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DYNAMIC CALIBRATION OF ON-LINE QUALITY MEASUREMENT

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Abstract: In dynamic calibration on-line quality measurements are improved by using laboratory analysis as a calibration reference. Dynamic calibration is one method of effective use of uncertain measurements other methods include different SPC methods.

Keywords: uncertain measurement, SPC, TMP, Calibration

1 INTRODUCTION

Almost all measurements in the process industry are more or less inaccurate or uncertain. But we must often use those measurements to control the process [1,2] or quality monitoring [2,3] and some things can be done to achieve better results and more certain measurements. SPC methods and dynamic calibration gives a tool to handle those uncertain measurements. In this paper we are demonstrating the effects of a simple dynamic calibration, but the ideas can be easily expanded to more complex situations and variations.

1.1 Calibration

Calibration means the set of operations which establish, under special conditions, the relationship between values indicated by a measuring system and the corresponding known value of a measurement. In practise, calibration of on-line measurement system is performed so that measurement device is on-line in the process and results is compared with laboratory analysis made at same time.

Possible errors in sensors is graphically explained in figure 1. They consist of offset; gain, range, or full-scale error; nonlinearity; cross-sensitivity; hysteresis and drift.

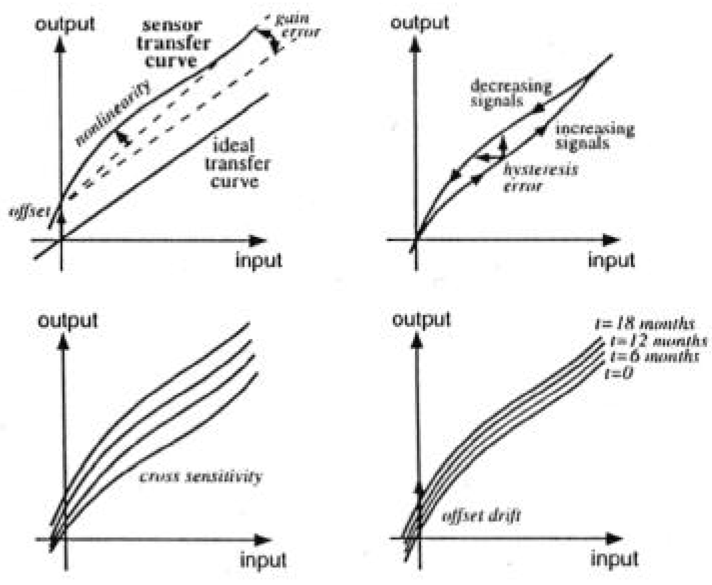

Figure 1. Possible errors in sensor transfer curve [4].

2 PROBLEM

Quality observer is a piece of software and it was developed for UPM-Kymmene Jämsänkoski TMP2-plant and its main purpose is to monitor mechanical pulp quality in TMP plant. This task is difficult for the operators because of the many parallel production lines in the plant. Also the data measured from these lines are more or less inaccurate. Other difficulties includes the irregular sampling times and sparseness and correlation of data.

Every time a measurement is made, the quality observer is called. When it detects that either variable has exceeded the allowed quality limits, it tells the operator the information of which variable caused the quality variation and in which line it happened. There is also a possibility to look the trend display. Trend display contains data from all associated process variables (freeness, fiber length, SEC, power split and plate vibrations) for several hours before the warning occurred. In practice this kind of display is very helpful to localize the causes of the detected variation. Two on-line quality measurements, freeness and fiber length, are monitored [3].

This quality monitoring application is implemented to mill but we have had some problems with the drifting of the measurement of on-line quality analyser as shown in figure 1. The application is sensitive for drifting and other on-line analyser faults because the calculations are based on pre-given goal values.

Drifting and other differences can be fixed by compensating the on-line measurements with laboratory analysis (i.e. using dynamic calibration).

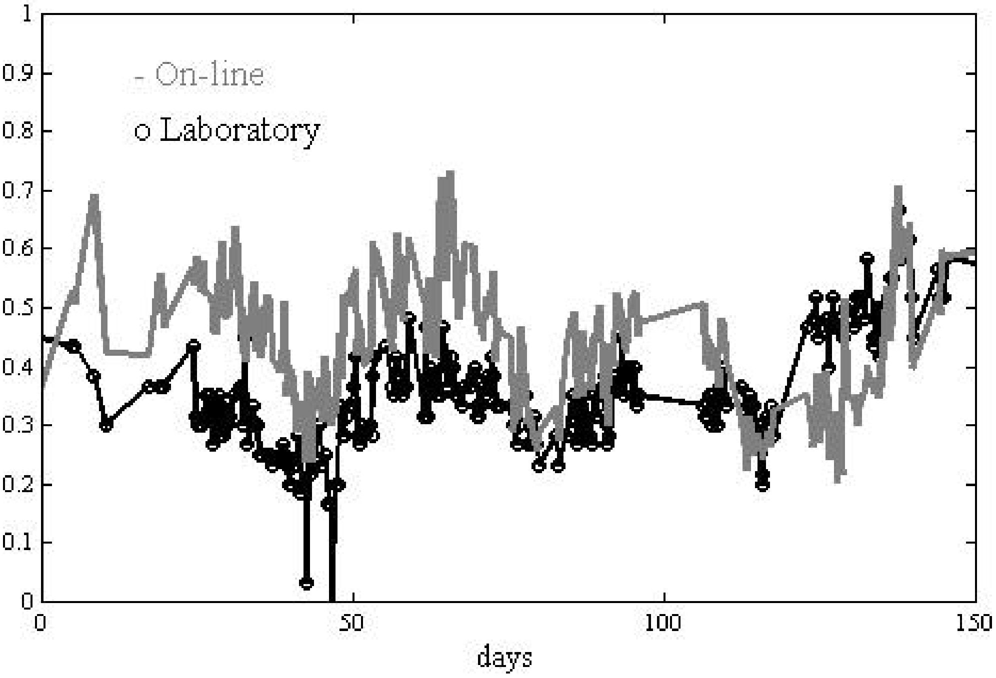

Figure 2. On-line analyser measurement drifting problem.

3 DYNAMIC CALIBRATION

Dynamic calibration is one example of effective use of uncertain measurements. The laboratory analysis is used to improve the on-line measurements. Calibration curve is based on the difference of smoothed values of the measurements. Smoothing can be done using exponentially weighted moving average (EWMA) or other averaging.

3.1 Averaging

Weight coefficient of EWMA can be calculated as shown in equation 1.

$$m_i = Pe^{(t_n - t_{(n-i+1)})b} \quad (1)$$

where:

$$b = \frac{\ln(\frac{k}{P})}{win},$$

P is the maximum of weight coefficient,
k is the minimum of weight coefficient,
win is the window length.

Figure 1 shows an example of the weighting window when the maximum weight *P* is 1, the minimum weight *k* is 0.15 and the window length *win* is 3 weeks.

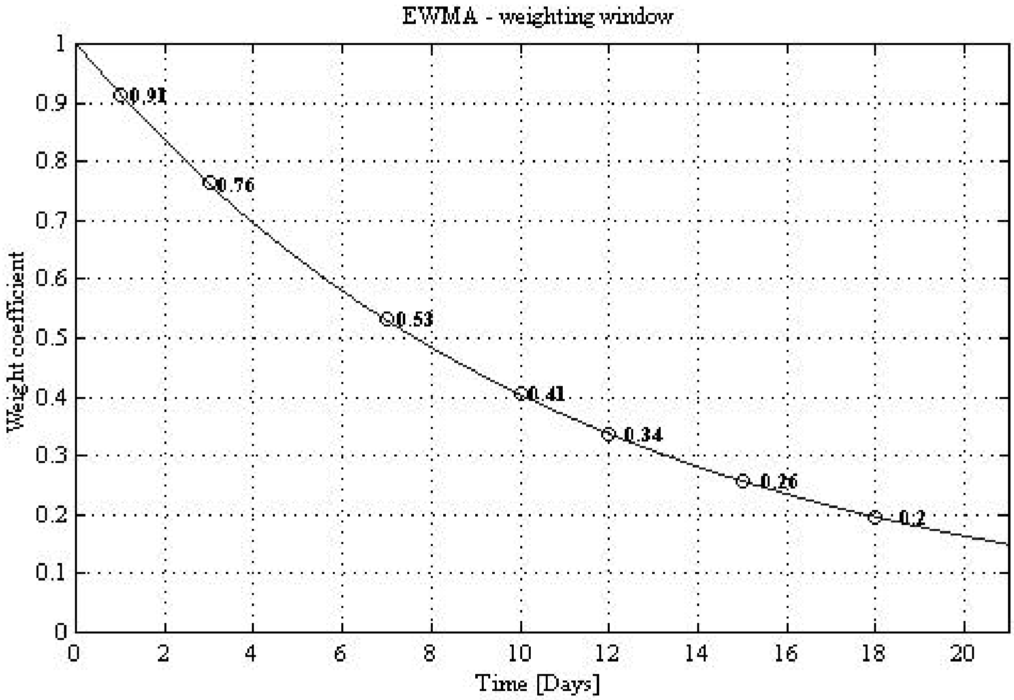

Figure 3. EWMA weighting window, when parameters are: P = 1; k = 0,15 ;win = 21 days.

Weighted average $\hat{x}_n$ can be calculated as shown in equation 2.

$$\hat{x}_n = \frac{\sum_{i=1}^{N_n} m_i x_{(n-i+1)}}{\sum_{i=1}^{N_n} m_i} \quad (2)$$

where:
x_n is a measurement at the time t_n,
N_n is the number of measurements in *win* at the time t_n.

4 SOLUTION

Solution to the drifting measurement problem is use of the dynamic calibration. We can use the laboratory analysis as a calibration reference to the on-line measurements. But then arises the question of the reliability of the laboratory analysis. On the other hand the laboratory analysis is the base of the control decisions made by operators. And if laboratory measurements are smoothed with 3 week EWMA average the variance is much smaller than variance of individual sample.

Figure 4 shows an example of simple dynamic calibration. Both on-line and laboratory analysis were smoothed with EWMA (3 weeks of data history were used) and then calculated the differences between the measurements. The differences was added to the on-line measurements and as we can see they now match much better than figure 2 shows.

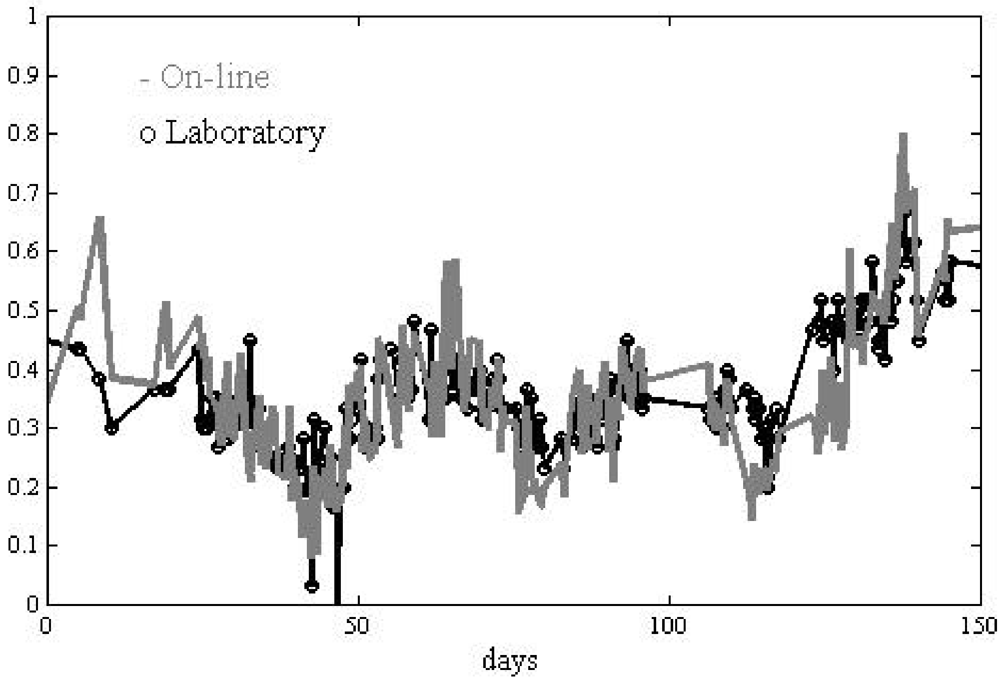

Figure 4. On-line measurements has gone through the dynamic calibration.

Dynamic calibration is also a good tool for detecting and monitoring on-line analyser faults, drifts and the need for calibration. We can monitor the difference between the laboratory analysis and the on-line measurement and if that difference is behaving strangely we notice that there is something wrong in the on-line analyser.

5 CONCLUSION

The use on uncertain on-line measurements from the process is necessary because them are only measurement we have. But if combined with laboratory analysis by dynamic calibration we can achieve much more accurate and reliable results. And if we have better measurements we have better control over the process.

Problems with the dynamic calibration are the calibration method, offset or gain correction. Should the calibration made every time the laboratory analysis is made i.e. what is the reliability of the laboratory measurements. How strong the calibration effect should be? And how small changes are reasonable and should the fuzzy limits be in use.

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