SAIMM
Realising the Productivity Potential of Joy Continuous Miners in Underground South African Coal Mines

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Mining Productivity Consultant.
Joy Global: Who We Are

The leading supplier of advanced equipment, systems and direct services for the global mining industry.

Vision
To be a world-class service company delivering the most reliable and productive products, systems and solutions that solve mining’s toughest challenges.

Mission
To partner directly with customers to enable them to achieve zero harm, the highest production and the lowest lifecycle cost for their mining operations, while making every customer a reference.

Values
Integrity
Respect
Diversity
Teamwork
Reliability
Performance

World-class
People
Service
Products
Financials
Processes

Operating Beliefs
Socially & Environmentally Responsible
Uncompromising Quality
Zero Harm Mentality
Maximizing Operating Leverage
Focus on Customers
Leading Innovation
Strategies: Creating Competitive Advantage

Direct Service

Consistent global world-class components, processes, methods, and metrics throughout the global network with the ability to rapidly customize locally

JBS Operational Excellence™

Zero Harm • Velocity • Productivity • Quality • References

Innovations Creating Growth

China and High Growth Markets

LCM • Consumables • JoySmart™ Services

Hard Rock Mining Systems

World-Class COE’s

Lead with Service

$8B Market

$2B Market

JoySmart Solutions

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Continuous Miner Cutting Cycle Simulations
(In development)

Total Tonnes Cut: 18.00
Total Tonnes Loaded: 18.00
Cycle Time (sec): 65
Loading Time (sec): 56
Room and Pillar Development
Continuous Miner Cutting
All Joy Continuous Miners are created equal – Yet many CMs under perform against their design potential (why such variability)?

Joy Smart Solutions enables us to unlock the potential
The Magic Formula

Production Time
(Shift Utilisation & Equipment Utilisation) \times
Production Rate
(CM tune-up & Operator Performance) =
Production Tonnes
Key Deliverables from JoySmart Solutions

- **Highest Production**
  Benchmarking Equipment and Operator Performance and ‘closing the gaps’
  Improving Time Management and Operating Discipline
  Reducing Downtime and Waste – Early Detection and Improving Operating and Maintenance Practices

- **Lowest Operating Costs**
  Increased Efficiency and LCM

- **Improving Safety**

'**Making each Section Our Reference**'
Continuous Miner – ‘Prime Mover and Bottleneck’

1 Sump → 1 Shear → 1 Shuttlecar
Continuous Miner Cutting Cycle – Tune-Up Optimisation

Cutter Amp Feedback Settings
- Control Sump Speed
- Control Shear down rate

Conveyor Amp Feedback Settings
- Control Shear Down Rate

Variable Frequency Drive Traction
Continuous Miner Cutting Cycle Profiles – Real Time Simulation Analysis

幄

-shift hour 8
- 25,200 - 28,800 s
- cutting height
- max 5.0 metres

-cycle 104
-cycle 105
-cycle 106
-cycle 107

-legend
- cutting height
- cutter amps (avg)
- lh tram amps
- rh tram amps
- conveyor amps

-bunkered tons
-load conveyor on time
-load tons
-fill factor %

-tram time
-away time
-cycle time
Example - Section Productivity - Key Performance Indicators

**Production Time & Production Rate**
- Production Rate (blue line)
- Production Time (red line)

**Continuous Miner Cutting Rate**
- Cutting Rate (purple line)

**CM Downtime**
- Down Time Hours (line graph)

**Load and Away Time**
- Load Time (blue line)
- Away Time (orange line)

**Shuttlecar Fill Factor**
- Fill Factor (%)

**CM Relocation Time**
- Per Relocation Time mins (line graph)

**KPI Tracking of Core Mining Processes**
As visible in the Boxplot comparison it is clear to see the focus with the Operator coaching’s from Mining Specialist the improvement for all three shift Operators.

- A – Shift sustained the load quantity within 1% with an average load time of 70 seconds
- B – Shift decreased the load quantity by 25% whilst decreasing load time from 75 to 64 seconds
- C – Shift increased the load quantity with 23% and decreased his average load time from 83 to 69 seconds
So What is in the JoySmart Solutions Tool Box
Visual Aide to repeating ‘Perfect Cutting Cycle’

A Production Timing Indication Light (PTIL) is a system for continuous miners that will interact, through visual feedback, with the shuttle car and CM operators.

It gives indications to the operators by using different signs:

✓ When correct sump depth has been reached
✓ When shuttle car should be full
✓ When the next shuttle car should be behind the miner

Thus creating cutting rhythm and consistent cycle tempo

1 Sump → 1Shear → 1Shuttlecar
Production Timing Indication Light (PTIL)

- The production timing indication light (PTIL) provides a visual indication to the operator, with regards to the time it takes to sump and load a shuttle car as well as the shuttle car away time.
- The PTIL will be set according to cutting conditions per section, thus settings will differ from section to section.
- The Production Timing Indication Light indicators are shown as Continuous Miners and Shuttle Cars.

On Board Display, improves cutting cycle accuracy and process tempo.
In-Section Audits; Productivity Analysis and Coaching

Section Layout and Set-Up

Cutting Sequence For 8 Road Section Splitting In R2

<table>
<thead>
<tr>
<th>L4</th>
<th>L3</th>
<th>L2</th>
<th>L1</th>
<th>BR</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>23</td>
<td>22</td>
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<td>14</td>
<td>13</td>
<td>12</td>
<td>11</td>
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</tbody>
</table>

Shuttle Cars Used: 3
Anchor Points: In Order
Changeout Points: In order
Distance to Tip: LTR 2 Splits in front of tip, 75m
CM cable not suspended in LTR from R1 to L2

Embedded Mining Experts – Coaching and Best Practice Knowledge Transfer

Relentless pursuit of the BASICS

An extract the detailed section evaluation report
Optimise Complete Value Stream

- Monitor the operating environment
  - Additional sensors
  - System Modelling and Simulation
- Monitor operator effectiveness
- Mining sequence and routes
  - Future section mapping (Wi-Fi)
- Manage out bye factors
- Bolting constraints

Monitoring the full value stream - an integrated approach
Joy Connect: KPIs & Time Management

Time Distribution Graph

Shuttle Car Shift Analysis

<table>
<thead>
<tr>
<th>Car</th>
<th>Target Start</th>
<th>First Activity</th>
<th>Last Activity</th>
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<tbody>
<tr>
<td>SC 257</td>
<td>09:30</td>
<td>09:40</td>
<td>10:00</td>
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<tr>
<td>SC 258</td>
<td>09:30</td>
<td>09:40</td>
<td>10:00</td>
</tr>
<tr>
<td>SC 259</td>
<td>09:30</td>
<td>09:40</td>
<td>10:00</td>
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</table>

Fill Factor %: 85.5%

Roof Roller Shift Analysis

<table>
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<th>Roller</th>
<th>Target Start</th>
<th>First Activity</th>
<th>Last Activity</th>
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<tr>
<td>HR1</td>
<td>09:30</td>
<td>09:40</td>
<td>10:00</td>
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</table>

Average TMS Cycle Time: 8.68 minutes

Feeder Breaker Shift Analysis

<table>
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<th>Target Start</th>
<th>First Activity</th>
<th>Last Activity</th>
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<tr>
<td>HR1</td>
<td>09:30</td>
<td>09:40</td>
<td>10:00</td>
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</tbody>
</table>

Closing Time

Cycle Time: 04:54

JoySmart Solutions
Real Time Shift Report

- ..\Documents\Data\JoySmart Solutions\ShiftProgression.ppsx

Real Time Visual Data – Empowering Short Term Decision Makers
Cutting Cycle Analysis – Operator Interventions

- Mining experts examined cutting cycle and developed a method to break up cutting cycle in order to compare operators/shifts.

**Example of a Miner Operator Cutting Profile**

Re-playing CM Operator Practices – Coaching Tools to Best Practice
Cutting Cycle Analysis

Fair Correlation to Consistent cutting cycle.

- **TOTAL SHIFT CUTTING CYCLES:** 83
- **INCOMPLETE / NON CUTTING CYCLES:** 38
- **AVERAGE CUTTING CYCLE TIME:** 70.55 s
- **PLUS EXTRA CLEAN UP TIME:** 75.10 s

<table>
<thead>
<tr>
<th>MOVE</th>
<th>SUMP</th>
<th>SHEAR</th>
<th>C/UP</th>
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</thead>
<tbody>
<tr>
<td>22.25 s</td>
<td>20.12 s</td>
<td>28.18 s</td>
<td>4.55 s</td>
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</table>
AMC - Productivity Improvement Potential

The Move to Zero Defects

Base case Manual Operator

Auto Cycle Profile

<table>
<thead>
<tr>
<th></th>
<th>Cutting Height</th>
<th>Cutting Amps</th>
<th>Conveyor Amps</th>
<th>Traction Amps</th>
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</thead>
<tbody>
<tr>
<td>Cycle Time</td>
<td>84</td>
<td>78</td>
<td>21</td>
<td>25</td>
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<tr>
<td>Sump Time</td>
<td>21</td>
<td>25</td>
<td>25</td>
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<td>Shear Time</td>
<td>30</td>
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<tr>
<td>Load Time</td>
<td>48</td>
<td>42</td>
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<tr>
<td>Trim Time</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Cut Tons</td>
<td>9</td>
<td>10.8</td>
<td>10.8</td>
<td>10.8</td>
</tr>
<tr>
<td>Fill Factor</td>
<td>75%</td>
<td>90%</td>
<td>90%</td>
<td>90%</td>
</tr>
<tr>
<td>Cutting Rate</td>
<td>6.4 t/min</td>
<td>8.3 t/min</td>
<td>8.3 t/min</td>
<td>8.3 t/min</td>
</tr>
</tbody>
</table>

A perfect cutting cycle; Replicated on command.
In Summary

Current Coal Mining Business Environment -

- The Thermal Coal Export Market Commodity Price Cycle
- External Cost Pressures, e.g. Power and Labour
- Lack of Investment and Capital Constraints

The Productivity Improvement lever is potentially fully within our internal control. When pulled it can help position us on the right place on the cost curve.

Example of Coal Cost Curve
In Summary

Mining Machinery - Effectively Utilised by PEOPLE
Any Questions?