Mt Bundey Quarry
Crusher Optimisation Project 2016

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Project Background

The Plant:

- The Mt Bundey crushing plant was built and commissioned in 2009.
- It includes a C110 jaw; GP200S secondary crusher; GP300 tertiary crusher and a Rotopactor Barmac.
- The GP200 and GP300 are in closed circuit with a 20x8' Terex screen
- -22mm + 4.75mm aggregate feeds the Barmac, which is then fed to a FCR stacker or aggregates screening section
- The plated capacity of the plant is 200t/hr

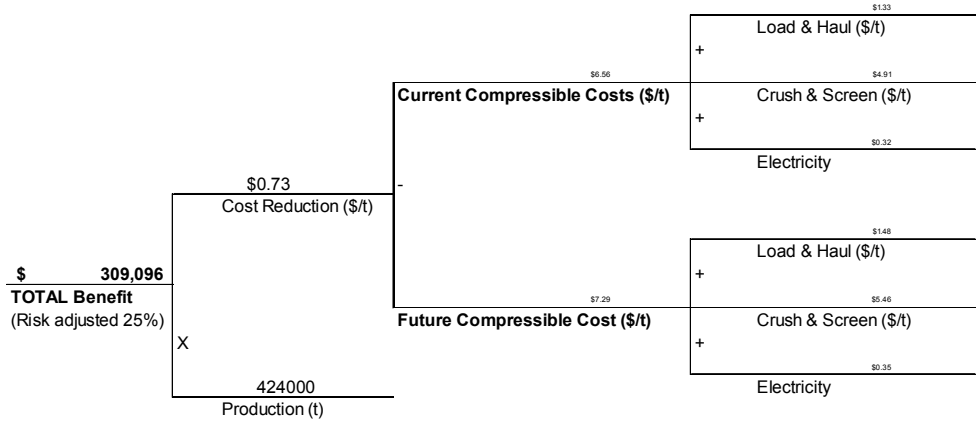
Background:

- Mt Bundey secured supply of quarry materials to the Ichthys Onshore LNG Project (INPEX) in 2012. Supply rates were demanding, peaking at 100,000t/month, with the site having previously produced at most 30,000t.
- Considerable CIP work on the plant was undertaken in 2012-2015, which was optimised to 278t/hr (FCR) and 262t/hr (aggregates). This increased production to >45kt/month normal hours, and allowed the site to flex to meet demand using night shift.
- Whilst the prior CIP work allowed the plant to exceed plated capacity, site personnel recognised that further improvement in throughput would reduce production costs.
- CIP opportunities were identified in regards to belt capacity; automation sequencing; crushing circuit optimisation; and screen efficiency. Of these, crushing circuit optimisation offered the greatest opportunity.

Scope & Objectives

Scope:

- The objective was to achieve a 10% improvement in average plant throughput by optimising the crushing circuit:
    - Increase FCR throughput from 278t/hr to 306t/hr
    - Increase aggregate throughput from 262t/hr to 288t/hr
- It was estimated that a 10% improvement in production would reduce costs by >$309k/annum
- The project aimed to diagnose bottlenecks from July-December 2015
- Whilst minor works could be incrementally completed during the diagnostic phase, major works would be complete during the Christmas.



tph increase	27.8
current rate	278
% increase	10.0%

Example driver tree used to determine cost savings.
The aim was to reduce compressible costs by reducing required crushing hours.

Diagnosis

Diagnostic Phase:

- Diagnosis of plant bottlenecks was undertaken through a series of team CIP sessions as well as beltweigher trace analysis
- Two main bottlenecks were identified within the overall crushing circuit:

1. Barmac Capacity
   - The Barmac capacity was limited to 200t/hr, limiting FCR throughput
   - Excessive bypass of the Barmac affected seal aggregate shape
   - Surges in t/hr rate regularly caused the Barmac to trip out or overflow
2. Crushing capacity of the closed secondary/tertiary crushing circuit
   - The closed circuit was restricted to <280t/hr without overflowing the secondary or tertiary crushers
   - The GP300 bottleneck caused the primary crushed rock to be turned on/off by the automated plant, resulting in inconsistent overall throughput rates

Increase Barmac Capacity

During the diagnosis phase, a number of options to improve Barmac throughput were discussed at a site level, and in consultation with Metso personnel. A summary of these options is included below

Option	Cost	Risk	Decision
Install twin drive Barmac (disused at another Boral Quarry)	>$150k for civils and electrical	Site at peak electrical draw	Cost and risk prohibitive
Increase bypass on Barmac for FCR	**$15k for modified chutes**	**May not eliminate overloading during surges**	**Approved – in parallel with other ideas**
Convert to a deep rotor Barmac	>$150k for civils and electrical	Site at peak electrical draw	No – Cost and risk prohibitive
Increase height of chamber by installing a rolled steel lip	$10-15k	May not eliminate overloading, but would be reversible	On hold – pending other projects
Build a new lid; raise its height; and install doors to cascade material	**$15k**	**May not eliminate overloading, but would be reversible**	**Approved – in parallel with other ideas**

The new chute and lid were built in November 2015. They were installed in just two days during the planned Christmas shutdown. They were completed on time at a total cost <$25k.

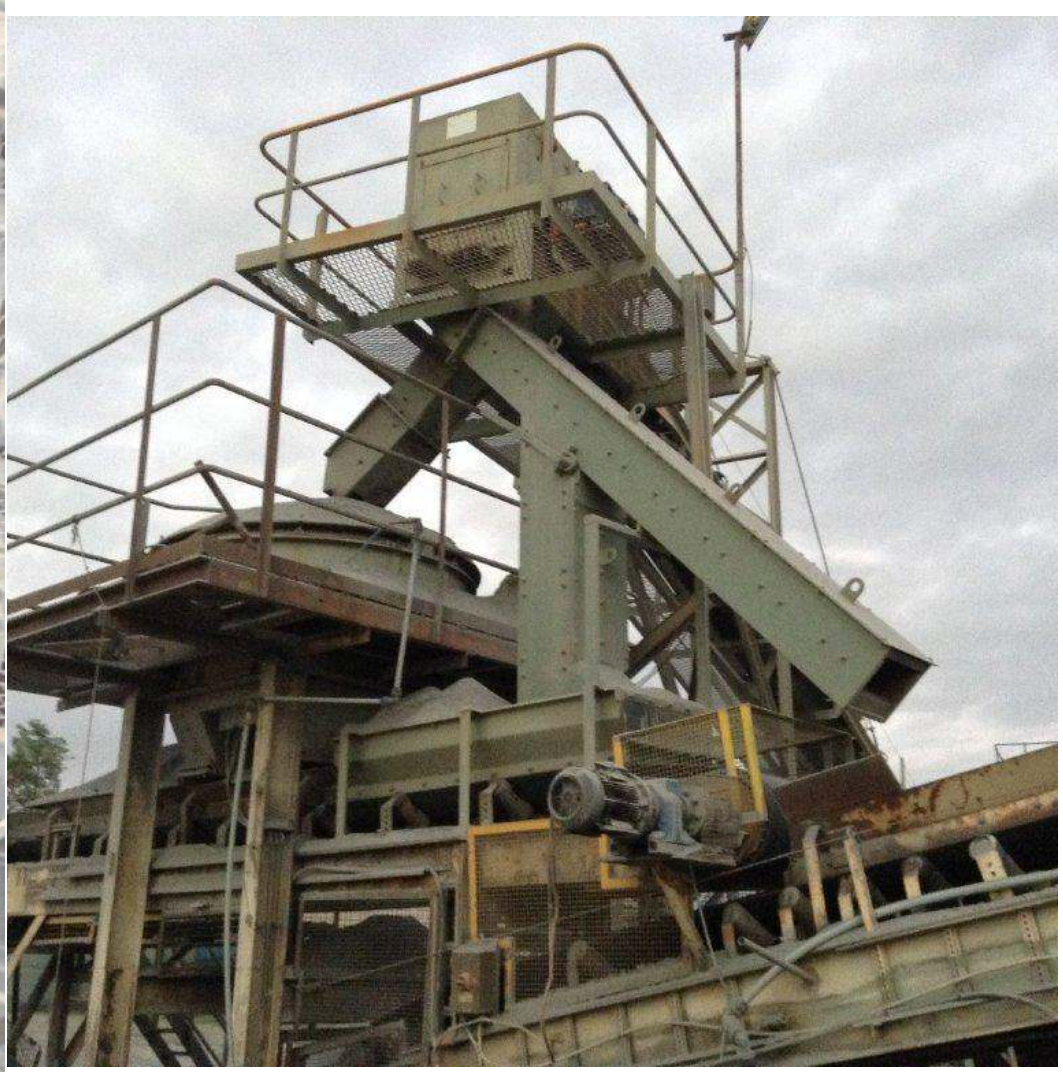
Relieve load to Barmac

In addition to the planned increases to the Barmac throughput, site personnel investigated options to reduce the load on the Barmac. Two ideas were identified as follows:

1. Split the chute on the bottom deck of the control screen, and install a hydraulic bypass, to allow FCR to be scalped out prior to the Barmac:
    - The control screen normally scalps out -4.75mm, fed -22mm +4.75mm crusher run to the Barmac, and returned +22mm to the closed crushing circuit
    - The -4.75mm normally falls into a sump, and was fed out on the dust belt
    - The chute feeding the -22mm +4.75mm onto CV6 was cut vertically in half; allowing one half to be converted into a downward opening door controlled by hydraulics

2. Design a new chute system to allow product to be split between aggregate and FCR regimen at the same time:
    - The changes to control screen configuration were designed to improve FCR rates, however did not address surges in productivity to the Barmac on aggregates mode
    - A new chute system was designed to allow bypass of product which was diverted to the FCR belt, allowing all aggregates to be passed through the Barmac to improve shape

Photos showing new Barmac lid, and new chute systems designed, built and installed in-house.



Optimise cone crusher performance

Change feed size and stroke settings:

- It was identified in July 2015 that improvements in productivity from Barmac improvements would cause the closed crushing circuit to become the new bottleneck
- In consultation with Metso personnel, a plan was developed to optimise feed size and stroke settings

1. Increase GP300 stroke from 25mm to 32mm:
    - A full OEM inspection of the GP300 was undertaken in July 2015, including replacement of bushes to ensure the crusher was fully to OEM spec
    - The feed size was reduced slightly (45mm top size down to 38mm top size) to reduce some loading on the GP300
    - The increase in stroke was intended to increase throughput of the tertiary section, moving the (likely) bottleneck to the GP200 secondary crusher once the planned improvements took effect
    - The changes to the stroke setting in July 2015 demonstrated strong commitment to the CIP objectives, which would be mostly achieved following the December 2015 shut down

2. Increase GP200 stroke settings from 25mm to 32mm:
    - During the July 2016 OEM inspections, it was predicted that the changes to the GP300 stroke settings would likely allow a future increase to the GP200 stroke to further improve productivity
    - In order to ensure the integrity of the crusher, it was determined that the most suitable approach was to complete a repair to the tapers on the mainframe. This was done by building it up in a local workshop and machining it back to OEM spec over Christmas (as it was showing signs of weak).
    - An in-situ rebuild was planned for Mach 2016, and new bushes etc were ordered
    - The productivity of the plant was monitored from August 2015 to February 2016, confirming the stroke of the GP200 would be effective. The stroke was changed during a 6 monthly OEM inspection in March 16.

The opportunity to increase GP200 stroke was identified in July 2015, and systematic steps were taken to achieve successful completion in March 16.

Automate the jaw

The Mt Bundey plant was automated except for the primary jaw crusher. As a result of the 2012-2015 improvements in production rate, it was determined by site personnel that the manual control of the primary section created unwanted surges in production through the remainder of the plant. As a result, site personnel developed an option to automate the jaw:

- Sensor options and performance were discussed and supplied by Metso
- Site personnel discussed automation settings with local electrical/automation contractors, who programmed the existing Cicect system in December 2015
- The changes to the automation resulted in several teething issues which were systematically corrected in February-March 2016.

Project execution

All projects were completed sequentially as planned:

1. Increase GP300 stroke (July 2015) and monitor until March 2016. Cost $0 (completed during routine strip and inspect)
2. Install and raise new Barmac lid and bypass chute. Completed during planned Christmas shutdown. Cost <$25k
3. Modify gates in control screen to relieve load to Barmac. Completed during planned Christmas shutdown. Cost <$10k
4. Install new chutes in Barmac section to allow FCR and aggregates to be produced at once. Completed during planned Christmas shutdown. Cost <$15k
5. Automate the jaw. Completed during planned Christmas shutdown. Cost <$10k (including ongoing improvement once implemented)
6. Increase stroke of GP200. Completed in March 2016. Cost $0 (completed during routine strip and inspect)

Total cost $60k

The team

The CIP projects were managed as follows:

Team member	Position	Role in CIP
Phillip Pallisier	Quarry manager	• Lead ideas workshops • Develop business case • Plan and project manage implementation • Monitor and report on results
Andrew Parrotta	Quarry Supervisor	• Heavy participation in ideas workshops • Liaise with contractors and employees to execute projects
Site personnel	Operators	• Generate ideas (all ideas generated at site level) • Assist with implementation
Metso	Metso functional experts	• Technical review and advice • Oversee inspections • Change stroke settings and adjust ic50
Travis Potts	General Manager	• Review and approve CIP projects • Budget Christmas shutdown

Results. The projects achieved improvements of 23% for aggregates and 33% for FCR. The result is currently tracking at a benefit exceeding $500k/annum.

Regimen	Initial	Target	Result	Improvement
Aggs	262t/hr	288/hr	322t/hr	60t/hr (23%)
FCR	278t/hr	306t/h	369t/hr	91t/hr (33%)