

# A COMPLEMENTARY MILLING AND FLOTATION ADVANCED PROCESS CONTROL SYSTEM AT A PLATINUM CONCENTRATOR

Loutjie Coetzee\*, Ashendri Naidoo\*, David Phillipotts\* and Client\*\*

\* Mintek, South Africa, \*\* Platinum Mine, South Africa

## 1. INTRODUCTION

Mintek installed its advanced process control system on both the milling and flotation sections at a platinum concentrator (located on the Western limb of the Bushveld Complex in South Africa). The commissioning took place in 2010 and 2011. The MillStar control suite focussed on stabilising the primary mill feed, mill discharge and the flotation circuit feed. Two layers of the FloatStar advanced control were installed, one layer for flotation cell level stability and another for concentrate flow optimisation.

Performance tests showed that the APC system stabilised the mill feed and mill discharge without violating the circuit's operational constraints. Additionally, the frequency of flotation concentrate sump overflows was markedly decreased and the sump discharge was stabilised.

The most interesting aspect of the control system was the linking of the milling and flotation circuits through a flotation feed density controller. The operation of the mill discharge and classification circuit was adjusted to control the flotation feed density to setpoint.

Performance comparisons indicate that both the MillStar and FloatStar control systems individually improved overall performance of the milling and flotation circuits. The greatest improvement in overall performance, however, was achieved when all the MillStar and FloatStar control modules were simultaneously active. This suggests that the MillStar controllers complement the FloatStar controllers and this integrated approach is most effective in improving the performance of the flotation circuit.

## 2. APPLICATION OF MINTEK ADVANCED CONTROL SYSTEM

For a full description of the plant configuration and original control strategy and details of the advanced control strategy employed, please refer to the published paper by Coetzee *et al.* (2012)

### 2.1. Advanced Process Control

#### 2.1.1. Milling Circuit

The main objectives for the MillStar Advanced Control System were to:

- Stabilise the feed to the primary Merensky mill using MillStar Solids Feed Controller
- Stabilise the discharge end of the primary Merensky mill using StarCS MPC controller.
  - Controlling cyclone feed density to a tight setpoint.
  - Keep sump level stabilised.
  - Keep cyclone feed pressure in normal operating region.

- Actively control the rougher feed density to the required setpoint.

### 2.1.2. Flotation Circuit

The main objectives for the FloatStar Advanced Control System were to:

- Stabilise the flotation levels and ensure fast and accurate setpoint tracking for optimisation using FloatStar Level Stabiliser.
- Stabilise the circulating loads and mass pull using FloatStar Flow Optimiser.
  - Changing air and level setpoints to stabilise concentrate flowrates and therefore mass pull.
  - Stabilise concentrate sump level and maintain it within its limits.

## 3. RESULTS AND DISCUSSION

### 3.1. MillStar Advanced Control System Performance

The performance of the MillStar control system was compared to plant control primarily with regards to stability of the process measured using standard deviations.

Figure 1 shows a comparison of rougher feed density histograms for the MillStar control system and plant control. The MillStar control system was able to effectively control the feed density close to setpoint, with only minor deviations. Under plant control, the rougher feed density was not actively controlled and had greater variations. These variations strongly affected the flotation circuit performance.

The StarCS MPC controller further ensures that important mill discharge variables, such as cyclone feed pressure and sump level, is kept inside their operating limit, see Coetzee *et al.* (2012) for details.

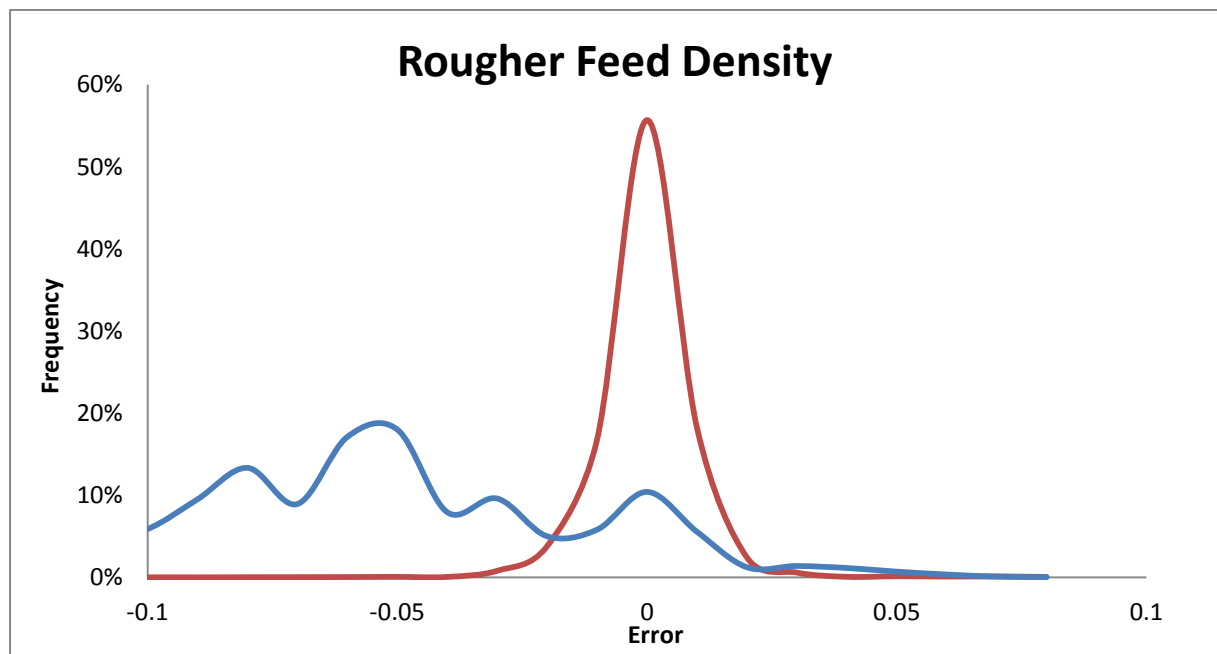


Figure 1: Rougher feed density histogram for MillStar (■) and Plant control (■).

### 3.2. MillStar and FloatStar Combined Control System Performance

After the commissioning of the MillStar system was completed, the performance of the flotation process could be compared under plant control (only using FloatStar Level Stabiliser and manual milling control), FloatStar Level Stabiliser with FloatStar Flow Optimiser and using manual milling control, and finally FloatStar Level Stabiliser with FloatStar Flow Optimiser using MillStar milling control.

The variability of the concentrate flow were reduced with the use of FloatStar Flow Optimiser and showed further improvement when using FloatStar Flow Optimiser in conjunction with MillStar (see Figure 2). An exception is noted on the Primary Low Grade Rougher when the deviation of the flow was slightly higher for the FloatStar Flow Optimiser as compared to the plant control. This is because the FloatStar Flow Optimiser had to frequently cease controlling the flow to setpoint in order to prevent level limits from being breached, and this resulted in reduced time spent outside of the level.

The use of the FloatStar Flow Optimiser significantly reduced the amount of time spent outside of the level upper and lower limits compared to the plant control scheme, see Coetzee et al. (2012) for details.

The reduced variability in the concentrate flowrate to the cleaners provides stability to the downstream circuits where disturbances are recycled between the multiple cleaning stages.

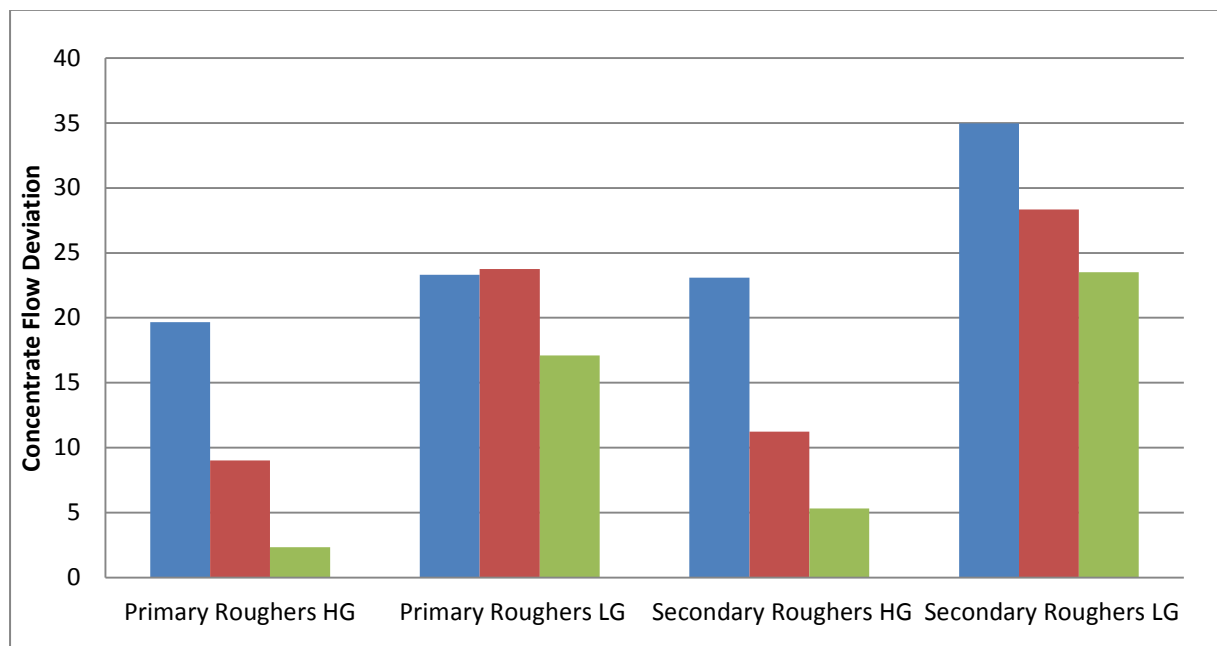


Figure 2: Concentrate Flow Standard Deviation – FloatStar Flow Optimiser Off (■), On (■) and with both FloatStar and MillStar On (■)

## 4. CONCLUSIONS

The MillStar discharge controller was implemented to stabilise the cyclone feed density and the sump level, while keeping the cyclone feed pressure within the required operating band. The result of stabilising the cyclone feed density is a stable cyclone overflow density. This cyclone overflow is fed to the primary rougher feed surge tank. The MillStar control system was successful in improving the stability of cyclone feed pressure, sump level and solids feed rate to the mill even while using constraint limits. The plant control scheme has no constraint

handling capabilities and, therefore, could not ensure that the cyclone feed pressure and sump levels remain within their respective operating and critical limits.

The rougher feed density was found to vary quite severely under plant control. The main cause for the rougher feed density variation was traced to cyclone feed density variations. A cascade controller was implemented between the rougher feed density and the cyclone feed density in order to change the cyclone feed density setpoint that the MillStar discharge controller is tracking in order to keep the rougher feed density at setpoint. The cascade controller is needed to account for any density disturbances coming from the primary cleaner tails. The MillStar control system showed a measurable improvement in rougher feed density stability compared to plant control when controlling density.

The FloatStar control system also showed a measurable improvement in the control of the concentrate flow rates in the flotation circuit and decreased the number of times the sump ran dry or/and overflowed.

The combined MillStar and FloatStar Advanced Control System provides the most benefit in terms of control and variability of concentrate flow rates between the different stages of the flotation circuit. The ability to remain within the level constraints is also maintained. The improved density control and stability emanating from the MillStar control on the primary milling circuit enables the FloatStar Flow Optimiser to work more effectively. The combined MillStar and FloatStar system demonstrates the benefit in approaching the control problems on milling and flotation plants in an integrated manner.

## 5. FULL PAPER

Coetzee, L.C., A. Naidoo, D. Phillpotts and M. Ramonotsi. *A Complementary Milling and Flotation Advanced Process Control System at the Platmin Pilanesberg Platinum Mines Concentrator*. In proceedings of the Precious Metals '12 conference held at the Vineyard Hotel, Cape Town, South Africa from November 12 to 13, 2012.

## 6. REFERENCES

- Alvarez, E. (2005). Advanced Process Control to Meet the Needs of the Metallurgical Industry. *World of Metallurgy*, 123-128.
- Louw, J. J., Hulbert, D. G., Smith, V. C., Singh, A., & Smith, G. C. (2003). Mintek's process control tools for milling and flotation control. *XXII International Mineral Processing Congress*, (pp. 1581-1589). Cape Town.
- Muller, B., Singh, A., Van der Spuy, D. V., & Smith, V. C. (2003). Model Predictive Control in the Minerals Processing Industry. *XXII International Mineral Processing Congress*, (pp. 1692-1702). Cape Town.
- Qin, S. J., & Badgwell, T. A. (2003). A survey of industrial model predictive control technology. *Control Engineering Practice*, 733-764.
- Ramasamy, M., Narayanan, S. S., & Rao, C. D. (2005). Control of ball mill grinding circuit using model predictive control scheme. *Journal of Process control* 15, 273 -283.
- Shean, B. J., & Cilliers, J. J. (2011). A review of froth control. *International Journal Of Mineral Processing*(100), 57-71.