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Fault detection for simulated valve faults in a high pressure leaching process

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Abstract: A simulation of a high pressure leaching process in a base metals refinery (BMR) is used to simulate fault conditions for two types of valve faults. The faults were modelled using empirical models fitted to actual process data from Western Platinum Ltd. BMR. The effects of the faults on process performance were determined. Following this, principal component analysis (PCA) was used to determine whether these faults could be detected. It was found that both faults had a significant effect on control performance, and that PCA was able to detect both faults accurately.

Keywords: Fault detection; dynamic modelling; abnormal events

1. INTRODUCTION

The high pressure leaching stage in a base metals refinery is an important step in platinum processing, serving the dual purpose of recovering valuable base metals (copper) and enriching the platinum group metals (PGM) grade. The high pressure leaching stage is a complex process, with numerous factors that affect the performance of the plant, such as: varying feed compositions; complex leaching mechanisms; and multiple control loops. Additionally, faults sometimes occur, such as valve malfunctions, causing degradation of the plant's performance. Accurate detection of such faults is important, since it would allow further diagnosis to direct plant engineers for process recovery steps. Feature extraction techniques for multivariate process monitoring may be applied for detection of these faults. Principal component analysis (PCA) is one such feature extraction technique that has been widely applied for fault detection.

In this paper, a simulation of the high pressure leach is used to simulate valve faults in order to quantify the effects on control performance. PCA and KPCA are then applied to the simulated data to determine whether the valve faults could be accurately detected using these techniques.

This work is organized as follows: section 2 gives an overview of the high pressure leach process and its dynamic model; section 3 describes the valve faults, their simulation as well as impact on control performance; section 4 describes the fault detection methodology; results are presented in section 5 and conclusions made in section 6.

2. OVERVIEW

2.1 Process Description

At Western Platinum Ltd. base metal refinery, the first stage leach residue is mixed with spent electrolyte and formic acid leach filtrate in a second stage slurry preparation tank in preparation for the leaching process (refer to Fig.1). The purpose of the leaching process (referring specifically to the second and third pressure leaching stages) is to dissolve base metals (predominantly copper and nickel sulphides present in the first stage leach residue) while limiting the dissolution of platinum group metals.

The mixed slurry reports to a flash recycle tank where concentrated sulphuric acid and water are occasionally added if the correct slurry mix was not obtained in the upstream preparation tank.

The mixed slurry continues into the first compartment of the second leaching stage via stream 7. The autoclave is operated at a pressure of 550 kPa and temperatures ranging between 125 °C and 140°C (McCulloch et al., 2014). Note that the first three compartments and the fourth compartment of the autoclave make up the second and third leaching stages, respectively. The fourth compartment is connected to the other compartments only by a vapour space, preventing any slurry transfer.

Stream 9 is used to recycle a fraction of the slurry in the first compartment. The recycling of slurry from a high pressure tank to an atmospheric tank causes liquid to flash, which serves as a way to disperse a portion of the heat released from base metal leaching. Stream 8 act as a gas bleed which prevents a build-up of inert gasses.

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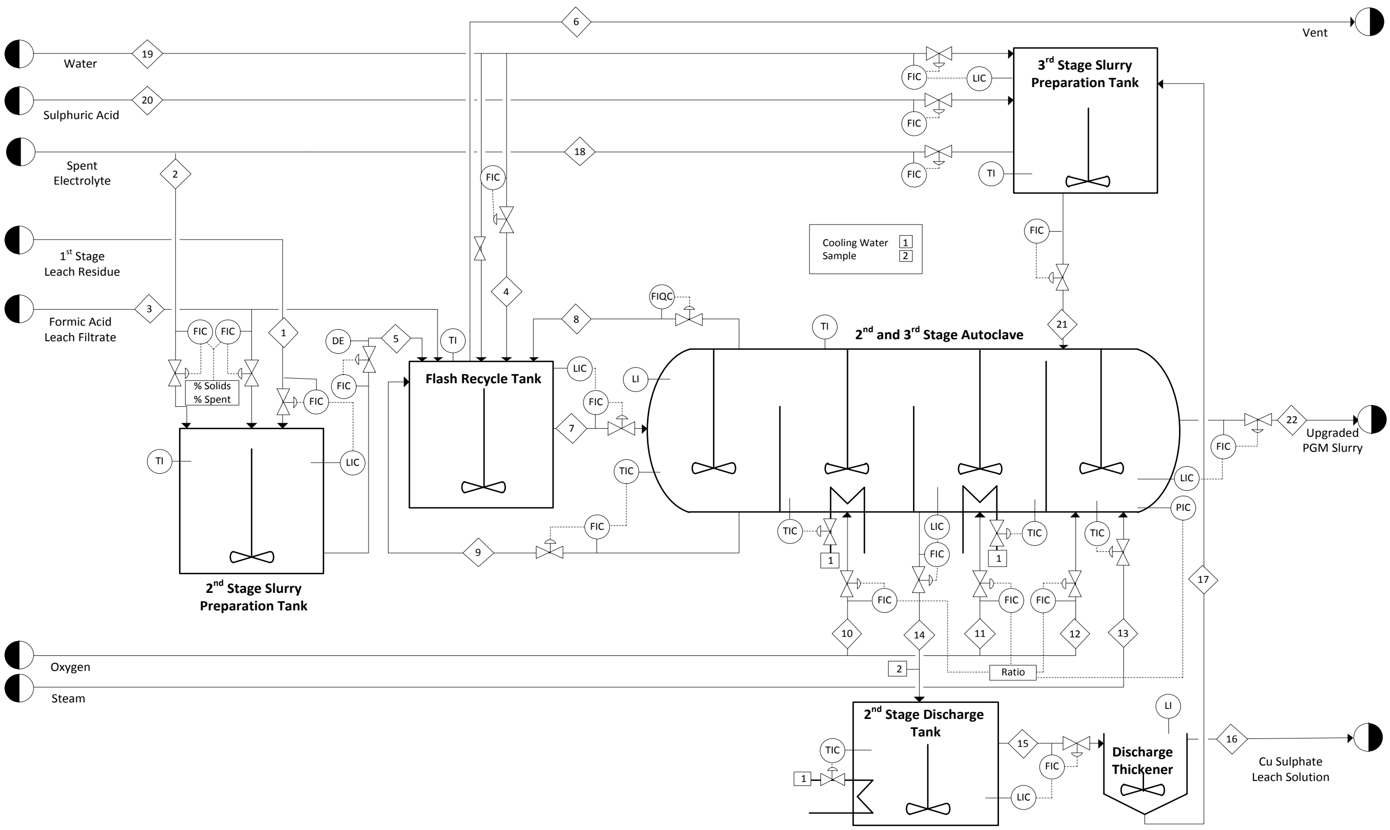

Fig.1. Schematic diagram of the Western Platinum BMR: pressure leaching stages and surrounding process units

The inert gasses, together with flashed water vapour exits the flash recycle tank via stream 6.

Oxygen is added to the second, third and fourth compartment via stream 10, 11 and 12, respectively. Cooling water serves as heat sinks within the second and third compartment, while steam addition via stream 13 serves as a heating source for the fourth compartment.

The slurry overflows from one compartment to another, and is pumped out of the third and final second stage compartment into a discharge tank. Most of the copper sulphide minerals have been leached at this point. The copper in the solid residue is ideally reduced to less than 18 wt% when exiting the second leaching stage.

The second stage discharge thickener increases the solid content of the PGM concentrate by removing copper sulphate leach solution. The leach solution is treated in selenium/tellurium reactors prior to copper electrowinning. The solid residue leaving the discharge thickener via stream 17 is mixed with fresh water, sulphuric acid and spent electrolyte which is then pumped into the third and final leaching stage. The upgraded PGM solid residue exiting the fourth compartment ideally contains less than 3 wt% copper with PGMs upgraded to compositions above 40 wt% (constituting predominantly of platinum).

This PGM slurry is sent for further processing in order to recover individual PGMs.

To give an indication of the data produced by the simulation, some time series trends are plotted in Fig.2.

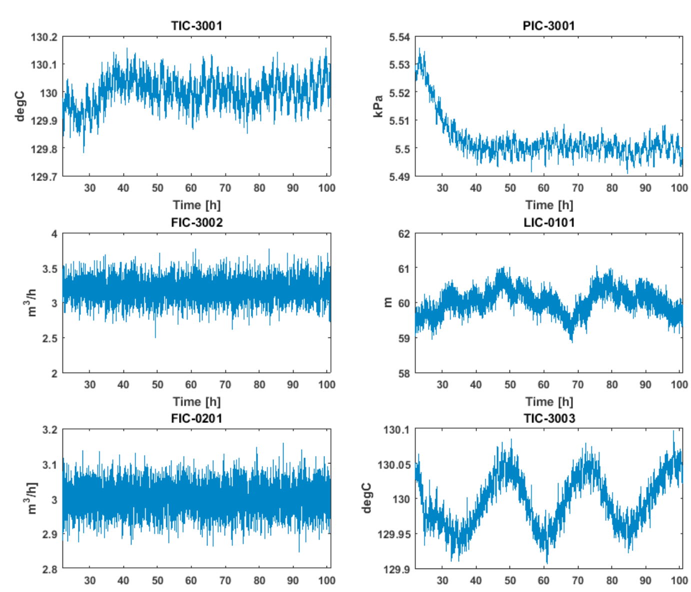

Fig.2. Time series trends of some simulation variables

2.2 Dynamic Process Model Description