Statistical Process Control for Monitoring Small-scale Biomass Combustion Power Plants

Twan Bearda[1], Nicolas Depraetere[2], Bart Verbeeren[2],

Frank Alaerts[1], Jeroen Vanfraechem[1], Jeroen Poot[2]

[1] Entras, Kanunik De Dekkerstraat 21A, 2800 Mechelen. Website: www.entras.be

[2] Canguru, Schaliënhoevedreef 20D, 2800 Mechelen. Website: www.cangurusolutions.com

Introduction

Performance monitoring is an important aspect in improving the energy performance of thermal power plants. This is especially true for small-scale plants that incinerate waste streams such as low-grade biomass. Varying waste stream compositions result in variations of the operating points of the plant. Such variations are normal, but can make it difficult to detect problems with components such as pumps, valves and sensors.

Figure 1. Variations in waste stream composition can result in variations of process parameters.

In order to avoid costly standstills and technical interventions, constant monitoring of process parameters is required. This is usually facilitated by a user-friendly software interface which is provided by the constructor of the plant, and as such is the backbone of many power plants. Often explicit tolerance limits are defined for optimal plant operation, based on detailed knowledge of the plant and the process. However, the detection and interpretation of trends and excursions still requires the skills of an experienced operator.

To improve the monitoring process and optimize plant operation, different solutions have been proposed, ranging from expert systems to neural networks or fuzzy logic. Such sophisticated systems have clear benefits in terms of efficiency improvement. At the same time, their implementation seems limited to large and/or new installations, where the implementation cost is outweighed by performance gains. For existing small-scale installations, these advanced control systems may be too costly or too complex.

In this paper we present the development of a monitoring tool based on the principles of Statistical process control (SPC). First, we describe the context of the power plant for which the monitoring tool was developed. Next, the methodology is discussed. Finally, we show how the application of the tool facilitates monitoring and troubleshooting of a 9MWe biomass combustion power plant. The tool can be deployed fast, requires minimum a-priori knowledge and can be used as an add-on to existing control software.

Context

The monitoring tool was developed for a small-scale biomass combustion facility. The plant features a 33MW boiler and a steam turbine of 9MWe. The plant is controlled by a distributed control system (DCS) that was provided by the manufacturer. The DCS provides setpoints for approximately 90 variables and is well equipped with measuring devices to monitor the condition of the plant. In total, more than 700 variables were available for analysis. As with many modern DCSs these data can be inspected in real-time or as archived data with a time resolution down to 10s. In our study we used archived data with a time resolution of 60s.

Methodology

Traditional applications of SPC assume that the value of a process parameter varies around a mean value. SPC provides a way to determine the mean value and the control limits which properly reflect the variation that is intrinsic to the process. When the process parameter strays outside the control limits it is said to be "out-of-control", and the root cause should be traced and eliminated.

In order to implement SPC in the context of a biomass combustion power plant, the traditional methodology needs to be adapted in several ways. First, as pointed out before, in such a plant there are no fixed process means but rather constantly changing operating points. Second, the processes do not change infinitely fast, *i.e.* they are autocorrelated, whereas in classical SPC all observations are assumed to be independent of each other. Third, the processes in the plant are all interrelated, which can make it difficult to find the root cause if many signals are "out of control". Finally, during discrete events such as sootblowing or shutdown the actual conditions can deviate strongly from the optimal operating points. A useful algorithm should be robust against such events, in order to avoid a large number of false alarms.

The tool created by Canguru/Entras meets these challenges in an interactive and engaging visual interface. An example of its application is given in the subsequent section.

Application

In a period of stable power production in the winter of 2018/2019, a possible problem with the secondary air valve was suspected. The process parameter related to this valve is the secondary air pressure. Throughout the month of January, the pressure was relatively stable, though some fluctuations towards the end of the month were observed (Figure 2). On January 28, a failure to meet the target pressure occurred. Although this did not result in any production loss, it was decided to investigate this issue more closely.

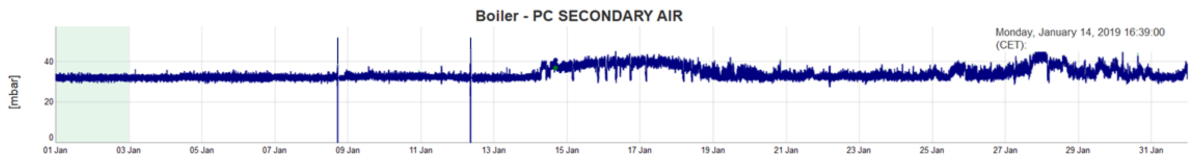

Figure 2. Secondary air pressure in January 2019.

Using the SPC tool, a suitable transformation of the measured signal was applied. Figure 3 shows the transformed signal with its control limits. Note that the tool adequately deals with two “hot stops” on January 8 and January 12. With the “out-of-control” events highlighted, it is clear that the response of the valve starts to deviate well before January 28. Apparently the designation of the signal as being “stable” in January was wrong. Figure 4 shows the number of events per day. The failure of the valve on January 28 is preceded by an increasing number of “out-of-control” events which is visible up to 2-3 weeks before the failure. Recognition of this trend might have prevented the failure of the valve and could have reduced the risk of production loss.

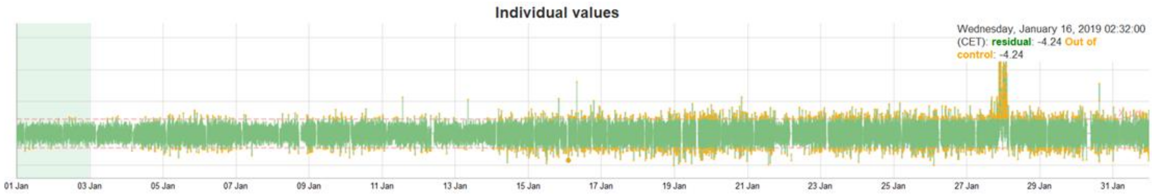

Figure 3. Transformed value of the secondary air pressure. Also shown are the control limits (red dashed line) and "out-of-control" events (yellow markers).

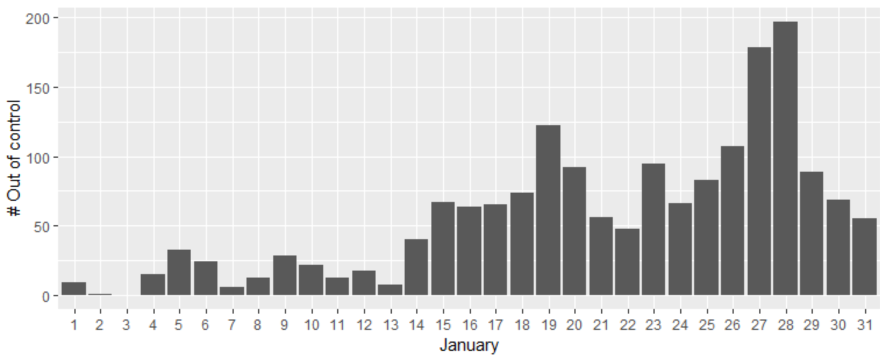

Figure 4. Number of "out-of-control" events per day for the secondary air pressure during January 2019.

Conclusions

Canguru/Entras have developed a software tool which can be used for monitoring process parameters in thermal power plants. Based on conventional SPC techniques, we have shown that the tool can identify possible issues with plant components, and thus allows for pro-active maintenance and repair. Having a small footprint and being complementary to existing systems, the tool is especially suited for integration in small-scale biomass combustion power plants.