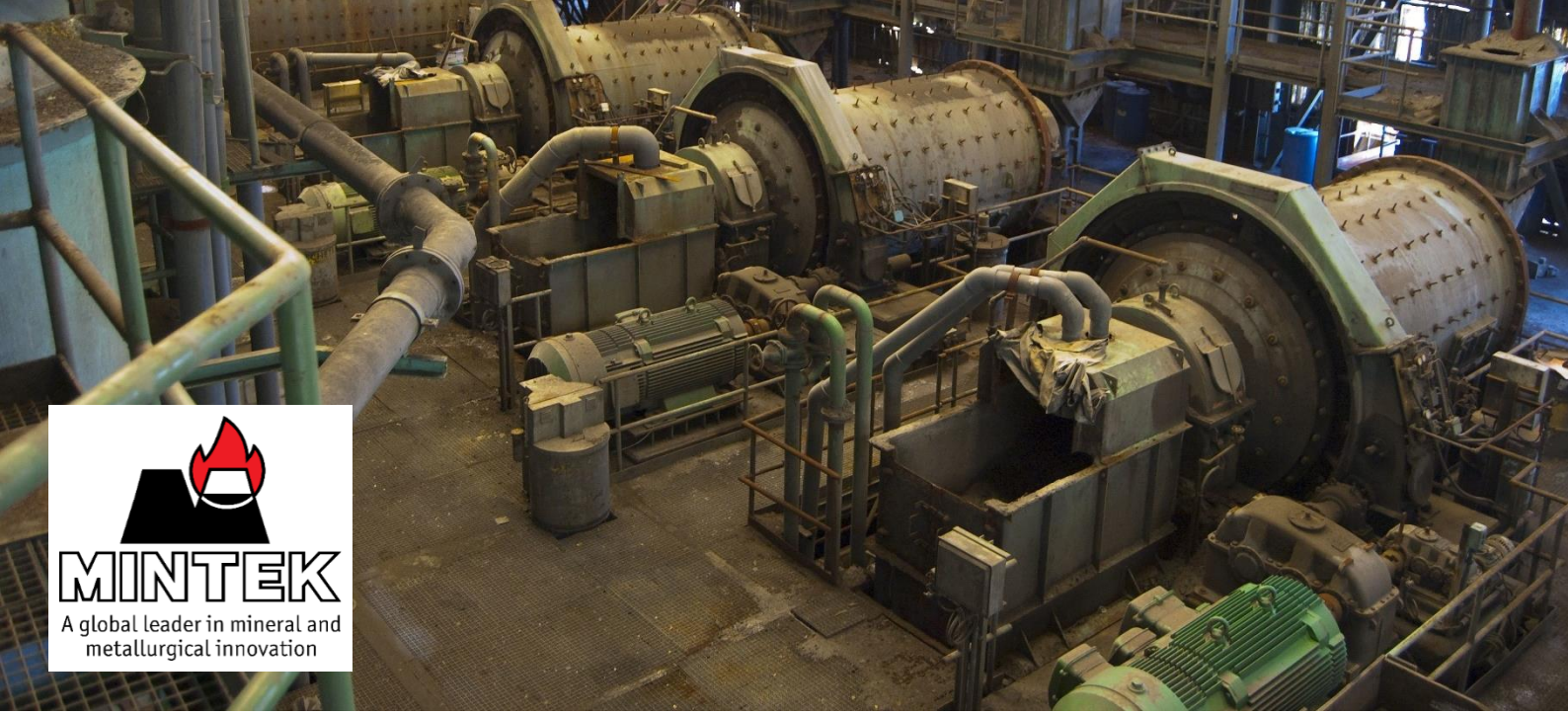


MillStar Mill Load Control

Mintek has applied advanced process control and optimisation techniques to improve the metallurgical performance of a copper concentrator in Zambia.

This case study will focus on the **MillStar control system** on the plant's milling circuit. The use of advanced process control on the milling circuit is intended to assist the FloatStar controllers in improving the performance of the flotation circuit.

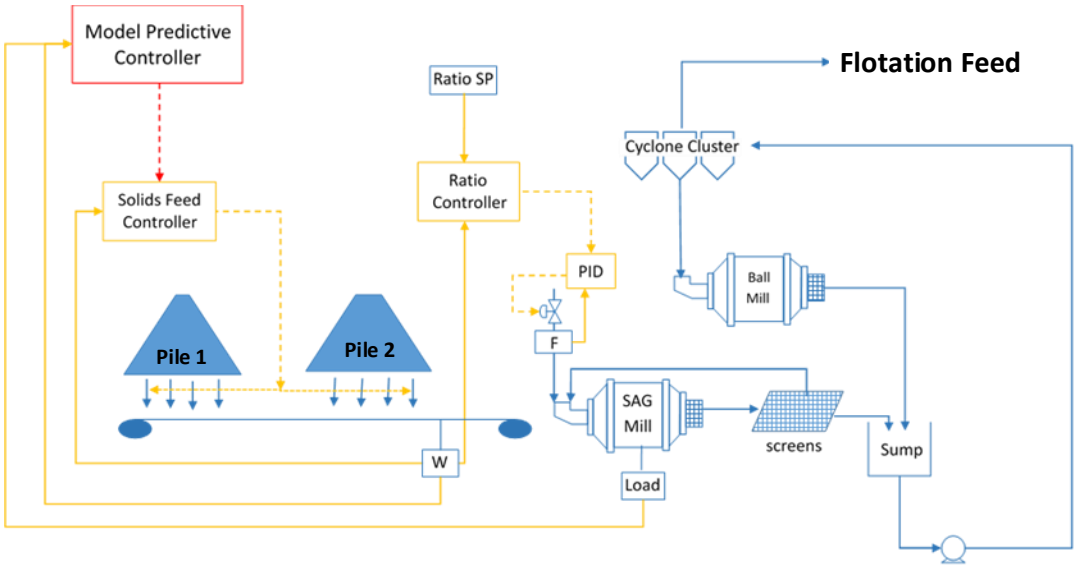
Control System Objectives

The following objectives for the stabilisation of this milling circuit were set in conjunction with plant metallurgists:

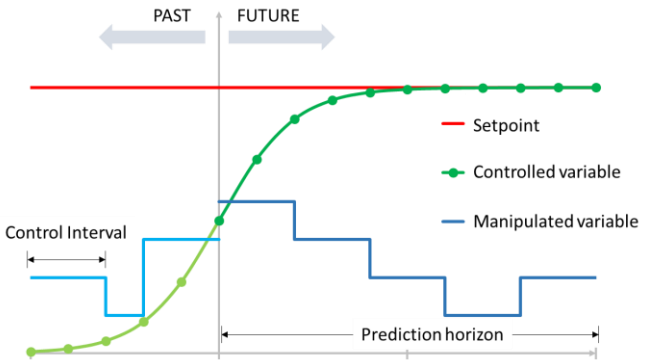
- Stabilise the solids feed to the SAG mill
- Control the ratio of solids-to-water in the SAG mill
- Control the SAG mill load - specifically:
    - Eliminate instances of mill overloading and mill under loading
    - Reduce manual interventions of the operators trying to control the mill load

Control System Design

The diagram below shows the circuit layout together with the MillStar controllers that were implemented on the circuit:



The MillStar control system includes a Ratio Controller for control of solids-to-liquids ratio in the mill; Solids Feed Controller for stabilising the feedrate to the mill; and the **Model Predictive Controller (MPC)** for control of mill load.



Mintek's MillStar MPC is a versatile tool that controls a process based on mathematical relationships between process variables (e.g. level, pressure) and actuators (e.g. valve position, pump speed). An objective function is formulated based on the dynamic response that is desired from the process, whether it be minimising the movement of certain actuators, setpoint tracking of specific process variables, keeping them within limits or a combination.

The model-based controller solves this optimisation problem in order to determine the movements of the manipulated variables to achieve the desired process response. This formulation enables it to overcome obstacles such as the interaction between process variables, and having an unequal number of manipulated and controlled variables.

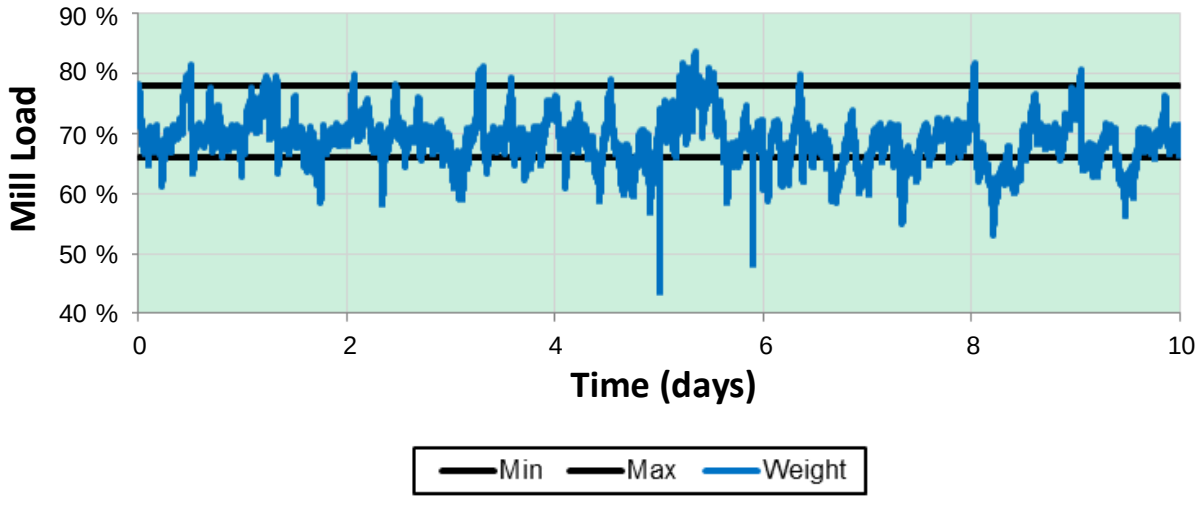
Here, the MillStar MPC uses a model of the plant to control the primary SAG mill weight to ensure it does not exceed a given upper limit (**mill over-loading**) or lower limit (**under-loading**):

- Mill over-loading results in losses in milling efficiencies
- Under-loading causes accelerated wear and damages to the mill liners and lifters.
- Uncontrolled mill load also requires continuous ore blending at the feeders.

To address the over- and under-loading, the Mintek MPC uses a plant model to predict the mill weight changes and then sets the mill speed as well as the recommended solids feedrate for the MillStar Solids Feed controller.

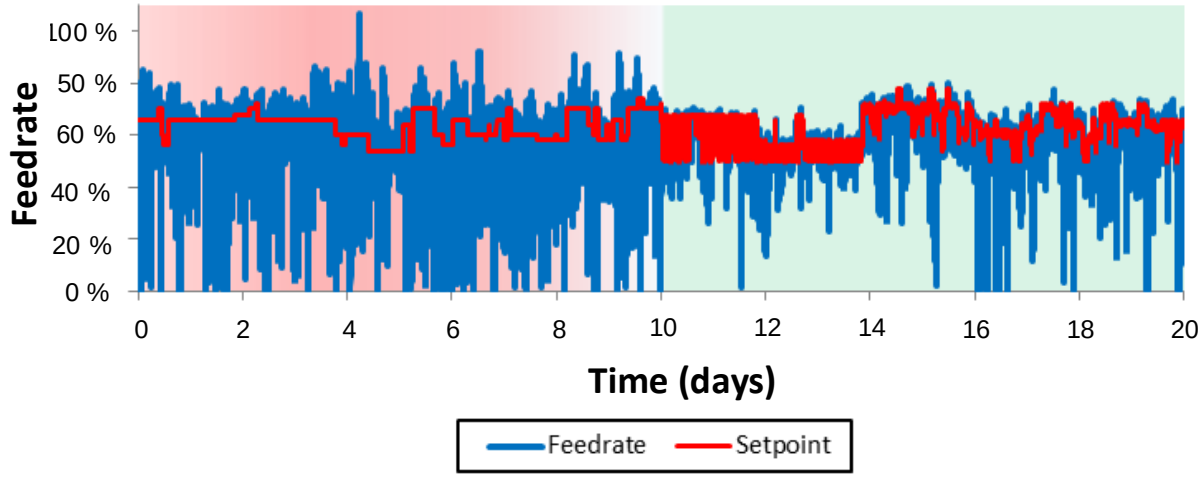
Results

The figure below shows an example of the load control in action. There are **very few instances of mill overloading** (i.e., a load of above 78 %) recorded when MPC controller is on and in all those instances, the overload was **corrected quickly**. MPC also keeps instances of mill **under-loading** (a load of below 66 %) to the **minimum** by reducing the mill speed to the allowed minimum speed while **maximising the solids feedrate**. Instances of under-loading shown on the trend are beyond the scope of the controller as they are caused by operational conditions like tripped conveyor belts.



The MillStar MPC is able to achieve this while **eliminating the need to switch off the individual feeders**, which helps maintain a **higher feed to the mill** by eliminating periods of no feed. It also achieves this by using both the mill speed and the feedrate to control the mill weight - considering **all** the variables and their interactions as opposed to the previous controllers that acted independently of one another.

Illustrating this, the image below provides an indication of the solids feedrate over a period of 20 days: 10 days with MillStar control off and then 10 days of MillStar control on. This trend highlights the **reduced variation of feedrate** over the 10 days that the MillStar control was on.



The MillStar MPC controller allows the process to **run for longer periods without any interruptions** in terms of switching off the feeders to bring the weight under control. These interruptions occur far more frequently when MillStar control is off as shown by the frequent drops in feedrate. This creates many instabilities on the circuit while also requiring continuous operator intervention. **Freeing the operators** from these routine interventions allows them to **add value to the process through higher level activities**.

MillStar was able to improve the average throughput by stabilising the milling circuit by improving the load control and reducing the need for feed cuts. **This resulted in a throughput improvement of 4.4 %.**

A key advantage of being able to control the mill load within the set bounds is in stabilising the feed to the mill thus providing an **opportunity to optimise the throughput**. Future work will include Real Time Optimisation that will automatically optimise the throughput by operating closer to process and operational constraints.

This white paper has been brought to you by Mintek. Feel free to pose any questions you might have to MillStar@Mintek.co.za. To connect with Mintek Process Control experts on LinkedIn, click here.