ONLINE GROSS ERROR DETECTION SYSTEM APPLIED TO AN ALUMINA REFINERY EVAPORATION PROCESS

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Abstract

This paper presents the delivery of an advanced state-of-the-art online model-based system for instrument gross error detection (GED) and process monitoring applied to an alumina evaporation process. The system implemented at an Alcoa-operated refinery has been demonstrated to be able to detect faulty instruments and to provide reconciled process readings to site engineers. The reconciled readings are available via customised screens on a regular schedule. Examples provided in this paper demonstrate the capability of the GED system to address process and instrument issues within the building.

1. Introduction

Refinery performance, in particular operating energy efficiency, suffers when instrument accuracy and reliability deteriorates due to inaccurate or erroneous measured data being used for process control, optimization or other plant decision-making. The use of on-line process models to systematically detect and replace suspect instrument readings facilitates continuation of plant operation at required targets. Data reconciliation also provides a means to assess the severity of scale on process equipment. Early development and application of GED at Alcoa has been reported in the literature (Robertson and Sharma, 1993; Campbell, Tade and Sharma, 1995). The in-house developed model-based GED system has been applied in the past to analyse plant data in the Evaporation area for São Luis and Pinjarra alumina refineries, in the Heat Interchange area at Kwinana, the Powerhouse at Pinjarra, and the Bright Hydrate Plant at Kwinana. Due to a strategic change in the software vendor's business direction, these applications were no longer commercially supported. Consequently, a major process modelling migration exercise took place internally in the mid 2000 (Bahri *et al.*, 2005). The opportunity was also taken to replace the legacy GED method to take advantage of new developments in the GED technology. This paper discusses the deployment of a state-of-the-art GED system for the evaporation process at the Jamalco alumina refinery.

2. Objectives of project

The GED system is seen as a tool to enable energy intensive parts of the refinery to run close to their optimal operating conditions through systematic identification of instrument or process issues. The evaporation building, one of the energy-intensive processes within the alumina refining circuit, was therefore identified as requiring advanced monitoring tools such as the GED method to enable energy reduction. In this project, it is essentially a tool to improve monitoring of the evaporation building using rigorous process models and reconciled key performance indicators (KPIs) such as evaporation rates and steam economy. Based on a recent collaboration between Alcoa and Aspen Technology Inc., Lee and Love (2009) successfully trialled an advanced state-of-the-art model-based GED prototype and replaced the legacy system at the São Luis refinery. However, the on-demand GED model at São Luis was accessible only by process engineers and instrument problems were not visible to a wider audience such as maintenance staff. Consequently, any corrective actions such as field investigation are reliant on the engineers to take follow up actions. This project is aimed at developing and delivering an on-line GED monitoring tool to support these business objectives as well as addressing limitations with on-demand systems.

3. GED architecture

Figure 1 shows the architecture of the automated/on-line GED modelling application employed in this work. The GED model reads and writes instrument tags via object linking and embedding (OLE) for process control (OPC) connectivity available in the process modelling client. As part of this work an in-house script that automates the scheduling of the runs was developed and deployed. Because model outputs are written to the existing historical database server, end users can monitor the building performance directly via the GED process monitoring screens without the need to run the model. Automated delivery of binary information means the electrical and instrument engineers could take appropriate follow up action(s) rapidly if a gross error is flagged for a particular instrument. Having model outputs such as the instrument gross errors or reconciled building KPIs available in the existing historical databases at locations remote to the central modelling server on a scheduled basis was considered a major breakthrough by the development team. This tool was made possible by bringing Alcoa's rigorous process models on-line through integration with the existing manufacturing execution system (MES) environment.

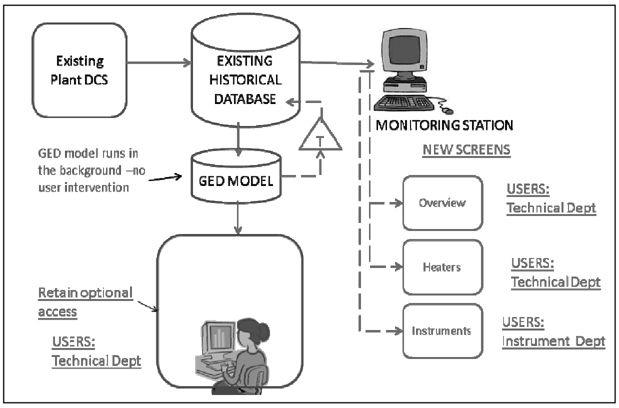

Figure 1. The online GED modelling architecture

4. Application of GED to Jamalco evaporation process

Following the successful trial of the GED prototype at Alumar and on request by Jamalco, development of a GED system for the same building at this refinery commenced in quarter four of 2009. Justification for this work, completed during the first half of last year, was based on an opportunity to reduce energy use by running the building closer to optimal targets. The GED, identified as one of the several action items, was aimed at bringing the evaporation energy gap down through increasing evaporator economy.

Figure 2 gives an overview of the plant data compared to reconciled data from the GED model. The plant data and reconciled data are easily identified by different colour codes. Where instrumentation was unavailable the GED model effectively provided estimated data for a number of the unmeasured variables such as flash tank vapour pressures and temperatures within the Jamalco facility.

The model-based calculated building KPIs i.e. total evaporation, the steam economy and the average heater overall transfer coefficient (or U-factor) are given in the bottom left of the screens. Through regular on-going support and review of the GED outputs, the development team found that these KPIs, as exemplified in Figure 2 had provided useful information to the end users for rapid decision making.

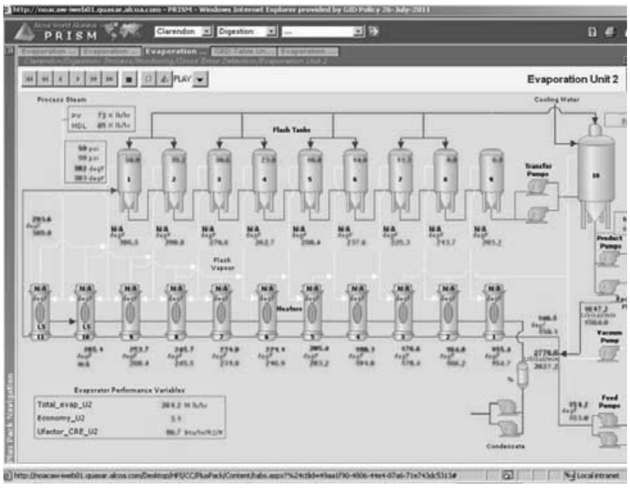

Figure 2. Overview model-based process screen

Figure 3 is a screen that shows the summary of each of the instruments being monitored. The third column is the instrument readings and the forth column is the reconciled readings. The EPS is the extent of instrument errors and is calculated as offset over standard error or instrument reliability. Any instrument gross error detected is represented by the letter 'Y'. In this snapshot clearly the instrument tag DGP.TR_T5_1.PV i.e. heater T5 exit temperature meter was detected as having a gross error because the EPS value significantly exceeded the limit.

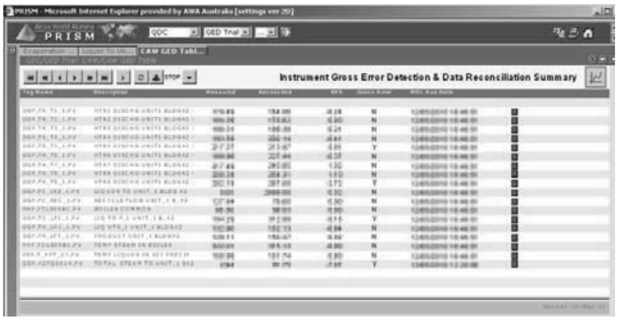

Figure 3. Instruments GED summary

Figure 4 shows the trends of measured and reconciled heater 5 temperature over a period of one month. The screen shows that an initial gap between the measured and reconciled temperature (which was flagged by the system as a gross error) was subsequently closed after corrective actions were taken by the site.

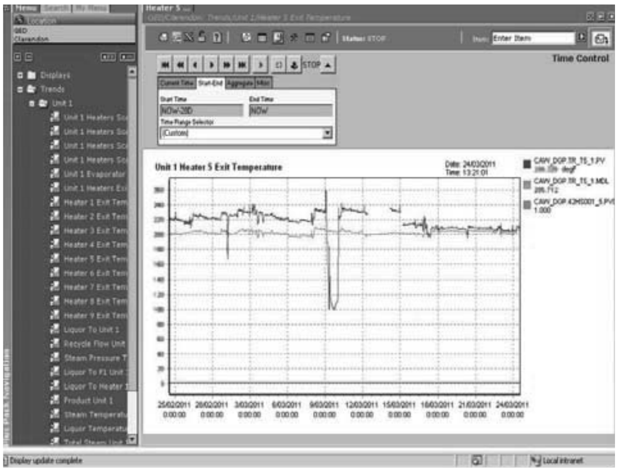

Figure 4. Measured and reconciled heater 5 temperature

5. Conclusions

An online GED system has been successfully deployed to the Jamalco evaporation building. Customised screens for gross errors detection of process instruments problems by the GED system such as exemplified in this paper facilitate rapid troubleshooting. The ability to provide reconciled data such as the evaporation economy and heater U-factor (i.e. building KPIs) on a scheduled basis using a rigorous process model supports rapid decision making and has enabled the end-users to bring the building energy performance closer to its optimal conditions.

6. Acknowledgement

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