Mechanizing the bolting cycle in Stillwater Mining Company’s small drifts and narrow stopes (10ft wide or less).

Matt O’Reilly, PE - Planning & Production Manager - Stillwater Mining Company
Steve Nye – Western District Sales Manager – JH Fletcher & Company
Tim Burgess – Vice President of Engineering – JH Fletcher & Company
For many years the hand held jackleg drills have been the only choice for installing ground support in narrow vein or small drift development. Keeping stopes/drifts small minimizes dilution and can maximize profits. These jacklegs though very mobile and nimble come with some risks. They provide no protection to the operator and have even generated a common phrase to describe the work, "a young man’s job".

The paper will describe the Stillwater Mining Company’s interest in changing the long history of jackleg usage and culture with an emphasis on improving safety in the work environment. The paper will also provide the challenges of designing a mobile machine to work in 6.5ft wide stopes, detail the four year project history, describe Stillwater’s mining methods and conditions, and discuss the setbacks/advances made.
Stillwater Mining Montana Operations
Stillwater Mine
- Only ~11 miles of 28 mile strike length developed
- Stillwater Proven reserve 3,248,000 tons @ 0.60 opt  1,932,000 ounces
- East Boulder Proven reserve 2,632,000 @ 0.40 opt  1,055,000 ounces
- Total Proven and Probable 43,461,000 @ 0.46 opt  19,911,000 ounces
Mechanization of the mining process has been ongoing for 150+ years in the mining business.

Narrow vein resource mining operators have been the last to move to mechanization as grade and quality of the ROM ore is critical to the success of the operation. With this constraint operators have been reluctant to move away from the jackleg drill for bolting as their were no suitable alternatives for installing ground support in steep dip narrow vein or reef type deposits.

Narrow LHD’s and narrow jumbo drills have been developed and improved upon over the years which made significant improvements to the mechanization of narrow ore body extraction. During this time bolting equipment technology has not been applied to narrow mining applications much to the fact that equipment manufacturers had no business case for development and operators chose to continue to manage the risk of jackleg operation.
The Case for Mechanization

• The Safety of the Miners

• Since 2013, 26% or 32 of Stillwater Mine’s MSHA reportable incidents have been related to jackleg use; the nature of injuries is as follows,
  • 10 Lacerations
  • 9 Strains
  • 6 Contusions
  • 4 Crushing
  • 2 Foreign Body
  • 1 Puncture
The Case for Mechanization

Stillwater Mine and UG Metal Total Incidence Rate Comparison

- Stillwater NFDL Inc. Rate
- Underground Metal Mines NFDL Rate

MSHA Metal Mines Rate is through 3/31/2016

SMC Incidence Rate is through 6/30/2016
Stillwater Mining Methods & Conditions

- **Mining Mix**
  - 90% Ramp & Fill
  - 6% Sublevel Extraction / Pillar Extraction
  - 4% Captive

- 90% PGM production comes from near 40 production rounds per day totaling 1,200 rounds per month. Each of these rounds is bolted by a talented miner using a jackleg drill.

- At any given time during a shift there can be up to 10 to 15 miners bolting production headings using a jackleg drill.
Stillwater Mining Methods & Conditions

The J-M Reef is the world's richest known deposit of PGM's.

Geologist Maps every Face –
- Provides guidance on ore width and direction
- Makes call on shipping
- Gives feedback on dilation over break
Stillwater Mining Methods & Conditions

- Overhand Ramp & Fill Mining
Stillwater Mining Methods & Conditions

- Underhand Ramp & Fill Mining
• Sublevel Extraction Mining
Stillwater Mining Methods & Conditions

- Conventional Captive Stope Mining
The Challenges of Designing a Mobile Machine to work in 6.5 ft. wide stopes

Stillwater Mine
JH Fletcher Stope Bolter in Production Stope
Design Challenges
Design Challenges
Design Challenges
• ORIGINAL PERFORMANCE PARAMETERS

✔ MACHINE MUST IMPROVE SAFETY VERSUS A JACK LEG
✔ TRAM AT 5 MPH, NEGOTIATE RAMPS AND INTERSECTIONS, BE STABLE
☐ MACHINE MUST WORK IN 6.5’ WIDE STOPES
✔ BOLTING HEIGHT OF 14.5’
✔ INSTALL BOLTS AS PERPENDICULAR TO ALL FACES AS PRACTICAL
✔ INSTALL 5’ SPLIT SETS AND 8’ TORQUE TENSION BOLTS
☐ BE EFFICIENT ENOUGH TO BOLT 2 PLACES AND TRAM UP TO 1.5 MILES IN ONE SHIFT
Bolter Productivity

Rounds Bolted Per Shift

<table>
<thead>
<tr>
<th>Shift</th>
<th>12/9/2015</th>
<th>12/10/2015</th>
<th>12/11/2015</th>
<th>12/12/2015</th>
<th>Average/Shift</th>
<th>Average Day Shift</th>
<th>Average Night Shift</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day Shift</td>
<td>2</td>
<td>0.5</td>
<td>2.5</td>
<td>2</td>
<td>1.5</td>
<td>1.6</td>
<td>1.5</td>
</tr>
<tr>
<td>Night Shift</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1.6</td>
<td>1.6</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Bolts Installed Per Shift

<table>
<thead>
<tr>
<th>Shift</th>
<th>12/9/2015</th>
<th>12/10/2015</th>
<th>12/11/2015</th>
<th>12/12/2015</th>
<th>Average/Shift</th>
<th>Average Day Shift</th>
<th>Average Night Shift</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day Shift</td>
<td>52</td>
<td>51</td>
<td>53</td>
<td>53</td>
<td>41.3</td>
<td>47.0</td>
<td>35.5</td>
</tr>
<tr>
<td>Night Shift</td>
<td>27</td>
<td>32</td>
<td>25</td>
<td>37</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Bolter Productivity
IMPROVEMENTS DURING PROJECT

- ADDITION OF 18” OF BASKET EXTEND
- ADDITION OF 72” OF FEED FROM ORIGINAL SHORTER 58” FEED ASSEMBLY
- ADDITION OF 20” OF DROP MAST TO FEED FOR POSITIONING – CURRENTLY THERE IS NO DROP MAST CAPABILITY
- ADDITION OF NEW SYSTEM TO POSITION FEED – ELIMINATES THE TURRET
- ADDITION OF THINNER CANOPY FOR MORE ROOM IN BASKET
- ADDITION OF ELECTRO-HYDRAULIC CONTROLS FOR IMPROVED CONTROL AND MORE ROOM IN BASKET
- ADDITION OF NEW DRILL GUIDES AND ELIMINATION OF DRILL GUIDE EXTEND CYLINDERS FOR SMALLER FOOT PRINT AGAINST THE BACK
- ADDITION OF AUTO BASKET LEVEL
Ergonomic Improvements

- 10” improvement in reach for all positions
- Less obstruction
  - Front wall modification
  - Control manipulation
  - Eliminated turret
Design Improvements
Design Improvements
Design Improvements
Design Improvements
Design Improvements
Design Improvements
Questions?