aa

25% Increase in a mines throughput ($25M)

+61 (0)467637130 info@blankpaperinternational.com

OVERVIEW

An underground mining operation had been struggling with their Six Sigma program. The program had been underway for about 12 months and for various reasons had struggled to gain traction. 12 projects had been selected and were progressing at various paces. In mining, tons is king and this mine was no different – maximise throughput safely over all other objectives. We know that not all improvement projects are created equal. Projects run on non-bottleneck operations will not increase throughput. The business had identified 4 projects that focused on the bottleneck, with the remaining projects in other areas of the business. The key project on the process bottleneck was the 'SAG' mill project.
In this case study we'll focus on how we used Designed Experiments (DOE) to achieve the throughput increase. Designed Experiments are a key tool (see our Process Improvement Toolbox), used to improve processes and can be used both in operational projects and occasionally in transactional projects. This case study will not detail every step that was completed on the project.

THE CONTEXT AND CHALLENGE

The Sag mill in question is essentially a large rotating drum, approximately 10 metres in diameter, and 7 metres in depth. Crushed Ore is fed into the centre of the rotating drum, and subsequently drops to the outside of the Drum. The SAG mill drum has several tons of Iron Balls (each about 100mm in diameter) in the centre of the barrel, that are lifted up as the drum rotates and then as the ball gets over the 90 degree point the balls drop onto the Ore at the bottom of the drum, crushing the ore. Once the crushed ore is crushed to a small enough size, it flows out of the SAG mill and onto the next step in the process. The SAG mill was controlled from a control room which was continuously manned.

FINDINGS

Initially we started by confirming that the Sag Mill operation was in fact the bottleneck of the process. Once confirmed that we were working on the correct process step we moved to mapping the process.
We mapped the process by walking the process to witness its operation for ourselves. During this visit to the 'Gemba' (the place where the work is done), we were able to talk to the operators, trying to build a practical understanding how the SAG mill was operated. Gemba visits showed that the control room operators each operated the Mill in a different way and usually the the first thing an oncoming shift would do was alter the control settings used by the previous shift.

We had formed an improvement team, which verified the process map and helped to develop a cause and effect diagram to identify all of the potential reasons we were unable to hit the target

+61 (0)467637130 info@blankpaperinternational.com

throughput rates. One of the potential reasons for low throughput was the lower than optimum volume of Balls (called Ball Charge) in the SAG mill -the more balls in the mill, the more crushing the mill should achieve. This would turn out to be the critical factor in determining Mill throughput.

Designed Experiment: It was then decided that we needed to run a designed experiment. Why was this deemed necessary? A Designed Experiment (called DOE) is a set of trials that are run in a controlled manner. The SAG Mill settings are changed, run up to stable state and then the resulting impact on the process output can be reviewed. One of the advantages of a DOE is that the factors can be changed all at once and we can work out the impact of each factor on the output. Without DOE we would have had to resort to making small changes to each input factor one at a time -much slower than Designed Experiments.

We are also not limited to only measuring one output, we can have multiple outputs. A DOE is a planned experiment, with the DOE being run on real time data versus a regression model that uses historical data. We had previously applied a regression model to the data but the process exhibited a great deal of noise and the results were meaningless. The other benefit of DOE is that you do not need to have much knowledge of the process. You do need to ensure that you have chosen the correct factors; hence why you need to involve operators who understand the process.

We ran what is called a full factorial experiment, meaning a full combination of input changes would be trailed; in our case 16 combinations of input settings.
Running our DOE: The Control Room operators understood how to change the variables but not the mathematical relationship between the settings of the Inputs and throughput. This is where DOE are a fantastic tool. You don't need to understand much about the process. When we made a change in the SAG mill input settings it took up to two hours for the output to stabilise. It took approximately 30 hours to complete our DOE.

THE SOLUTION

The following solutions were implemented; Automation of the testing operation, the software was updated to the latest version which resulted in lower cycle times, new Printed Circuit Board's used to reduce defect rates, new microphones used with lower defect rates, and missing printer codes rectified.

THE RESULTS

We ran the experiment, collecting data, and analysing that data. The DOE outcomes were:

- A mathematical model predicting SAG mill throughput rates based on input settings.
- Optimised input factor setting that would maximise Mill throughput and minimise variation.
- Determined the relative importance of each of the input factors.
- Increased throughput by 26% for a four hour period.
- Provided inputs into new Standard Operating Procedures.
- Moved the process bottleneck to another step in the process.
-

There is no doubt that a Designed Experiment is one of the best tools in the business improvement professionals toolbox. If you can run a DOE then successful results are almost a certainty.