, as I was visiting my car dealer for another oil change, I asked another mechanic to check the transmission … I got the same scenario when I took the car back – with a frown in bonus: "Mr. Ruel, I tested your car in the parking and I assure you that your transmission is fine." He also added that he had seen in the computerized system that I had asked the same thing three months ago!

Fourth verdict

My doubts were persisting … A few months later, as I was visiting my car dealer for another oil change, I asked the manager to have my transmission checked by a specialist. The following day, as per their request, I visited the specialist who does specialized jobs on

transmissions for my car dealer. He made a road test and I went with him. His verdict was: "I detect a slight pause during the accelerations, but if I was you, I would forget about it!" … I then asked him: "If it was your car, what would you do?" Without hesitation, he told me he wouldn't touch it. I then resigned myself to use my car without repairing the transmission.

Fifth verdict

But my doubts were still persisting … I had been suspecting the transmission to be unusual for a year. It was time to do my oil change; as my car dealer's mechanics were on strike, I went to another car dealer. I asked the manager to check my transmission, explaining that I felt a slight hesitation during the accelerations. He asked to explain exactly what I felt and promised to do the verification, wanting to please its new customer. An hour later, he called me to tell me that the transmission, even if it worked normally, contained fretting corrosion in the transmission oil … and, that the whole transmission had to be replaced. I took my car to my usual car dealer, as my transmission was still guaranteed. When they drove my car to make the job, they had a breakdown: the transmission had failed!

Why?

What happened? Why was I the only one who had detected this problem in advance? Why, 25,000 miles before the breakdown, after one year of use and many inspections, no one else had identified the problem? Why did we need to check the transmission interior, rather than its behaviour, to find the problem?

The answer is very easy: I had a benchmark! Let me tell you that next time, I will insist even more to have some inspections done; I will use my suspicions as a sign of bad functioning.

Performance supervision software does the same thing: It identifies the loop, sectors and processes behaviour using a benchmark. As soon as an anomaly is detected, an alarm is sent out and a preliminary diagnostic is suggested.

Performance in the Industrial Environment

In the industrial environment, performance definition must be as precise.

Ideal plant

A performing plant:

- uses minimal energy, raw material and additives
- maintains low maintenance, operation, engineering and management costs
- rarely has breakdowns; shutdowns are perfectly planned; layout of work is optimal
- has minimal inventory and high quality production that meets the customer's requirements.

Wow! What a plant!

To determine our plant performance, we simply need to check if the above affirmations are true. What do we measure? How do we measure?

In reality, each industry sector has its own way of measuring performance. Beyond this wish list, we need to determine some performance parameters. In fact, each area of a plant could have its own benchmark. For example, in a paper mill, the paper machine performance and the steam plant have different objectives, hence different ways to evaluate performance.

Paper Industry

- **Paper machine --** A paper machine's performance is a function of the variability many variables: thickness, basis weight, moisture, whiteness, etc. as this variability will be reflected in the characteristics of the finished paper sheet. The machine has a limited production capacity and the production performance will thus be measured in quality and machine running time.

- **Pulp plant --** A pulp plant's performance is a function of producing at the lowest cost and with a constant quality a pulp corresponding to the machine paper needs. The running time is less critical since it is possible to store some of the production in order to respond to demand during shutdowns.

- **Thermal central** -- A thermal central plant's performance is a function of its capacity to respond rapidly to demand, maintaining a stable supply of steam. Moreover, it is unthinkable to stop a thermal plant's production: it is impossible to stock energy.

Other sectors

- **Petrochemical**

  In the petrochemical industry, a petrochemical plant's performance is often evaluated as a function of its production capacity. Since it produces liquids, variability is not really important: Any major variability disappears during blending. A well performing plant produces in large quantities, safely.

- **Pharmaceuticals**

  In the pharmaceutical industry, there are usually many small production units functioning as batch processes. Performance consists of producing rapidly, complying with rigorous norms.

- **Mining, metallurgy**

  In the mining and metallurgy industry, raw material varies a lot and controls must be very robust to maintain quality and stability, while protecting production equipment.

Performance

Performance measure varies according to the industry type and plant sector. As a consequence, it is important to consider objectives.

At the simple loop level, performance measure choices will also have an impact. We will have to choose indexes for a loop so that the system determines performance based on the sector global objective.

Flow loops examples

- **Boiler feed flow --** For example, to measure the feed flow loop performance of a boiler producing steam, we will essentially look to its ability to follow quick set point changes.

- **Mix tank flow --** Many flow loops feeding a mix tank will perform if they are synchronised (tunings set so that they have the same speed).

- **Paper machine pulp flow --** A pulp flow loop on a paper machine will perform if its variability is minimized.

Performance indexes

The performance measure depends on the objectives that are established. Supervision software can be set up quickly thanks to benchmarking. This allows one to build templates in order to select limits for the chosen performance indexes using statistic tools.

For example, a boiler feed flow loop can use the following indexes:

- absolute average error
- loop response time
- % oscillation
- % service (% of time while controller is in control)
- % of time while valve is at limits (completely opened or closed)
- % of time in normal mode
- number of mode changes by operation per day

The loop will be performing if these indexes are inside chosen limits.

How do we choose these limits?

Some Benchmarking Possibilities

- World class plant
- Best plant within a group
- Comparable plant in the same sector
- Plant functioning normally
- Plant functioning at its best
- Etc., etc.

No matter the how limits are selected, supervision software will measure performance by measuring the percentage reached as a function of the limits. In any case, a decreasing percentage will indicate amelioration. Thus, it will be particularly interesting to observe how this percentage evolves with time.

During set up of supervisor software, most the plants prefer to choose performance indexes as a function of a period during when sector production is excellent. This allows the ability to benchmark the sector against itself. A few days when production was excellent is chosen for the benchmark. Templates enable one to choose superior and inferior limits for all the

loops as a function of the performance objective. It is common to use a statistic limit in the templates: for example, mean ±3 sigmas.

A few examples …

- **Valve --** A coupling on a valve slackens. Performance supervision software will detect a stroke that is abnormally high from the command to the valve, even if loop performance remains acceptable. The problem will be immediately signalled and a breakdown can be avoided.

- **Pump --** A pump cannot provide sufficient pressure. The output pressure loop will reach its maximum. The performance supervision software will immediately signal that the pressure command is no longer in control.

- **Transmitter --** The performance supervision software signals that a certain loop variability is high. The production and operation staff do not detect that anything is wrong. The day after, the instrumentation technician checks the loop behaviour and finds out that the transmitter is erratic.

- **Process equipment --** We detect that some flow loops oscillate abnormally; the system diagnostic is that the process is the cause of this oscillation. Then again, the production and operation staffs do not find anything wrong, and everything seems stable. When he compares the flow controller output with similar loops outputs, a technician finds out that a screen has mechanical problems.

Conclusion

Plant performance measure depends of selected indexes and objectives. In any case, we have to benchmark and then evaluate the plant behaviour. Performance supervision software will send out an alarm as soon as a sector or a loop deviates from the "normal" situation. Alarm thresholds will differ according to chosen limits, but the principle will always remain the same: we must be alerted before problems occur and be able to identify the causes.

Questions or comments pertaining to this article are welcome, and can be forwarded by e-mail to:

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Michel is a registered professional engineer, university lecturer, and author of several publications and books on instrumentation and control. Michel has 30years of plant experience, including with these companies: Monsanto Chemicals, Domtar Paper, Dow Corning and Shell Oil. He is experienced in solving unusual process control problems and he is also a pioneer in the implementation of fuzzy logic in process control. Michel is a fellow member of ISA.

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