Assess Complex Process Situations in the Blink of an Eye

Abstract

The concept of Mass Data Displays has been around for quite some time, however usage in the process industries has been limited due to the effort of configuration and calibration. This white paper will provide a summary of the work done at ABB Corporate Research in Ladenburg, Germany to develop and test tools that could provide efficient calibration of Mass Data Displays.

Key words

Mass data display, high performance HMI, visualization, histograms, plant operating ranges, process signals, spatial recognition

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Mass Data Display of Process Data

ABB Corporate Research in Ladenburg has successfully tested a Mass Data Display (MDD) in a waste incineration plant. Mass Data Displays are able to ergonomically show hundreds of process signals in one single view. MDD are good candidates to be permanently shown on large screens. This allows variables to always be shown at the same spot - which supports the spatial recognition capabilities of the human brain (SDCV - spatially dedicated, continuously visible).

A key concept of Mass Data Displays is to show normalized values. Normalization is an important element of recent initiatives such as High Performance HMI. The idea is to focus (not only) on the absolute value of a given process signal but also to show its value relative to the desired operating ranges of the process.

As attractive and straight-forward this idea might appear, a closer analysis reveals that several issues need to be considered:

- During the transient phases of the plant such as startup, shutdown or grade changes the desirable operating ranges of several signals is dynamically changing. A complex dynamic simulation model of the plant would therefore be required in order to accurately predict these ranges. As such models are usually not available; we have decided to focus on steady state only.
- For some of the process signals, operating ranges can be easily derived from technological considerations, e.g. a too high lubrication oil temperature might indicate a problem with the bearing but for other signals, the desired operation ranges might not be so obvious.
- Some ranges vary with respect to the operation mode of the plant, e.g. they are different depending if a power plant is running at its full load or at its half load capacity.

In the picture below, each process signal is associated with a “compass needle” on the display. If the needle is in horizontal position, it means that the process signal value is optimal for the current plant state. The closer the angle of the needle gets to 90° or even to 180°, the more “unusual” the signal behaves. By clicking on suspicious “needles”, the operator can investigate more deeply the corresponding signal behavior in a trend display.

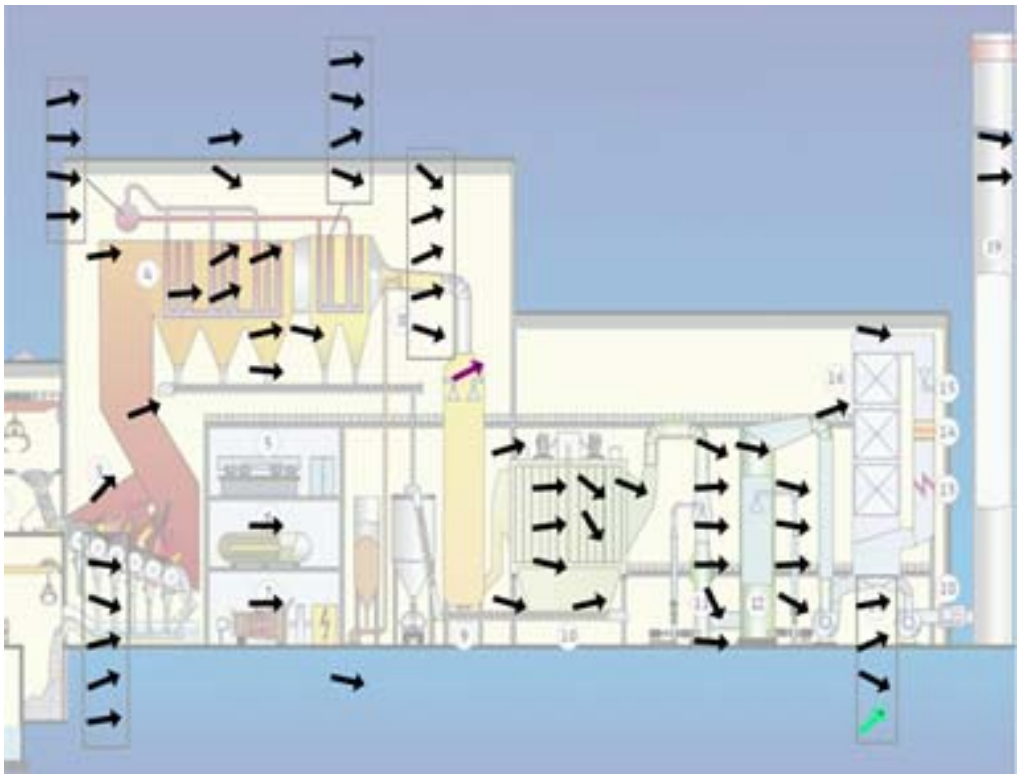

Figure 1: Process Signal Display

This visualization tool enables monitoring slowly developing effects like e.g. the efficiency of a heat-exchanger due to a dirt accumulation. Good knowledge about the degree of fouling is very important for the planning of maintenance actions.

Although the concept of Mass Data Displays has been around for quite a while, the required configuration and calibration effort has limited its widespread usage in industry so far. High-fidelity process models are usually cost prohibitive. The key focus of our research project was therefore to provide tools allowing an efficient calibration of Mass Data Displays.

Selected historical data episodes with validated nominal process behavior are used to define a reference for the desired signal ranges.

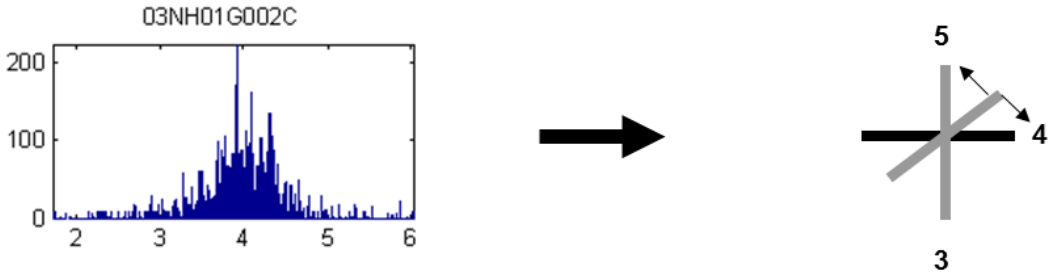

Figure 2: Calibration of MDD elements

For each plant state, typical intervals are recorded and displayed as histograms. They show how the process signal values are distributed over time. The center of gravity (4 in the example illustrated above) can be used as reference value for the process signal. The more the value goes outside the range of three standard distributions, the bigger the angle of the “needle” becomes. The sensitivity of the Mass Data Display depends on the factor of the standard deviation corresponding to an angle of 90°. Using a high factor value makes the needles mostly horizontal with the drawback that interesting effects like developing faults will be less visible.

The current state of a plant is determined with the help of a reference signal. In the case of a power plant, this is usually the generated electrical power signal. Once this signal is in steady state, we use linear approximation from previous steady states to estimate the center of gravity for all the other signals.

With such a calibration, the Mass Data Display can show how the process has behaved in similar situations of the past. It is driven by a static steady state model of the process. Deviations from horizontal will sometimes appear even in normal situations, but as the basic concept can easily be understood by operators. The Mass Data Display is a helpful support tool and could provide significant benefit when integrated into a high performance operator environment.